Evolutionary Psychology
Series Editors: Todd K. Shackelford · Viviana A. Weekes-Shackelford

David C. Geary
Daniel B. Berch *Editors*

Evolutionary Perspectives on Child Development and Education

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Evolutionary Perspectives on Child Development and Education

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Preface

The chapters in this volume stem from a fall 2013 conference on evolutionary approaches to educational issues. The conference was funded by the American Educational Research Association and cosponsored by the Evolution Institute and brought together anthropologists, biologists, educational researchers, and psychologists to present, discuss, and vet research and ideas on how an evolutionary approach can enhance educational outcomes and inform educational policies. Our focus was not simply on the three *R*s (reading, writing, and arithmetic) but also on the social dynamics and relationships that emerge in classroom and educational settings. Given that the bulk of education occurs during development, we decided to expand the scope of the volume to include broader developmental issues, not simply educational ones, and thus invited a few other scholars to contribute chapters. The result, we believe, is a unique and informative collection that highlights the contributions, debates, and promises of an evolutionary framing of children's development and their success in school.

The volume is organized into three parts. The first part includes five chapters that broadly focus on children's natural exploratory behaviors and play and the implications for their cognitive and academic development. Bjorklund and Beers open with an introduction to evolutionary developmental psychology and the implications for our understanding of how evolution has shaped children's natural learning biases. They then use this approach to illustrate how well-intended attempts to accelerate young children's academic learning may misfire and cause unintended and deleterious consequences. Lancy's chapter reinforces Bjorklund and Beer's approach by nicely illustrating children's self-directed learning in traditional societies. He makes a cogent argument that adult-directed teaching in these contexts is rare and the concept itself is foreign to adults in these societies. Gray argues that Lancy's observations about child-directed learning should be taken to heart and used in modern educational settings, that is, that this approach is sufficient for children to learn the three *R*s needed to be successful in the modern world.

Pellegrini's chapter focuses on children's play and exploration with objects. He proposed that these activities are not simply a way to learn about objects and how they can be used, but may also contribute to behavioral and cognitive flexibility as well as facilitate children's social development. He also cautions that "play" as defined by ethologists does not necessarily have the same meaning as "play" in the context of an educational goal, and thus the outcomes of these activities may differ. Toub and colleagues close the first part with a thoughtful discussion of how children's bias to engage in play can be used in educational settings to facilitate their learning of the three *R*s. Their guided play may also help to reconcile debate within evolutionary educational psychology, specifically, the amount of adult-directed learning needed to acquire evolutionarily novel academic competencies.

The second part includes three chapters that focus on children's social relationships and the evolutionary functions of their social behavior. Hawley opens with a discussion of eight myths or incorrect assumptions most people make about evolutionary approaches to human behavior. As with Pellegrini, she notes that part of the problem is that biologists and psychologists often use the same terms, such as altruism, but mean different things. She aptly explains the differences and then discusses how children's social behavior, even behavior that many would consider prosocial, is really about gaining social influence and access to material resources. These implicit goals can be achieved by being "nice" or being a bully, but work best with a mix of prosocial and bullying behaviors. Volk focuses on the latter and details the social functions and benefits of bullying, aspects of this behavior that only make sense in evolutionary context—this of course is not the same as condoning the behavior, only more fully understanding it. He correctly notes that bullying is not confined to children and adolescents and can take many forms and lead to better control of many different types of resources, from social dominance to material goods.

The second part closes with Shaw tackling the related question of "fairness," specifically, the moral framing of how resources are divided among group members (e.g., equal amounts for everyone or proportional amounts based on contributions). The two previous chapters make it clear that differential and unequal access to resources is the norm and yields benefits to more dominant individuals. The moral stance that everyone should receive an identical and equal share of resources makes sense from the perspective of those who would otherwise get fewer resources. The issue goes deeper than this, however. Even people (children and adults) who have control over how resources are distributed often opt for an equal distribution, especially when there is an audience. There must then be some benefit that outweighs the loss of foregone (shared) material resources. Shaw makes an intriguing case that at least part of the benefit derives from social dynamics, more precisely, signaling that one is not attempting to gain the favor of specific others in an attempt to form a friendship or larger alliance with them. The shifting of friendships and wider alliances has clear implications for the balance of social power within a group and thus is a potential source of conflict. In this view, it is not surprising that people try not to trigger this conflict by distributing resources "unfairly."

The third part brings us back to learning and cognition, but now focuses on specific, evolved biases in how people process and remember information and how these biases can help or hinder learning in formal school settings. Geary and Berch provide a broad overview of these issues and focus on differences between evolved abilities, such as language, and non-evolved abilities that are built from them, such as reading. The distinction gets at the core of current debate in evolutionary educational psychology, that is, whether the cognitive biases and behaviors (e.g., play and exploration) that allow children to flesh out and adapt evolved abilities to local conditions are sufficient for learning the myriad of non-evolved competencies that children are expected to learn in modern schools. These of course are issues covered in the first part of the volume. The question remains to be resolved, and whatever the final answer, the active debate highlights the vibrancy of this emerging field.

Nairne highlights one such bias; specifically, that our attentional and memory systems are attuned to detecting and remembering living things and things that potentially signal contagion. These are things, including potential predators and prey, that had clearly had significant consequences during our evolutionary history. The chapter and Nairne's work generally also nicely highlights the value added by an evolutionary perspective, in this case, informing controlled experiments on human memory and discovering a strong bias that eluded atheoretical memory researchers for more than a century. Sinatra and Danielson touch on another evolved bias that ironically interferes with people's learning about and deep understanding of evolution. People certainly have an interest in the natural world, as demonstrated by Nairne's work and discussed by Geary and Berch, but the evolution of this interest is utilitarian. We have evolved to attend to other species, because they are usable as food or to be avoided as potential predators, but these implicit folk-biological biases are not the same as scientific biology. Sinatra and Danielson do a masterful job of highlighting how our folk-biological biases actually interfere with the scientific understanding of evolution; the same interference is common for folk physics and scientific physics and no doubt for folk psychology and scientific psychology.

Sweller's chapter nicely integrates decades of research on cognitive load theory with evolutionarily informed instructional approaches. It has been known for some time that working memory constraints limit the ease and rate of learning in school, and Sweller and his colleagues have been at the forefront of designing and testing educational approaches to effectively deal with this constraint. In their chapter, they explicitly discuss how cognitive load theory and associated empirical findings fall neatly into place when set up in evolutionary context; specifically, when applied to evolutionarily novel learning as contrasted with fleshing out evolved cognitive domains. Kauffman and Wilson close the third part with description of their novel work with the Regents Academy; specifically, using evolutionary principles that foster social cooperation to create a learning environment for students at risk for dropping out of high school. They demonstrate that broadening the conceptualization of schooling as a social as well as academic environment can substantively improve the academic and social competencies of at-risk students.

Evolutionary Perspectives on Child Development and Education pulls together the latest theoretical contributions and research reviews of many of the leaders in the intersections between evolution, development, and education. The volume provides a compelling case for how an evolutionary perspective can fruitfully inform our understanding of children's development and their schooling in traditional and modern contexts.

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David C. Geary is currently a curators' professor in the Department of Psychological Sciences and the Interdisciplinary Neuroscience Program at the University of Missouri. His work spans a broad range of topics from children's mathematical cognition and development to the evolution of sex differences. He's written four sole authored books, *Children's Mathematical Development* (1994), *Male, Female* (1998, 2nd edition, 2010), *Origin of Mind* (2005), and *Evolution of Vulnerability* (2015), and one coauthored book, *Sex Differences* (2008) and is coediting the five-volume *Mathematical Cognition and Learning* series, the first two volumes of which have been released: *Evolutionary Origins and Early Development of Number Processing* (2015) and *Development of Mathematical Cognition: Neural Substrates and Genetic Influences* (2016). In addition, he has published about 250 journal articles and chapters and has had extensive funding from the National Institutes of Health and the National Science Foundation for his empirical research. He served on the president's National Mathematics Advisory Panel from 2006 to 2008 and chaired the learning processes task group and was appointed by President Bush to the National Board of Advisors for the Institute of Education Sciences, US Department of Education (2007–2010). Geary is a fellow of the American Association for the Advancement of Science, received a National Institutes of Health MERIT Award, is a corecipient of the G. A. Miller Award from the American Psychological Association, and has been a visiting scholar at the Chinese University of Hong Kong and the Institute of Advanced Study, Durham University.

Daniel B. Berch is professor of educational psychology and applied developmental science at the University of Virginia's Curry School of Education. Prior to this position, he was associate dean for research and faculty development at the Curry School and before that served as associate chief of the Child Development and Behavior Branch at the National Institute of Child Health and Human Development, NIH. His previous federal service included a stint as senior research associate at the US Department of Education, advising the assistant secretary for Educational Research and Improvement. Berch has published journal articles and book chapters on the development of numerical cognition, mathematical learning disabilities, and evolutionary perspectives on education. He is senior editor of the book *Why Is Math So Hard for Some Children?* and senior editor of the five-volume *Mathematical Cognition and Learning* series. He is also the lead founder of the international Mathematical Cognition and Learning Society. Among other honors, Berch received the NIH Award of Merit, was elected fellow of the American Psychological Association's Division of Experimental Psychology, served as an ex officio member of the US Department of Education's National Mathematics Advisory Panel commissioned by President George W. Bush, and was elected to the Evolution Institute's Scientific Advisory Board (and chairs its Education Subcommittee). He is coauthor (with David Geary) of an article entitled "Evolutionary Approaches to Understanding Children's Academic Achievement" published in Wiley's online reference work, *Emerging Trends in the Social and Behavioral Sciences*.

Part I
Development, Play, and Exploration in Early Learning

Chapter 1
The Adaptive Value of Cognitive Immaturity: Applications of Evolutionary Developmental Psychology to Early Education

David F. Bjorklund and Courtney Beers

Few educated people today would argue with the proposition that humans' hegemony over the Earth is a result of their enhanced intelligence and that this intelligence evolved from cognitive abilities of our great-ape ancestors over the course of the last 5–7 million years (Tomasello, 2014). Moreover, *Homo sapiens*, more than any other species, transmit nongenetic information from one generation to the next via processes of learning, in many cases acquiring information and concepts that have no deep evolutionary history (Geary, 2005). Stated slightly differently, humans are the most educable of species (Bjorklund, 2007a), and this education, occurring within a cultural milieu, happens throughout life beginning in infancy. Although it is adults who produce the most useful artifacts, establish and run cultural institutions, and whose cooperation and competition permit the continuation and advancement of society, the intellectual and social abilities used to achieve these outcomes develop over infancy and childhood and also evolved over the course of many millennia. From this perspective, children's universal cognitive abilities were subject to the forces of natural selection, just as the cognitive abilities of adults were. According to the *cognitive immaturity hypothesis* (Bjorklund, 1997, 2007b; Bjorklund & Green, 1992), infants' and young children's cognitive and perceptual abilities are well-suited for their particular time in life and are not simply incomplete versions of the adult form.

Humans, more so than any other species, take a long time to reach maturity (Bogin, 1999). Although primates in general have extended juvenile periods, this trend is exaggerated in *Homo sapiens*. The closer a species' common ancestor is

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with *Homo sapiens*, the longer is the period of immaturity: in lemurs approximately 2 years, in macaques approximately 4, in chimps (*Pan troglodytes*) approximately 8, and in humans approximately 15 years (Poirier & Smith, 1974), although physical and brain development continues for several more years in humans (Giedd et al., 1999). Extending the time before one reaches sexual maturity can be very costly. The chances of an individual dying before adulthood through disease, starvation, or predation increase with each year immaturity is prolonged. In biology, when there is great cost to a feature there must also be great benefit, lest the feature would not have survived the sieve of natural selection. Most theorists agree that the primary benefit of extending the pre-reproductive period of the human lifespan was to expand the brain (humans have more cortical neurons than any other mammal, including much larger whales, and nearly twice as many as chimpanzees, see Roth & Dicke, 2005), affording both the neural capacity and the time to acquire the technical (e.g., Kaplan, Hill, Lancaster, & Hurtado, 2000) and social (Bjorklund, 1997, 2007b) skills necessary for survival and reproduction in adulthood. Moreover, a number of theorists have proposed that humans' enhanced cognition evolved principally to deal not only with unpredictable and harsh environments, but rather primarily with other members of the species (the social brain hypothesis, e.g., Alexander, 1989; Dunbar, 2003, 2010; Geary, 2005; Humphrey, 1976; Tomasello & Moll, 2010). As such, humans have evolved adaptations for dealing with social others and for learning from other members of the species.

However, much of children's intellectual and social development is not simply a reduced version of adult intelligence and sociality, but rather is adapted to their particular social niche. This requires that children's cognition (and social cognition) be specially adapted to their time of life, rather than merely being incomplete versions of adult adaptations.

In this chapter, we first outline some of the basic concepts of *evolutionary developmental psychology*, specifically examining adaptations of infancy and childhood. We then look at an evolutionary developmental perspective of how young children learn, focusing on learning through observation and play. We next examine two topics related to early education in which an evolutionary developmental perspective can be helpful—young children's learning via "new" media (see also Toub et al., this volume), and the potential benefits of children overestimating their own social and cognitive abilities. We conclude that an evolutionary developmental perspective offers a useful lens for understanding how to balance various types of early educational experiences as well as how such a balance can promote children's well-being and their future academic success.

Adaptations of Infancy and Childhood

With respect to development, at least two types of adaptations of infancy and childhood can be identified, as noted. *Ontogenetic adaptations* (Bjorklund, 1997, in press; Oppenheim, 1981) refer to evolved characteristics of infants and children that were specifically selected to serve an adaptive function at a specific time in development. In comparison, *deferred adaptations* are those aspects of childhood that were selected, at least in part, for their role in preparing children for adulthood in ancient environments (Hernández Blasi & Bjorklund, 2003).

Ontogenetic Adaptations

It is no mean feat surviving infancy and childhood, and natural selection has produced some adaptations that serve the specific purpose of helping young members of a species do just that. Some of the most obvious are adaptations during the prenatal period that permit the embryo to get nourishment in a totally different way than it will after birth (or hatching). For example, embryonic birds have a yoke sack to nourish them before hatching, and mammals have an umbilical cord to provide nourishment and remove wastes. Once the animal is born, these structures cease to be functional, as nourishment and waste removal will be handled by different systems (see Oppenheim, 1981). These are clear examples of ontogenetic adaptations, features that serve to adapt young organisms to their immediate environments and "disappear" when they are no longer needed. Many neonatal reflexes are also easily seen as ontogenetic adaptations. For example, when infants' cheeks are stroked, they will open their mouths and orient toward the direction of the stimulation (the rooting reflex) and will reflexively suck when pressure is placed on their lips, both functional in nursing. These reflexes disappear within 4–6 months, as infants' brains develop, permitting them intentional control of these behaviors.

Many forms of inefficient cognition characteristic of infants and young children may actually be behaviors that are adapted to the particular niche of infancy and childhood. For example, neonatal imitation, the copying of facial expressions such as tongue protrusions by newborns (Meltzoff & Moore, 1977), may not be a reflection of sophisticated social cognition, but rather a reflex-like behavior that fosters infant–mother interaction at a time in life when infants have little intentional control over their own behavior, disappearing when infants develop such control (Bjorklund, 1987); babies' strong dependence on context for learning may prevent young infants from retrieving memories in "inappropriate" situations (Rovee-Collier & Shyi, 1992); preschool children's egocentric worldview (Piaget, 1983) results in children referencing objects and events to themselves, which enhances their memory of those objects and events (e.g., Ratner, Foley, & Gimpert, 2002; Ross, Anderson, & Campbell, 2011; see Sellers & Bjorklund, 2014).

Even infants' poorly functioning sensory systems can be seen as adaptations. Such limitations prevent infants from processing sensory stimulation in one system (vision, for example) before other systems (hearing, for example) are developed. For instance, a number of studies have shown that providing young animals perceptual stimulation in excess of species-typical norms results in atypical development (e.g., Kenny & Turkewitz, 1986; Lickliter, 1990; Lickliter & Lewkowicz, 1995).

For example, Lickliter (1990) showed that providing extra visual stimulation to bobwhite quail (*Colinus virginianus*) embryos, days before they would normally receive such stimulation, resulted in subsequent enhanced visual discrimination abilities but impaired auditory responding (they failed to discriminate and approach their own species call when it was paired with that of a chicken). Presumably, early sensory stimulation serves to organize the young organism toward certain, usually adaptive outcomes; but when sensory experience is withheld, received earlier than is normative, or experienced in excess of species-typical levels, species-atypical patterns of development result. Animals' neurology, physiology, and sensory systems are coordinated with species-typical experiences, both pre- and postnatally, to reliably produce species-typical behavior.

Deferred Adaptations

Hernández Blasi and Bjorklund (2003) referred to adaptations that principally serve to prepare children for adulthood as *deferred*, meaning many of the benefits of an adaptation are delayed until adulthood and expressed in terms of providing practice for adult-like functioning. Note, however, that it is unlikely that all benefits of such adaptations are deferred. Some may also be immediate, and in fact, likely are, because a potentially costly adaptation is unlikely to persist if all its benefits are years in the future.

A good candidate for a deferred adaptation is *play* (see also Pellegrini, this volume; Toub et al., this volume). The well-known homily "play is the work of children" reflects the fact that "play" is what children spend most of their time doing (e.g., Pellegrini, 2013) and the belief that play is important to children's development. Play characterizes the activities of most young social mammals. In fact, Groos (1898/1975, p. 75), a pioneer in play research, wrote, "animals cannot be said to play because they are young and frolicsome, *but rather they have a period of youth in order to play*." Play has been viewed as important for human development and evolution (e.g., Bateson, 1976; Gopnik, Griffiths, & Lucas, 2015; Pellegrini, 2013). In fact, Nielsen (2012) proposed that fantasy play, in addition to imitation, is a critical feature of human childhood and played a central role in the evolution of human intelligence. According to Nielsen (2012, p. 176), "By pretending children thus develop a capacity to generate and reason with novel suppositions and imaginary scenarios, and in so doing may get to practice the creative process that underpins innovation in adulthood."

In the remainder of this chapter, we examine some of the ways in which infants and young children learn and how such knowledge can be applied to education. In this next section, we first look at the principal ways in which young children across the globe and across time learn: through observation/social learning and through play. This is followed by an examination of both the benefits and limitations on young children's learning through instruction (social learning) and discovery (play).

How Young Children Learn

From an early age, humans are motivated to both think about as well as learn from others (Tomasello & Carpenter, 2007). For instance, children seem to be sensitive to, even have a bias towards, participating in social behaviors that further support their cognitive development (Gauvain & Perez, 2015; Geary & Bjorklund, 2000; Tomasello, 2014). As noted earlier, the social intelligence hypothesis proposes that humans possess a set of specialized social–cognitive skills that enable the effective transmission of knowledge from experts to novices (Herrmann, Call, Hernández-Lloreda, Hare, & Tomasello, 2007), at least for evolutionarily relevant information (Geary, 2005). Not only do humans learn from past generations, but they also modify and make improvements on the information that is passed down (Tennie, Walter, Gampe, Carpenter, & Tomasello, 2014). While other species, such as chimpanzees, also transmit knowledge within their social groups, their process in doing so is far less advanced. For example, most social learning in chimpanzees does not seem to involve teaching or even copying specific behaviors of a model to achieve a goal (i.e., imitation), but rather a form of *emulation*, in which the observer uses different behaviors than the model to achieve a similar goal (Nielsen, 2006). Humans' enhanced ability to learn through social processes may help to explain why cognitive capabilities are far more advanced in humans than in any other species (Toub et al., this volume).

Learning Through Watching

The way in which children are thought to learn best varies from one culture to the next. In industrialized cultures, the dominant view is that children learn through direct instruction, or teaching, and that this teaching should begin in infancy (Lancy & Grove, 2010). Yet, the act of teaching is rather complex because it requires the existence of a bidirectional relationship between an instructor and learner, where both parties understand the motives of the other and where the expert intentionally instructs the novice, at some expense to him- or herself (Tomasello, 2000). The idea of teaching in general is subjective. In more traditional cultures, formal instruction is rather uncommon (Lancy, this volume). Instead, children guide their own learning, and adult participation is used only to promote specific skills at opportune times (Lancy, 2015; but see Kline, 2015). In lieu of direct adult instruction, the "entire community and its surroundings are seen as the 'classroom,' and the 'curriculum' is displayed as an 'open book'" (Lancy & Grove, 2010, pp. 164–165). Of course, there may be a struggle here. Evolution has endowed children with certain propensities that direct them towards learning in specific contexts, but to live successfully in modern society (e.g., learning higher-order mathematics), children may experience conflict between the skills that need to be acquired and the manner in which to learn it (Geary, 2005; Periss & Bjorklund, 2011).

Overimitation. According to Bandura's social learning/social cognitive theory (1986, 1989), children learn by observing the behaviors of others, noticing the consequences of their actions and determining if these actions should be incorporated into their own sets of behaviors. Observation is the key here, an essential element of social learning. One form of observational learning, *imitation*, is thought to be the best mechanism for acquiring the cultural knowledge that is so important for effectively fitting within one's social group. Imitation is defined as "reproducing an observed outcome using the same action the model used with an understanding of the intention behind the actions" (Nielsen, 2012, p. 172). To truly fit the definition of imitation, an observer must witness the actions of a model and then match the behavior to a high degree of fidelity (Horner & Whiten, 2005). Interestingly, children become more imitative across childhood (McGuigan & Whiten, 2009) and will even copy a model's behavior by reproducing actions that are clearly not needed to achieve a goal, referred to as *overimitation* (e.g., Hoehl, Zettersten, Schleihauf, Grätz, & Pauen, 2014; Lyons, Young, & Keil, 2007). For example, Horner and Whiten (2005) administered a test of imitation to a sample of children between the ages of 3 and 4 years. In the experiment, the children witnessed a model use a tool to retrieve a reward from a box (either transparent or opaque). Half of the demonstrator's actions in retrieving the reward were deemed irrelevant (i.e., could have been skipped) and the other half of the actions were relevant (i.e., needed to be performed to complete the goal). The researchers found that the children imitated the irrelevant actions of the model in both the transparent and opaque condition, despite the fact that in the transparent condition they could have reached the reward with fewer actions.

Overimitation emerges gradually in childhood over the first few years of life, paralleling the development of children's social–cognitive skills. Younger children will choose to emulate a model, that is, they will watch a model perform a set of actions, but will use different movements or actions to complete the same goal (Whiten, McGuigan, Marshall-Pescini, & Hopper, 2009). Various ideas have been put forth to explain why over-copying behaviors increase with age (Nielsen, Mushin, Tomaselli, & Whiten, 2014). It may be that young children direct their attention to a task differently than older children. That is, children under the age of 3 focus their attention on the end goal, whereas 3- to 5-year-old children focus on a model's actions (McGuigan & Whiten, 2009). In addition, as children get older, their social–cognitive skills continue to develop and they become more attentive to the fact that other people have both intentions and actions and that these actions most likely have meaning (McGuigan & Whiten, 2009). By considering all of these different elements, researchers suggest that overimitation is really a sign of one's growing cognitive maturity (Gardiner, Greif, & Bjorklund, 2011).

According to Nielsen (2012), overimitation could be seen as maladaptive; after all, replicating non-essential acts is energy-consuming, and too much time focused on a model's behaviors could result in a failure to understand the ultimate goal of the performance. However, he proposes, "directly replicating others also affords the rapid acquisition of a vast array of skills that have been developed and passed on over multiple generations, avoiding the potential pitfalls and false end-points that can come from individual learning" (p. 171). This hypothesis seems to be consistent with the findings in the literature.

Besides resulting in more successful performances, imitation may also be evolutionarily adaptive because it is an effective way for children to rapidly acquire the cultural information and artifacts that are so important to their social group (Bjorklund & Ellis, 2014; Nielsen et al., 2014). Children pick out the types of social interactions that they feel are particularly important for living in richly symbolic environments (Froese & Leavens, 2014) and learn those techniques through faithful imitation. Researchers refer to this as the *normative account*, proposing that the observer understands the actions that are relevant and those that are irrelevant for completing the task, but he or she believes all of the actions to be important for the "bigger overarching action sequence" (Keupp, Behne, & Rakocz, 2013, p. 393). In other words, children believe that irrelevant actions, particularly those that are difficult to understand, must have a greater purpose (Kenward, 2012; Williamson & Markman, 2006), and knowing how to perform these actions is important because it may "alig[n] oneself with one's cultural in-group" (Nielsen, 2012, p. 171).

Children choose to imitate based on a number of variables, including a model's intentions, status, efficacy, and manner of instruction (e.g., Gardiner et al., 2011; Hoehl et al., 2014; McGuigan, 2013; Williamson & Meltzoff, 2011). For example, Buttelmann, Zmyj, Daum, and Carpenter (2013) found that 14-month-old children were less likely to copy a model who read a story in a language different from their own, demonstrating a bias to copy actions of an in-group member more so than an out-group member. In other studies, children were selective in faithfully imitating an adult's behavior based on status. For instance, McGuigan (2013) found that 5-year-old children who watched a model retrieve a reward from a puzzle box were more likely to reproduce the same irrelevant actions of a high-status model (i.e., principal or head teacher) than that of a low-status model (i.e., unfamiliar stranger or low-status familiar person). Modeling those who are more prestigious, McGuigan concluded, would be highly adaptive in the context of cultural learning because higher status within a group tends to reflect that the person has more power and a better health and reproductive history. Csibra and Gergely (2011; Gergely & Csibra, 2005) have similarly proposed that overimitation is a human-unique adaptation that fosters the fast and accurate transmission of information between individuals, which they refer to as *natural pedagogy*.

Emulation. As previously mentioned, children become more imitative with age; however, Froese and Leavens (2014) do not believe that imitation on a single task continues for any long period of time. Instead, they propose that through the process of imitation an individual can learn the meaning of conventionally constrained behavior and then replace their imitative approach with an emulative one. In emulation, discussed briefly earlier with respect to social learning in chimpanzees, an individual represents the goal of the model, but, unlike imitation, engages in different behaviors to achieve that goal. A study conducted by Simpson and Riggs (2011) offers some support for this hypothesis. They studied how a group of 3- and 4-year-old children represented imitative actions over short and longer delays. The 90 children in this study watched a model use both relevant and irrelevant actions to obtain a block from within a clear puzzle box. After watching the model, some of the children were given an L-shaped tool and then told to retrieve the block. Others did not have an opportunity to retrieve the block until 5–8 days later. Not surprisingly, the children given the short delays reproduced all relevant actions and frequently reproduced irrelevant actions. However, what was surprising was that the children in the long-delay condition were far less likely to perform the irrelevant actions. The researchers concluded that children must form two different representations of the actions that they observe—one for the actions that they know to be relevant and one for the actions that they know to be irrelevant. The short-term representation fades over the delay as children begin to understand the meaning behind the actions, and this leaves only the essential steps in long-term memory that are necessary for completing the task. In other words, children replicate opaque actions in case the behaviors may be useful later for performing a normative social task. Once the actions are better understood, the irrelevant information can be discarded, leaving just the relevant information behind (Nielsen et al., 2014; Whiten et al., 2009).

Why would moving from an imitative to an emulative approach over time be adaptive? The argument is that emulation allows for modifications and improvements to be made to those techniques that are used within a social group (Tennie et al., 2014). This is better known as the *ratchet effect* (Wood, Kendal, & Flynn, 2013). Upgrading of cultural knowledge in this way is not seen in other primates to the same extent that it is in humans. Perhaps this is due to the fact that children have an extended period of immaturity in which they have opportunities not only to learn from others, but also time to engage in pretend play and discovery. Gopnik et al. (2015) note that this extended time allows children to further explore, to think in more abstract ways, and to consider alternative possibilities to solutions that older children may fail to see. By the second year of life, children also spend a great deal of time playing, and it is through this activity that children learn to manipulate objects and act out techniques that they have observed in others. Familiarizing themselves with cultural artifacts and tools, children move from faithfully imitating to emulating others. Using a more emulative approach allows children to learn new affordances of objects and to generate novel ideas and solutions that can be applied to the cumulative culture (Nielsen, 2012). This human cumulative culture effectively guides children's cognitive development, organizes the context of the information presented within the social environment into categories and references, and becomes part of children's thoughts and behaviors (Gauvain & Perez, 2015; Rogoff, 2003; Tomasello, Kruger, & Ratner, 1993).

Learning Through Playing

As we noted earlier, *Homo sapiens* benefit from an extended period of immaturity for several reasons. One affordance is the added time to practice skills that may be important for future success in adulthood (Bjorklund, Periss, & Causey, 2009). *Play* is used as one means for this practice and honing of abilities, serving both as an immediate and deferred function in childhood (Bjorklund & Ellis, 2014; Bjorklund, Hernández Blasi, & Ellis, 2016). By definition, play is a "type of exploratory learning in which the young animal engages in a variety of behaviors in a low-risk, low-cost context" (Gopnik & Walker, 2013, p. 15). Play behaviors are performed by a variety of different, mostly social, species (Bjorklund et al., 2009). For humans, play provides an opportunity to explore the world, other people, and one's self without taking on too great of a risk. In fact, half of children's (ages 3–12) free time is spent in unstructured play (i.e., around 15 h/week) (Hofferth & Sandberg, 2001). Pellegrini and Bjorklund (2004) make this point particularly clear: "play seems to have been especially adapted for the period of childhood and is what children are 'intended' to do" (p. 38). While this may be so, play does come at a cost, as it is both energy and time consuming, and not merely an act undertaken for the sake of enjoyment or for some energy release (Bjorklund et al., 2009; Bjorklund & Pellegrini, 2002; Pellegrini & Smith, 2005).

The development and reward of play. There are various types of play that children engage in during the early childhood period, including locomotor play, object-oriented play, and pretend play (see Bjorklund et al., 2009; Pellegrini, this volume). Pretend play differs from other types of play in that it requires children to use pretense, that is, invoking imaginary situations that are distinguished from reality (Cemore & Herwig, 2005). Furthermore, it is characterized by an "as-if" stance (Lillard et al., 2013) that advances during early childhood (Carlson, White, & Davis-Unger, 2014) as a result of children's growing abilities to use symbols to represent something other than itself (DeLoache, 2004). Children typically begin to exhibit behaviors associated with pretense around 2 years of age. They attribute living characteristics to non-living objects or make an object stand in for something else (Carlson et al., 2014). For example, a young girl may use a stick to represent a spoon. As symbol use improves, children use objects more often that are increasingly perceptually distinct from the objects they represent (Kelly et al., 2011) and in a way that is much more abstract from the original representation. Eventually, children will even create pretend overtures of others (Carlson et al., 2014), for instance, a 3-year-old boy puts a teddy bear to sleep. Around 3–5 years of age, children begin what researchers refer to as the high period for pretense (Lillard et al., 2013). Fantastical themes dominate play scenarios (e.g., a pirate excursion) and play also becomes more socially operated (e.g., having a tea party), often called sociodramatic play.

Those passionate about the topic of play defend its rewards. According to Berk, Mann, and Ogan (2006), pretend play functions as an experience-expectant process; that is, children play so as to stimulate the brain for focused learning. Several studies suggest that children who engage in larger amounts of play show more positive outcomes in other areas, including, language development, perspective taking, and executive-function abilities (Berk et al., 2006; Pierucci, O'Brien, McInnis, Gilpin, & Barber, 2014). In a retrospective study, adults who reported engaging in substantial amounts of free play as children displayed greater evidence of social success as adults (e.g., friendships, self-esteem, psychological health, physical health) than adults who reported engaging in less free play as children (as measured by participants' subjective and reported experience of free play) (Greve, Thomsen, & Dehio, 2014). Further analyses suggested that these positive effects of childhood free play on adult outcomes were mediated by greater adaptivity (flexible goal adjustment).

Play and executive function. During play, children engage in a unique and complex system of make-believe in which a certain amount of cognitive control is instrumental. Vygotsky (1978) proposed that children exhibit higher cognitive abilities during symbolic play than in other situations. He wrote, "in play, the child always behaves above his average age, above his daily behavior; in play it is as though he were a head taller than himself" (Vygotsky, 1978, p. 102). Vygotsky believed that during pretend play, children use symbols (e.g., language) in which to refer to events (Berk & Meyers, 2013), and as a result, they are able to regulate their own behavior. Because pretend play often takes place in social groups, children practice acting out social rules and are scaffolded by others to inhibit certain behaviors (Elias & Berk, 2002). This idea led Vygotsky (1978) to suggest that children reach their greatest self-control in play, as they are required to put aside their immediate desires in order to remain part of the play scenario.

Young children face challenging situations every day in which they must consider how to respond and how not to respond. Carlson, Davis, and Leach (2005) proposed this sentiment stating, "development can be thought of as the progressive *acquisition* of knowledge or skills, but also enhanced *inhibition* of responses that mask these abilities" (p. 609). The ability to do just that requires *executive functions* (EF), which are processes involved in regulating attention and determining what to do with information just gathered or retrieved from long-term memory. Executive functions play a central role in planning and behaving flexibly, especially when dealing with new information, and consist of a related set of basic information-processing abilities, including *working memory*, the structures and processes used for temporarily storing and manipulating information; selectively attending to relevant information; inhibiting responding and resisting interference; and cognitive flexibility, as reflected by how easily individuals can switch between different sets of rules or different tasks (see Garon, Bryson, & Smith, 2008; McAuley & White, 2011; Zelazo, Carlson, & Kesek, 2008). These abilities are the underlying structures for both higher-level cognition (e.g., problem solving and decision making) and emotional and behavioral control (e.g., self-regulation) (e.g., Barker et al., 2014; Rueda & Posner, 2013).

Individual differences in EF abilities are related to factors of age, genetics, and experience. EF develops across childhood and adolescence, with the brain's neural systems experiencing structural and functional changes over time in the prefrontal cortex (PFC) and in the connections that link the PFC to other cortical structures (Carlson, Zelazo, & Faja, 2013; Zelazo & Carlson, 2012). Carlson et al. (2013) suggest that the increase in proficiency of EF with age is due to the growth of myelination within the PFC, speeding up the electric pulses through the axons. At the same time, gray matter decreases with age due to synaptic pruning and, as a result, more efficient neural circuits are created. Early childhood is an important time for both brain structure and EF development, particularly for children between the ages of 2 and 6 when significant gains are made in terms of attention, inhibition, planning, and cognitive flexibility (Berk & Meyers, 2013; Carlson et al., 2013). A shift also takes place from that of using externally driven EF, that is, “behaving in a goal-directed way when given reminders” (Barker et al., 2014, p. 2) to more self-directed EF in which one uses internal rules and reminders to meet an objective.

Accompanying age, genetics is also a factor for individual differences in measures of EF. According to Friedman et al. (2008), executive function is the most highly heritable (99 % common factor) psychological traits ever assessed. While EF is highly heritable and also tends to show stability over time, it can nonetheless be modified by experience, particularly when there is a change in an individual’s environment. For example, EF exercises have been used within innovative preschool curricula programs with positive results (Diamond, Barnett, Thomas, & Munro, 2007; Röthlisberger, Neuenschwander, Cimelia, Michele, & Roebers, 2012). Researchers find that children who engage in EF training exercises not only improve on task performance, but also exhibit changes in brain structure and function (Carlson et al., 2013). It is important to note that research finds transfer of training across EF components to be somewhat “narrow” (for example, from inhibition to working memory), and children must practice their abilities on increasingly complex activities in order for EF abilities to continue to improve (Diamond, 2012).

To understand why differences in EF matter, it is important to view the development of EF in terms of potentially life-long outcomes. Measurement of EF in preschool predicts academic (e.g., reading and math), social (e.g., theory of mind), and emotional competencies in adolescence and even adulthood (e.g., Berk & Meyers, 2013; Carlson & White, 2013). Researchers find that EF correlates to school readiness more than does IQ (Diamond et al., 2007). That is, children who show poorer EF skills (e.g., shorter attention spans and lower inhibition) also show poorer school-readiness skills (Blair & Diamond, 2008). Children who display poorer EF skills are also more likely to have future health issues, substance dependence, and even a criminal history by adulthood than children with better EF skills (Zelazo & Carlson, 2012).

There has been considerable interest regarding the use of play as a tool for strengthening young children’s cognitive and social development (Weisberg, Kittredge, Hirsh-Pasek, Golinkof, & Klahr, 2015). The push for more research in this area may reflect the growing recognition that children learn many skills best in stress-free and supportive environments. Many preschools show signs of student unrest, with young children exhibiting what many consider abnormally high levels of behavioral disorders. In fact, preschool children are expelled at a rate three times that of elementary and secondary students for unmanageable behaviors (Gilliam, 2005). For this reason, there is a call in the literature to consider to what extent EF abilities, as a measure of preschool readiness, can be altered by environmental experiences such as play (Barker et al., 2014).

Some researchers believe there is a lack of evidence within the literature to suggest that pretend play enhances executive functioning, citing poor methodological procedures in former studies (e.g., Lillard et al., 2013). Others in the field acknowledge past methodological errors, but they also argue that it is too soon to cast away the evidence, particularly with a wave in more recent findings (e.g., Gopnik & Walker, 2013). EF is critical in many areas of functioning, as noted above, and even if these interventions may not work as strongly as originally assumed, there is strong evidence to suggest that natural development of EF may require engagement in pretend play. Not only does executive functioning play a role in children's ability to immerse themselves in pretend play (Kelly et al., 2011), but pretend play itself also facilitates the development of executive functions. That is, the relationship between pretend play and EF is bidirectional (Carlson et al., 2014). For this latter argument, Blair and Diamond (2008) explain:

> During social pretend play, children must hold their own role and those of others in mind (working memory), inhibit acting out of character (employ inhibitory control), and flexibly adjust to twists and turns in the evolving plot (mental flexibility); all three of the core executive functions thus get exercise. (p. 907)

Pretend play is no doubt a complex activity. Children who engage in symbolic play must be able to hold two or more things in mind without mixing up what is make-believe and what is reality (Carlson et al., 2014). This is an impressive feat because it requires dual representation or "mentally represent[ing] the concrete object itself and its abstract relation to what it stands for" (DeLoache, 2004, p. 69). Children typically achieve dual representation around 3 years of age; younger children tend to focus on a concrete object itself rather than what it represents (DeLoache, 2004). Carlson et al. (2014) argue that the ability to consider alternative representations is the link for the bidirectional relationship between pretense and executive function. They propose "that 'playing' with representation in pretense and the growing ability to consider alternatives in thinking and acting through EF development may be rooted in the same core abilities" (p. 10). Using symbols to represent other objects (i.e., dual representation) requires the use of EF abilities (e.g., inhibition and attention), and using EF for symbol representation in pretense further exercises these abilities.

The link between pretense and EF abilities may be through private, or self-directed, speech. Studies indicate that young children use private speech, or talking aloud during cognitively challenging tasks (Berk & Meyers, 2013), to guide their behaviors. Eventually self-directed speech becomes inner speech, or what Vygotsky (1962) believed to be transforming speech inward to self-direct behavior. Some research confirms this and suggests that children who engage in self-talk are more likely to be attentive to a purpose as well as to show further gains in task performance than children who do not engage in self-talk (Elias & Berk, 2002). For example, Kraft and Berk (1998) found that children who were encouraged by their preschool teachers to participate in open-ended activities, such as make-believe, were more likely to exhibit private speech than were children in preschools with fewer opportunities for free play. Private speech is seen more often during acts of symbolic play, and particularly in sociodramatic play, where children use different roles to build a story line. For instance, Elias and Berk (2002) reported that highly impulsive 3- and 4-year-old children were more apt to strengthen their EF skills (i.e., use self-regulated behaviors) over the school year if they had engaged in a higher frequency of sociodramatic play behaviors. This finding is consistent with this type of play being a natural component of EF development, as noted above.

There are also several education programs that claim to increase executive functioning skills via training exercises, of which *Tools of the Mind* may be the best known. The *Tools of the Mind* (*Tools*) preschool curriculum emphasizes the incorporation of what is referred to as EF-promoting activities (Diamond et al., 2007). The program encourages children to use self-regulatory speech and engage in dramatic play. Children are also instructed in how to "use toys and props in a symbolic manner, develop extensive and consistent scenarios, maintain rules and character roles, and plan the play scenarios before beginning to play" (Carlson & White, 2013, p. 10). This curriculum approach is said to strengthen children's EF skills, which in turn improves their school readiness. To look at such a claim, Diamond et al. (2007) compared one urban preschool that incorporated *Tools* to another preschool that incorporated the school district's version of *Balanced Literacy*. Children were measured in the second year for inhibitory control, working memory, and cognitive flexibility. In the end, *Tools* students outperformed the *Balanced Literacy* children on the EF tests, suggesting that an early childhood EF training program may increase young children's EF skills, and consequently, their school readiness. It is not possible to determine which components of the *Tools* program were critical in enhancing EF, although one must consider the possibility that providing children with the opportunity for more sociodramatic play may have been a critical ingredient in the program's effectiveness.

Using play as a central means for strengthening executive functions is not a new concept per say. Hunter-gatherer societies view play as essential for children to transfer their experiences into a meaningful context and for learning how to survive in society. Based on observations by anthropologists, Gray (2013) states, "it may be no coincidence, therefore, that the same cultures that allow their children the greatest freedom to play also produce people who, apparently, have the greatest capacity for self-control" (p. 41).

It is important to note that the *Tools* curriculum took place inside a structured environment where children receive adult reminders to use EF skills. How do children learn to use more self-directed cognitive control? Self-directed executive functioning is related to how children carry out their own goal-directed actions, which is extremely important as children take on more challenging tasks. Barker et al. (2014) propose that the key for strengthening self-directed EF could be in the use of more open-ended activities. In their study, 6- to 7-year-old children who spent more time in less-structured activities demonstrated better self-directed EF, as indexed by verbal fluency performance, whereas the opposite was true for children who spent more time in structured activities, which predicted worse self-directed control. Their results suggest that children who engage in activities in which they can plan and create their own rules, such as during pretend play, may have more opportunities in which to strengthen their EF abilities.

Pretend play may not always predict better EF skills, however. In fact, Berk and Meyers (2013) propose that moderators such as child characteristics (e.g., low baseline EF skills, social economic status) and play factors (e.g., thematic content or complexity) could very well be associated with negative EF outcomes. An example of a moderator would be the features present in the environment. Pellegrini and Bjorklund (2004) state that children require safe environments in which to play and master skills. In the Diamond et al. (2007) study, children from an urban, low-income neighborhood benefited from an EF-promoting curriculum that incorporated make-believe play during the school day. The school offered a safe environment in which to do so. However, a safe home environment is not always available for children from lower social economic status (SES) communities. It may be more difficult for these children to achieve a higher level of cognitive complexity while engaged in pretense in a risky environment. Therefore, children who live in lower SES communities may especially need play incorporated into their preschool curriculum to receive potential benefits.

Because EF development is malleable in the early childhood years, as Zelazo and Carlson (2012) state, preschool may be a "particularly valuable window of intervention" (pp. 357–358). The findings presented here suggest that this could be accomplished through the encouragement of play during structured time (e.g., *Tools* curriculum) as well as during unstructured time. A number of the studies mentioned in this chapter have demonstrated that, to varying degrees, pretend play benefits aspects of children's cognitive development. Yet, the time during school in which children are engaged in pretend play continues to decrease (Hirsh-Pasek, Golinkoff, Berk, & Singer, 2009; Miller & Almon, 2009). This may be due to what Barker et al. (2014) suggest are societal shifts. That is, children's engagement in more structured and certain media-centered activities has taken them away from play and from developing more self-directed EFs. Furthermore, instructional practices have had an impact on children's academic and social outcomes. Playtime in early childhood classrooms continues to be cut from the curriculum and daily schedules in favor of what may be developmentally inappropriate approaches (Berk & Meyers, 2013; Toub et al., this volume). This is important because studies indicate that children who attend developmentally appropriate preschool programs experience less stress and anxiety than those who attend direct-instruction programs (Burts, Hart, Charlesworth, & Kirk, 1990; Hirsh-Pasek, Hyson, & Rescolra, 1990). Moreover, high levels of stress have been shown to impair executive functions (Blair & Diamond, 2008). Play, on the other hand, reduces stress and allows children to concentrate on more complex cognitive abilities. Gray (2013) concludes that as a society:

> We are pushing the limits of children's adaptability. We have pushed children into an abnormal environment, where they are expected to spend ever greater portions of their day under adult direction, sitting at desks, listening to and reading about things that don't interest them, and answering questions that are not their own and are not, to them, real questions. We leave them ever less time and freedom to play, explore, and pursue their own interests (p. 5).

It is important to note here that we realize there is disagreement, with Geary (1995, 2007) arguing these mechanisms may not be fully useful for learning in many evolutionary recent domains (e.g., reading, writing, and arithmetic), whereas Gray sees no such limitations.

Research suggests that executive functioning predicts both academic preparedness and social competencies (Berk & Meyers, 2013; Carlson & White, 2013;

Zelazo & Carlson, 2012). Unfortunately, not only are children seemingly coming into school unprepared, they are also coming in taking a higher number of psychotropic medications (Blair & Diamond, 2008). In fact, 10 million American children are currently being medicated for attention-deficit hyperactivity disorder (Panksepp, 2007). This may be due to a higher number of children exhibiting poorer control over attention and inhibition. It could also be due to the fact that more impulsive children are unable to attend to the strict direct instructional approaches that are currently being used in schools. Either way, if there is a bidirectional relationship between executive functioning and pretend play, research in this area may offer some better solutions. Increasing the time in which children are engaged in pretend play may not be the only solution (Carlson et al., 2014), but it could be one way to better prepare children with the EF skills that are essential for learning.

What children learn through discovering versus instruction. How children learn influences how children can best be educated. Human survival is dependent upon learning more than any other species (Boyd, Richerson, & Henrich, 2011; Tomasello, 2014), and much of this learning takes place during childhood, as children acquire the necessary ecological, technological, and social skills of their cultural group. Although children sometimes learn "on their own" through a hands-on, trial-and-error process, children are mostly educated by others. As we noted earlier, however, adults in traditional cultures rarely engage in direct, explicit teaching, as is customary in Western cultures (Lancy, this volume); rather, social learning is more apt to be indirect, through observation of adult activities or via play, in which other children, rather than adults, are the vehicles through which learning occurs.

Preschool education itself is a modern invention. It has only been in the last several decades that a majority of children from Western cultures have attended preschool. For most of this time, the emphasis was on the acquisition of social and behavioral (e.g., following instructions) skills that would serve as the foundation for more formal academic learning in primary school. In recent decades, however, the emphasis on formal instruction for preschool children has increased, and this has resulted in great debate among educators and researchers who advocate a developmentally appropriate preschool curriculum from those who stress the attainment of academic abilities such as reading and basic arithmetic (e.g., Bredekamp & Copple, 1997; Brown & Lan, 2013; Reed, Hirsh-Pasek, & Golinkoff, 2012). Research contrasting developmentally appropriate and direct-instructional preschool programs has produced mixed results, with some studies reporting greater intellectual benefits for developmentally appropriate programs (e.g., Stipek et al., 1998), some for direct-instructional programs (e.g., Stipek, Feiler, Daniels, & Milburn, 1995), and others no significant differences (e.g., Hyson, Hirsh-Pasek, & Rescorla, 1990). When examining motivational and psychosocial effects, more research reports advantages for children who attend developmentally appropriate programs compared to direct-instructional programs (e.g., Burts et al., 1993; Hirsh-Pasek et al., 1990; Schweinhart & Weikart, 1988; Stipek et al., 1995, 1998).

Given our discussion of the importance of play in young children's learning, it should not be surprising that we advocate for preschool programs that provide substantial learning opportunities through play, that is, developmentally appropriate programs. Yet, it is the rare preschool program that does not involve some explicit teaching, as well as the rare direct-instruction program that does not permit children at least some play time. Moreover, it is undeniable that children learn both through play and instruction, and that a balance between teacher-directed and child-initiated activities may be particularly beneficial for learning. Both paths provide a promising approach for strengthening children's executive functions and play behaviors, discussed earlier.

Bonawitz et al. (2011) proposed that direct instruction, or teaching, aids children by promoting efficient acquisition of the target information, but in doing so, it also "limits the range of hypotheses children consider" (p. 333). In contrast, learning through play, or *discovery learning*, may slow or even prevent the acquisition of specific information or a specific skill, but instead result in learning new properties of a stimulus or event. To test their ideas, Bonawitz and her colleagues showed preschool children a novel toy and instructed children in the *Pedagogical* condition how to perform a specific set of actions to produce a specific outcome (make a squeaking sound). Other children were shown the same actions with the same outcome but without specific pedagogical instructions, and still others were shown the new toy without any demonstration. Children were then given the opportunity to play with the toy (Wow, isn't that cool! I'm going to let you play and see if you can figure out how this toy works). Children in the Pedagogical condition spent significantly less time playing with the toy and discovered significantly fewer different functions of the toy compared to children in the other conditions. Rather, children in the Pedagogical condition spent more time than children in the other conditions playing with the squeaker, the one function they were shown. Similar outcomes were found in a second experiment that expanded upon the different demonstration conditions: preschool children given direct instruction with a novel toy discovered fewer functions of that toy than children not given direct instructions.

The teaching done by Bonawitz et al. (2011) took advantage of children's social-learning abilities, specifically imitation, and shows that simple pedagogical instructions can result in fast and efficient learning of simple behaviors. This is exactly the goal of teachers for many skills preschool children need to acquire. However, such direct instruction is a double-edged sword in that it serves to limit exploration and the discovery of novel properties of artifacts. As Bonawitz et al. (2011) state, "the decision about how to balance direct instruction and discovery learning largely depends on the lesson to be learned" (p. 329).

Applying Evolutionary Developmental Thinking to Children's Education

In this section, we examine two topics related to early education in which an evolutionary developmental perspective can be informative. First, we look at Educational DVDs aimed to teach infants vocabulary and other concepts. Do infants have the cognitive abilities to learn from such two-dimensional (2D) displays? Does the usually fast-paced presentation of information in these videos result in overstimulation and perhaps deficits in learning? And second, we take a brief look at the potential educational benefits of children's overly optimistic appraisals of their own abilities.

The Video Deficit and "Educational" DVDs and Videos for Infants

Our forechildren evolved in a three-dimensional (3D) world and would rarely have encountered 2D stimuli. Although cave paintings date back nearly 40,000 years, it is only recently that people encountered 2D stimuli on a daily basis, and only in the last century that 2D displays have become ubiquitous. Paintings and drawings were essentially the only iconic presentations until the advent of photography in the nineteenth century. It was the twentieth century that saw photographs in newspapers, books, and magazines, followed by movies, television, and now computers, touchscreen tablets, and smart phones, all capable of displaying both static and moving images. Humans clearly learn about the 3D world from 2D representations, and some have speculated that one reason for the steady increase in IQ scores over the twentieth century (the Flynn effect, Flynn, 2007) was the increasing demand to process visual (2D) information (Greenfield, 1998). However, the knowledge that pictures represent "real" objects—that a picture is a symbolic representation—is apparently not understood until about 18 months of age. Before this time, infants and toddlers treat pictures as worthy entities in their own rights, often attempting to pick them off the page of a book (DeLoache, Pierroutsako, Uttal, Rosengren, & Gottlieb, 1998).

Research has clearly shown that infants are capable of learning information from 2D stimuli (Barr, 2010, 2013), especially when learning experiences are frequently repeated (Linebarger & Vaala, 2010). For example, infants who observe a televised model engage in novel actions subsequently imitate those behaviors significantly greater than expected by chance (e.g., Barr, Muentener, Garcia, Fujimoto, & Chavez, 2007; Meltzoff, 1988). However, researchers consistently report a *video deficit*, in that infants much younger than 2 years of age remember or learn about half of the actions compared to infants who observe a live model (see Barr, 2010). In fact, Barr (2013) points out that this deficit is not restricted to videos but to other 2D displays such as picture books (Ganea, Bloom Pickard, & DeLoache, 2008) and touchscreens (Zack, Barr, Gerhardstein, Dickerson, & Meltzoff, 2009) and refers to the reduced ability to learn from such displays as a *transfer deficit.* Despite this well-documented deficit, the evidence that infants and toddlers *can* learn from video displays has led many parents to attempt to accelerate their children's cognitive development through the use of commercially available DVDs and educational software aimed at enriching infants' cognitive experiences.

Despite the enthusiasm of parents and advertisers, research has failed to find any cognitive advantage for infants who use these programs (e.g., DeLoache et al., 2010; Richert, Robb, Fender, & Wartella, 2010; Robb, Richert, & Wartella, 2009). For example, Robb et al. (2009) assigned 12- and 15-month-old infants to watch either episodes of Baby Wordsworth, a DVD highlighting words found around the infants' houses, or to a no-exposure control group for 6 weeks. They reported no difference in either expressive or receptive communication measures between the DVD and the control group. In an experimental study, 12- and 18-month-old infants were taught new words over the course of 1 month by either watching a video where parents were encouraged to interact with their children, watching a video without parental interaction, or direct parent teaching (DeLoache et al., 2010). Only the infants who had direct parent teaching showed subsequent learning of words greater than that of infants in a control condition who had not had any instruction.

Other research suggests that frequent viewing of baby DVDs may actually be detrimental to children's cognitive development (e.g., Courage, Murphy, Goulding, & Setliff, 2010; Zimmerman, Christakis, & Meltzoff, 2007). In fact, in 2011 the American Academy of Pediatrics reaffirmed its 1999 recommendation that parents should avoid exposing children under 2 years of age to television, background media, and other video media based on a lack of evidence of any educational advantage for such media use and its potential for negative consequences to children's cognitive development. For example, Zimmerman et al. (2007) reported that the amount of time 8- to 16-month-old infants spent watching "baby" DVDs such as *Baby Einstein*® was *negatively* associated with receptive vocabulary: Each hour children watched baby DVDs/videos was associated with 6 to 8 *fewer* vocabulary words. Moreover, although infants are often attentive to and seem to enjoy these DVDs, as well as television, it is not until 18 months that the *content* of the video, rather than the physical stimulus qualities of the display, will hold a child's attention (Courage & Setliff, 2010).

There are a number of reasons for young children's difficulties learning from 2D displays, among them is the cognitively challenging task of using one object to stand for another (representational insight, DeLoache, 1987) and also the possibility that repeated exposure to age-inappropriate stimulation may impair other aspects of children's cognition, specifically executive functions. Earlier we discussed executive functions as the set of basic cognitive abilities that are used to plan and regulate behavior and involve working memory, inhibition, and cognitive flexibility. The findings from several studies suggest that media exposure before the age of 2 is related to impaired executive functions (see Lillard, Li, & Boguszewski, 2015). For example, Radesky, Silverstein, Zuckerman, and Christakis (2014) reported that higher levels of media exposure at 9 months of age were associated with poorer self-regulation (e.g., irritability, distractibility, failure to delay gratification, problem shifting focus from one task to another) at 3 years of age, even after controlling for important parental and family characteristics. Similarly, Barr, Lauricella, Zack, and Calvert (2010) reported that viewing adult-directed television at age 1 was negatively associated with measures of executive function at age 4; there was no relation between viewing programs designed for young children and later or concurrent executive functions. In other research, Nathanson, Aladé, Sharp, Rasmusse, and

Christy (2014) reported that preschoolers (average age = 53 months) who had spent a greater number of cumulative hours viewing TV had poorer executive functions than children who had viewed fewer hours, and those children who began watching television earlier had poorer executive functions than those who began watching TV at a later age. The type of television programming was also associated with executive functions, with children who viewed mostly PBS shows having higher levels of executive functioning, whereas children who viewed educational cartoons, characterized by rapid pace and atypical sequencing, had poorer levels of executive functioning. This latter finding is consistent with experimental studies that reported viewing just 9 min of a fast-pace cartoon show resulted in reduced levels of executive functioning in groups of 4-year-old children (Lillard, Drell, Richey, Boguszewski, & Smith, 2015; Lillard & Peterson, 2011).

Unlike generations of infants in the past, the babies of today enter a world full of 2D images, most of which are symbols, representing "real" entities. Given our evolutionary history and the course of symbolic development, it is not surprising that infants have a difficult time making sense of these images. Yet, as Piaget noted many years ago, children become symbolic creatures and show increasing facility to deal with symbols beginning shortly before their second birthdays. In fact, in the high-tech modern world it is critical that children become proficient at learning from 2D displays—static and moving—and we doubt the simple exposure to such displays provides any long-term detriment to young children. What may be detrimental, however, is overexposure to 2D displays that, while amusing to and attracting the attention of infants and toddlers, rarely teache them and often distract them. Although the research is admittedly scant, the evidence is consistent with the position that stimulation in excess of the species norm early in development can have detrimental consequences (cf., Turkewitz & Kenny, 1982).

This is illustrated by some classic research with monkeys (Harlow, 1959) and human infants (Papousek, 1977). For example, Harlow (1959) presented monkeys with simple discrimination-learning problems weekly beginning at 60, 90, 120, or 150 days of age. At 120 days, all animals were given a series of more complicated learning problems. Rather than the additional experience giving the early-starting monkeys an advantage, the long-term performance of the monkeys that began training at 60 and 90 days of age was substantially lower compared to those that began training at 120 and 150 days. Harlow (1959) concluded that, "there is a tendency to think of learning or training as intrinsically good and necessarily valuable to the organism. It is entirely possible, however, that training can be either helpful or harmful, depending upon the nature of the training and the organism's stage of development" (p. 472). Similarly, Papousek (1977) reported that presenting human infants with an operant conditioning task (turn head in one direction to a buzzer, the other direction to a bell) beginning either at birth, 31 days, or 44 days produced substantially different outcomes. Babies who began training at birth required more days of training (128) and more trials (814) to reach criterion than the babies who started training at 31 days (71 days; 278 trials) and 44 days (72 days; 224). Papousek concluded that "beginning too early with difficult learning tasks, at a time when the organism is not able to master them, results in prolongation of the learning process."

The Advantages of Thinking You're Better than You Are

Young children are the optimists of the world. Compared to older children and adults, young children believe they have greater physical abilities (e.g., Plumert & Schwebel, 1997; Schneider, 1998), better memories (e.g., Lipko, Dunlosky, & Merriman, 2009), are more skilled at imitating models (Bjorklund, Gaultney, & Green, 1993), are smarter (e.g., Spinath & Spinath, 2005), know more about how things work (Mills & Keil, 2004), and rate themselves as stronger, tougher, and of higher social standing (e.g., Boulton & Smith, 1990; Humphreys & Smith, 1987) than is actually the case. Moreover, it is not simply that young children are unable to make accurate judgments about a person's characteristics or abilities. They do a reasonable job assessing other children's qualities and reserve their rosy assessments for themselves (Stipek & Daniels, 1988). Some have speculated that young children's overly optimistic perspectives of their own characteristics, abilities, and performance is an adaptation, protecting them from the negative consequences of failure at a time when most of their physical and intellectual abilities are limited (Bjorklund, 1997; Bjorklund et al., 2009; Seligman, 1991). According to Seligman (1991), "The child carries the seed of the future, and nature's primary interest in children is that they reach puberty safely and produce the next generation of children. Nature has buffered our children not only physically—prepubescent children have the lowest death rate from all causes—but psychologically as well, by endowing them with hope, abundant and irrational" (p. 126).

Children's optimism provides them the motivation to persist at tasks on which children more in touch with their abilities might quit. Their "immature," overly positive views of their own abilities serve to foster high levels of self-efficacy—beliefs about their having control over their own lives (Bandura, 1997). Bandura (1997) proposed that people with poor self-efficacy tend to behave ineffectually, irrespective of their actual abilities, whereas people with high levels of self-efficacy behave as if they have some control over their lives, which results in more effectual actions. With respect to preschool-aged children, if they were aware of how poorly they really performed many tasks, their sense of self-efficacy would be impaired and they may be reluctant to attempt new tasks and to persist at tasks they do attempt.

The benefit of children's overly optimistic perspective of their own performance is illustrated in a study assessing children's memory for a series of word lists (Shin, Bjorklund, & Beck, 2007). In this study, kindergarten, first-, and third-grade children were given repeated sort-recall memory trials using different sets of categorically related words on each trial. Prior to the study phase on each trial, children were asked to predict how many items they would remember. Children were subsequently classified into either a high- or low-accuracy group based on their prediction accuracy on the early trials, and changes from early (trials 1 and 2) to later (trials 4 and 5) trails were examined. The results for changes in recall, clustering (a measure of the degree to which items were recalled by categories), and number of memory strategies observed (e.g., rehearsal, self-test) are shown in Table 1.1. As you can see, the kindergarten and first-grade children who overestimated more (the low-accuracy

Table 1.1 Changes in memory measures over trials (Trials 4/5 minus Trials 1/2) for the Low- vs. High-Accuracy Groups

	Kindergarten	Grade 1	Grade 3
Recall	**Low > High**	**Low > High**	**Low > High**
Clustering	Low = High	**Low > High**	High > Low
# Strategies	**Low > High**	**Low > High**	High > Low

Source: Adapted from Shin et al. 2007
Entries in **bold** indicate a statistically significant difference

group) generally showed greater positive changes in recall and strategy use than the more accurate (high-accuracy group) children, although the opposite pattern was observed for the oldest children, at least for clustering and number of strategies used. Thus, at least for younger children, overestimating one's abilities on early trials was associated with greater gains in cognitive performance than for children who were more in touch with their cognitive abilities. These findings are consistent with Bandura's arguments that children's overestimation biases foster improvements in their abilities by motivating persistence and promoting self-efficacy.

Children's sense of success is often fostered by their attitude that performing the task is rewarding in its own right. That is, rather than being concerned about achieving a specific goal, performing a task is viewed as play, with no goal in mind other than engaging in the task. Similarly, when children are conscious of achieving a goal, parents and teachers may alter a goal when the original objective proves too difficult. As a result, children perceive they achieve goals adults had set for them and experience feelings of mastery (Stipek, Recchia, & McClintic, 1992). In general, children's tendencies to overestimate their abilities and task performance may give them basic confidence in their own competence. From an educational perspective, we agree with Stipek (1984) who argued that instead of trying to make young children's judgments of their abilities more accurate, we should "try harder to design educational environments which maintain their optimism and eagerness" (p. 52).

Conclusion

In this chapter, we used an evolutionary developmental perspective to argue that immature cognitive abilities are befitting for the early years of human life (Bjorklund, 1997, 2007b; Bjorklund & Green, 1992). We proposed that young children's inefficient cognition is adapted specifically for the period of early childhood and benefits children both in their immediate and future contexts (Bjorklund, 1997; Hernández Blasi & Bjorklund, 2003). Certain cognitive characteristics, once viewed as limitations, are explained in terms of their value in fitting children to a particular niche in infancy or childhood. We discussed this in terms of how a poorly functioning sensory system imparts protection in an over-stimulating environment (Lickliter, 1990), how the act of copying or overimitating a model's performance supports the rapid acquisition of culturally relevant information (McGuigan & Whiten, 2009; Nielsen, 2012), and how an overoptimistic perspective of one's competence and abilities ignites motivation and persistence in future performances (Bjorklund et al., 2009; Seligman, 1991).

An evolutionary developmental perspective is also useful when applied to early educational settings, as it provides an explanation for how young children naturally learn. According to the social intelligence hypothesis, children are sensitive to their social contexts and pay particular attention to cultural information present in their environment (Gauvain & Perez, 2015; Herrmann et al., 2007; Tomasello, 2014). As a result, they learn by observing and imitating the behaviors of others. This type of natural pedagogy is advantageous because children absorb cultural information that is deemed important in order to live successfully in a particular society (Froese & Leavens, 2014; Gergely & Csibra, 2005; Tennie et al., 2014). However, imitation also has its disadvantages; for instance, it limits future creativity (Bonawitz et al., 2011; Nielsen, 2012). Humans have evolved ways to effectively handle such an issue. Children use emulative actions, most often during play, to subsequently innovate or upgrade their cultural knowledge (Whiten et al., 2009). Moreover, much of what children learn is through play. Rather than being viewed as mere recreation, play should be viewed as reflecting the evolved mechanism by which children acquire the skills necessary for adult life, or what Gray (2013) has described as "self-motivated practice of life skills" (p. 156). Children not only acquire specific skills via play, but also related cognitive abilities (executive functions) that are used in planning and decision making in all aspects of their lives.

Many educational programs today try to "prepare" young children for their future adult roles without first considering how children have evolved to learn. Research indicates that early training for the attainment of academic abilities at a very young age increases the risk of delayed acquisition of knowledge and skills later (e.g., Papousek, 1977). A number of studies find that the use of educational videos and other screen-based media for the acceleration of learning can lead to deficits in several developmental domains (e.g., Barr, 2013; DeLoache et al., 2010; Lillard, Li, et al., 2015; Nathanson et al., 2014; Robb et al., 2009; Zimmerman et al., 2007). Due to the recent emphasis on testing and attainment of academic skills in early educational settings, playtime continues to be cut in favor of more direct instructional approaches. It is apparent that children can learn from such experiences, but it may come at a cost to their motivation as well as their psychosocial functioning (e.g., Burts et al., 1993). We advocate here for early educational programs that support age-appropriate experiences and that adequately integrate opportunities for children to engage in rich play. Both unstructured (i.e., play) and structured (i.e., direct instruction) activities should be incorporated in the educational setting, and as stated earlier, the type of pedagogical practices and activities employed depends on the type of lesson to be learned (Bonawitz et al., 2011).

Taking an evolutionary perspective does not guarantee that children will be "properly" educated, nor is having such a perspective necessary for realizing a developmentally appropriate curriculum. Moreover, evolutionary thinking as applied to education is not monolithic, as reflected by some of the chapters in this volume. However, there seems to be more agreement among evolutionary theorists concerning the "best practices" for educating young children, with more disagreement about how best to educate older children. Evolutionary theory provides a valuable framework in which different Darwinian-influenced hypotheses can be generated and tested with the goal of improving education for the most educable of animals.

References

Alexander, R. D. (1989). Evolution of the human psyche. In P. Mellers & C. Stringer (Eds.), *The human revolution: Behavioural and biological perspectives on the origins of modern humans* (pp. 455–513). Princeton, NJ: Princeton University Press.

American Academy of Pediatrics. (2011). Media use by children younger than 2 years. *Pediatrics, 128*, 1040–1045.

Bandura, A. (1986). *Social foundations of thought and action: a social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1989). Social cognitive theory. In R. Vasta (Ed.), *Annals of child development: Six theories of child development* (Vol. 6). Greenwich, CT: JAI Press.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.

Barker, J. E., Semenov, A. D., Michaelson, L., Provan, L. S., Snyder, H. R., & Munakata, Y. (2014). Less-structured time in children's daily lives predicts self-directed executive functioning. *Frontiers in Psychology, 5*, 1–16.

Barr, R. (2010). Transfer of learning between 2D and 3D sources during infancy: Informing theory and practice. *Developmental Review, 30*, 128–154.

Barr, R. (2013). Memory constraints on infant learning from picture books, television, and touchscreens. *Child Development Perspectives, 4*, 205–210.

Barr, R., Lauricella, A., Zack, E., & Calvert, S. L. (2010). Infant and early childhood exposure to adult-directed and child-directed television programming: Relations with cognitive skills at age four. *Merrill-Palmer Quarterly, 56*, 21–48.

Barr, R., Muentener, P., Garcia, A., Fujimoto, M., & Chavez, V. (2007). Age-related changes in deferred imitation from television by 6- to 18-month-olds. *Developmental Science, 10*, 910–921.

Bateson, P. P. G. (1976). Rules and reciprocity in behavioural development. In P. P. G. Bateson & R. A. Hinde (Eds.), *Growing points in ethology* (pp. 401–421). Cambridge, NY: Cambridge University Press.

Berk, L. E., Mann, T., & Ogan, A. (2006). Make-believe play: Wellspring for development of self-regulation. In D. G. Singer, R. M. Golinkoff, & K. Hirsh-Pasek (Eds.), *Play = learning: How play motivates and enhances children's cognitive and social-emotional growth* (pp. 74–100). New York, NY: Oxford University Press.

Berk, L. E., & Meyers, A. B. (2013). The role of make-believe and the development of executive functions: Status of research and future directions. *American Journal of Play, 6*, 98–110.

Bjorklund, D. F. (1987). A note on neonatal imitation. *Developmental Review, 7*, 86–92.

Bjorklund, D. F. (1997). The role of immaturity in human development. *Psychological Bulletin, 122*, 153–169.

Bjorklund, D. F. (2007a). The most educable of species. In J. S. Carlson & J. R. Levin (Eds.), *Psychological perspectives on contemporary educational issues* (pp. 119–129). Greenwich, CT: Information Age.

Bjorklund, D. F. (2007b). *Why youth is not wasted on the young*. Malden, MA: Wiley.
Bjorklund, D. F. (2015). Developing adaptations. *Developmental Review*, *38*, 13–35.
Bjorklund, D. F., & Ellis, B. J. (2014). Children, childhood, and development in evolutionary perspective. *Developmental Review, 34*, 225–264.
Bjorklund, D. F., Gaultney, J. F., & Green, B. L. (1993). "I watch, therefore I can do:" The development of meta-imitation over the preschool years and the advantage of optimism in one's imitative skills. In R. Pasnak & M. L. Howe (Eds.), *Emerging themes in cognitive development* (Vol. 1, pp. 79–102). New York, NY: Springer.
Bjorklund, D. F., & Green, B. L. (1992). The adaptive nature of cognitive immaturity. *American Psychologist, 47*, 46–54.
Bjorklund, D. F., Hernández Blasi, C., & Ellis, B. J. (2016). Evolutionary developmental psychology. In D. M. Buss (Ed.), *Evolutionary psychology handbook* (Vol. 2). New York: Wiley.
Bjorklund, D. F., & Pellegrini, A. D. (2002). *The origins of human nature: Evolutionary developmental psychology*. Washington, DC: American Psychological Association.
Bjorklund, D. F., Periss, V., & Causey, K. (2009). The benefits of youth. *European Journal of Developmental Psychology, 6*, 120–137.
Blair, C., & Diamond, A. (2008). Biological processes in prevention and intervention: The promotion of self-regulation as a means of preventing school failure. *Development and Psychopathology, 20*, 899–911.
Bogin, B. (1999). *Patterns of human growth* (2nd ed.). Cambridge, England: Cambridge University Press.
Bonawitz, E., Shafto, P., Gweon, H., Goodman, N. D., Spelke, E., & Schulz, L. (2011). The double-edged sword of pedagogy: Instruction limits spontaneous exploration and discover. *Cognition, 120*, 322–330.
Boulton, M. J., & Smith, P. K. (1990). Affective bias in children's perceptions of dominance relations. *Child Development, 61*, 221–229.
Boyd, R., Richerson, P. J., & Henrich, J. (2011). Colloquium Paper: The cultural niche: Why social learning is essential for human adaptation. *Proceedings of the National Academy of Sciences, 108*, 10918–10925.
Bredekamp, S., & Copple, C. (1997). *Developmentally appropriate practice in early childhood programs* (Revth ed.). Washington, DC: National Association for the Education of Young Children.
Brown, C. P., & Lan, Y. (2013). The influence of developmentally appropriate practice on children's cognitive and psychosocial development: A qualitative metasynthesis. *Teachers College Record, 115*, 1–36.
Burts, D. C., Hart, C. H., Charlesworth, R., DeWolf, D. M., Ray, J., Manuel, K., & Fleege, P. O. (1993). Developmental appropriateness of kindergarten programs and academic outcomes in first grade. *Journal of Research in Childhood Education, 8*, 23–31.
Burts, D. C., Hart, C. H., Charlesworth, R., & Kirk, L. (1990). A comparison of frequencies of stress behaviors observed in kindergarten children in classrooms with developmentally appropriate versus developmentally inappropriate instructional practices. *Early Childhood Research Quarterly, 5*, 407–423.
Buttelmann, D., Zmyj, N., Daum, M. M., & Carpenter, M. (2013). Selective imitation of in-group over out-group members in 14-month-olds. *Child Development, 84*, 422–428.
Carlson, S. M., Davis, A. C., & Leach, J. G. (2005). Less is more: Executive function and symbolic representation in preschool children. *Psychological Science, 16*, 609–616.
Carlson, S. M., & White, R. E. (2013). Executive function, pretend play, and imagination. In M. Taylor (Ed.), *The Oxford handbook of the development of imagination* (pp. 161–174). New York, NY: Oxford University Press.
Carlson, S. M., White, R. E., & Davis-Unger, A. C. (2014). Evidence for a relationship between executive function and pretense representation in preschool children. *Cognitive Development, 29*, 1–16.
Carlson, S. M., Zelazo, P. D., & Faja, S. (2013). Executive function, pretend play, and imagination. In P. D. Zelazo (Ed.), *The Oxford handbook of developmental psychology, vol. 1: Body and mind* (pp. 1–17). New York, NY: Oxford University Press.

Cemore, J. J., & Herwig, J. E. (2005). Delay of gratification and make-believe play of preschoolers. *Journal of Research in Early Childhood Education, 19*, 251–266.
Courage, M. L., Murphy, A. N., Goulding, S., & Setliff, A. E. (2010). When television is on: The impact of infant-directed video on 6- and 18-month-olds' toy play and on parent-infant interaction. *Infant Behavior and Development, 33*, 176–188.
Courage, M. L., & Setliff, A. E. (2010). When babies watch television: Attention-getting, attention holding, and the implications for learning from video material. *Developmental Review, 30*, 220–238.
Csibra, G., & Gergely, G. (2011). Natural pedagogy as evolutionary adaptation. *Philosophical Transactions of the Royal Society of London, Biological Sciences, 366*, 1149–1157.
DeLoache, J. S. (1987). Rapid change in the symbolic functioning of very young children. *Science, 238*, 1556–1557.
DeLoache, J. S. (2004). Becoming symbol-minded. *Trends in Cognitive Sciences, 8*, 66–70.
DeLoache, J. S., Chiong, C., Sherman, K., Islam, N., Vanderborght, M., Troseth, G. L.…O'Doherty, K. (2010). Do babies learn from baby media? *Psychological Science, 21*, 1570–1574.
DeLoache, J. S., Pierroutsako, S. L., Uttal, D. H., Rosengren, K. S., & Gottlieb, A. (1998). Grasping the nature of pictures. *Psychological Science, 9*, 205–210.
Diamond, A. (2012). Activities and programs that improve children's executive functions. *Current Directions in Psychological Science, 21*, 335–341.
Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science, 318*, 1387–1388.
Dunbar, R. I. M. (2003). The social brain: Mind, language, and society in evolutionary perspective. *Annual Review of Anthropology, 32*, 163–181.
Dunbar, R. I. M. (2010). Brain and behaviour in primate evolution. In P. M. Kappler & J. B. Silk (Eds.), *Mind the gap: Tracing the origins of human universals* (pp. 315–330). New York, NY: Springer.
Elias, C. L., & Berk, L. E. (2002). Self-regulation in young children: Is there a role for sociodramatic play? *Early Childhood Research Quarterly, 17*, 216–238.
Flynn, J. R. (2007). *What is intelligence?: Beyond the Flynn Effect*. New York, NY: Cambridge University Press.
Friedman, N. P., Miyake, A., Young, S. E., DeFries, J. C., Corley, R. P., & Hewitt, J. K. (2008). Individual differences in executive functions are almost entirely genetic in origin. *Journal of Experimental Psychology: General, 137*, 201–225.
Froese, T., & Leavens, D. A. (2014). The direct perception hypothesis: Perceiving the intention of another's action hinders its precise imitation. *Frontiers in Psychology, 5*, 1–15.
Ganea, P. A., Bloom Pickard, M., & DeLoache, J. S. (2008). Transfer between picture books and the real world by very young children. *Journal of Cognition and Development, 9*, 46–66.
Gardiner, A., Greif, M., & Bjorklund, D. F. (2011). Guided by intention: Preschoolers' imitation reflects inferences of causation. *Journal of Cognition and Development, 12*, 355–373.
Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin, 134*, 31–60.
Gauvain, M., & Perez, S. M. (2015). Cognitive development in cultural context. In L. Liben & U. Müller (Eds.) (R. M. Lerner, Gen Ed.), *Handbook of child psychology and developmental science. Vol. 2: Cognitive processes* (pp. 854–896). New York: Wiley.
Geary, D. C. (1995). Reflections of evolution and culture in children's cognition: Implications for mathematical development and instruction. *American Psychologist, 50*, 24–37.
Geary, D. C. (2005). Folk knowledge and academic learning. In B. J. Ellis & D. F. Bjorklund (Eds.), *Origins of the social mind: Evolutionary psychology and child development* (pp. 493–519). New York, NY: Guilford.
Geary, D. C. (2007). Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology. In J. S. Carlson & J. R. Levin (Eds.), *Educating the evolved mind* (Psychological perspectives on contemporary educational issues, Vol. 2, pp. 1–99). Greenwich, CT: Information Age.

Geary, D. C., & Bjorklund, D. F. (2000). Evolutionary developmental psychology. *Child Development, 71*, 57–65.

Gergely, G., & Csibra, G. (2005). The social construction of the cultural mind: Imitative learning as a mechanism of human pedagogy. *Interaction Studies, 6*, 463–481.

Giedd, J. N., Bluenthal, J., Jeffries, N. O., Castellanos, F. X., Liu, H., Zijdenbos, A.…Rapoport, J. L. (1999). Brain development during childhood and adolescence: A longitudinal MRI study. *Nature Neuroscience, 2*, 861–863.

Gilliam, W. S. (2005). *Prekindergarteners left behind: Expulsion rates in state prekindergarten systems*. New Haven, CT: Yale University, Child Study Center.

Gopnik, A., Griffiths, T. L., & Lucas, C. G. (2015). When younger learners can be better (or at least more open-minded) than older ones. *Current Directions in Psychological Science, 24*, 87–92.

Gopnik, A., & Walker, C. M. (2013). Considering counterfactuals: The relationship between causal learning and pretend play. *American Journal of Play, 6*, 15–28.

Gray, P. (2013). *Free to learn: Why unleashing the instinct to play will make our children happier, more self-reliant, and better students for life*. New York, NY: Basic Books.

Greenfield, P. M. (1998). The cultural evolution of IQ. In U. Neisser (Ed.), *The rising cure: Long-term gains in IQ and related measures* (pp. 81–123). Washington, DC: American Psychological Association.

Greve, W., Thomsen, T., & Dehio, C. (2014). Does playing pay? The fitness-effect of free play during childhood. *Evolutionary Psychology, 12*, 434–447.

Groos, K. (1898). *The play of animals*. New York, NY: Appleton.

Harlow, H. (1959). The development of learning in the Rhesus monkey. *American Scientist, 47*, 459–479.

Hernández Blasi, C., & Bjorklund, D. F. (2003). Evolutionary developmental psychology: A new tool for better understanding human ontogeny. *Human Development, 46*, 259–281.

Herrmann, E., Call, J., Hernández-Lloreda, M. V., Hare, B., & Tomasello, M. (2007). Humans have evolved specialized skills of social cognition: The cultural intelligence hypothesis. *Science, 317*, 1360–1366.

Hirsh-Pasek, K., Golinkoff, R. M., Berk, L. E., & Singer, D. G. (2009). *A mandate for playful learning in preschool: Presenting the evidence*. New York, NY: Oxford University Press.

Hirsh-Pasek, K., Hyson, M. C., & Rescolra, L. (1990). Academic environments in preschool: Challenge or pressure? *Early Education and Development, 1*, 401–423.

Hoehl, S., Zettersten, M., Schleihauf, H., Grätz, S., & Pauen, S. (2014). The role of social interaction and pedagogical cues for eliciting and reducing overimitation in preschoolers. *Journal of Experimental Child Psychology, 122*, 122–133.

Hofferth, S. L., & Sandberg, J. F. (2001). How American children spend their time. *Journal of Marriage and Family, 63*, 295–308.

Horner, V., & Whiten, A. (2005). Causal knowledge and imitation/emulation switching in chimpanzees (*Pan troglodytes*) and children (*Homo Sapiens*). *Animal Cognition, 8*, 164–181.

Humphrey, N. K. (1976). The social function of intellect. In P. P. G. Bateson & R. A. Hinde (Eds.), *Growing points in ethology* (pp. 303–317). Cambridge, NY: Cambridge University Press.

Humphreys, A. P., & Smith, P. K. (1987). Rough and tumble, friendship, and dominance in schoolchildren: Evidence for continuity and change with age. *Child Development, 58*, 201–212.

Hyson, M. C., Hirsh-Pasek, K., & Rescorla, L. (1990). Academic environments in preschool: Challenge or pressure? *Early Education and Development, 1*, 401–423.

Kaplan, H. S., Hill, K., Lancaster, J. B., & Hurtado, A. M. (2000). A theory of human life history evolution: Brains, learning, and longevity. *Evolutionary Anthropology, 9*, 156–185.

Kenny, P., & Turkewitz, G. (1986). Effects of unusually early visual stimulation on the development of homing behavior in the rat pup. *Developmental Psychobiology, 19*, 57–66.

Kenward, B. (2012). Over-imitating preschoolers believe unnecessary actions are normative and enforce their performance by a third party. *Journal of Experimental Child Psychology, 112*, 195–207.

Kelly, R., Hammond, S., Dissanayake, C., & Ihsen, E. (2011). The relationship between symbolic play and executive function in young children. *Australasian Journal of Early Childhood, 36*(2), 21–27.

Keupp, S., Behne, T., & Rakocz, H. (2013). Why do children overimitate? Normativity is crucial. *Journal of Experimental Child Psychology, 116*, 392–406.

Kline, M. A. (2015). How to learn about teaching: An evolutionary framework for the study of teaching behavior in humans and other animals. *Behavioral and Brain Sciences, 38*, e31.

Kraft, K. C., & Berk, L. E. (1998). Private speech in two preschools: Significance of open-ended activities and make-believe play for verbal self-regulation. *Early Childhood Research Quarterly, 13*, 637–658.

Lancy, D. (2015). *The anthropology of childhood* (2nd ed.). Cambridge, England: Cambridge University Press.

Lancy, D., & Grove, M. A. (2010). The role of adults in children's learning. In D. F. Lancy, J. Bock, & S. Gaskins (Eds.), *The anthropology of learning in childhood* (pp. 145–179). New York, NY: AltaMira Press.

Lickliter, R. (1990). Premature visual stimulation accelerates intersensory functioning in bobwhite quail neonates. *Developmental Psychobiology, 23*, 15–27.

Lickliter, R., & Lewkowicz, D. J. (1995). Intersensory experience and early perceptual development: Attenuated prenatal sensory stimulation affects postnatal auditory and visual responsiveness in bobwhite quail chicks (*Colinus virginianus*). *Developmental Psychology, 31*, 609–618.

Lillard, D. S., Drell, M. B., Richey, E., Boguszewski, K., & Smith, E. D. (2015). Further examination of the immediate impact of television on children's executive function. *Developmental Psychology, 51*, 92–805.

Lillard, A. S., Lerner, M. D., Hopkins, E. J., Dore, R. A., Smith, E. D., & Palmquist, C. M. (2013). The impact of pretend play on children's development: A review of the evidence. *Psychological Bulletin, 139*, 1–34.

Lillard, A. S., Li, H., & Boguszewski, K. (2015). Television and children's executive function. *Advances in Child Development and Behavior, 48*, 219–247.

Lillard, A. S., & Peterson, J. (2011). The immediate impact of different types of television on young children's executive function. *Pediatrics, 128*, 644–649.

Linebarger, D. L., & Vaala, S. E. (2010). Screen media and language development in infants and toddlers: An ecological perspective. *Developmental Review, 30*, 176–202.

Lipko, A. R., Dunlosky, J., & Merriman, W. E. (2009). Persistent overconfidence despite practice: The roles of task experience in preschooler's recall predications. *Journal of Experimental Child Psychology, 103*, 152–166.

Lyons, D. E., Young, A. G., & Keil, F. C. (2007). The hidden structure of overimitation. *Proceedings of the National Academy of Sciences of the United States of America, 104*, 19751–19756.

McAuley, T., & White, D. A. (2011). A latent variables examination of processing speed, response inhibition, and working memory during typical development. *Journal of Experimental Child Psychology, 108*, 45–468.

McGuigan, N. (2013). The influence of model status on the tendency of young children to overimitate. *Journal of Experimental Child Psychology, 116*, 962–969.

McGuigan, N., & Whiten, A. (2009). Emulation and "over-emulation" in the social learning of causally opaque versus causally transparent tool use by 23-and 30-month-old children. *Journal of Experimental Child Psychology, 104*, 367–381.

Meltzoff, A. N. (1988). Imitation of televised models by infants. *Child Development, 59*, 1221–1229.

Meltzoff, A. N., & Moore, M. K. (1977). Imitation of facial and manual gestures by human neonates. *Science, 198*, 75–78.

Miller, E., & Almon, J. (2009). *Crisis in the kindergarten: Why children need to play in school*. College Park, MD: Alliance for Childhood.

Mills, C. M., & Keil, F. C. (2004). Knowing the limits of one's understanding: The development of an awareness of an illusion of explanatory depth. *Journal of Experimental Child Psychology, 87*, 1–32.

Nathanson, A. I., Aladé, F., Sharp, M. L., Rasmusse, E. E., & Christy, K. (2014). The relation between television exposure and executive function among preschoolers. *Developmental Psychology, 50*, 1497–1506.

Nielsen, M. (2006). Copying actions and copying outcomes: Social learning through the second year. *Developmental Psychology, 42*, 555–565.

Nielsen, M. (2012). Imitation, pretend play, and childhood: Essential elements in the evolution of human culture? *Journal of Comparative Psychology, 126*, 170–181.

Nielsen, M., Mushin, I., Tomaselli, K., & Whiten, A. (2014). Where culture takes hold: "Overimitation" and its flexible deployment in Western, Aboriginal, and Bushmen children. *Child Development, 85*, 2169–2184.

Oppenheim, R. W. (1981). Ontogenetic adaptations and retrogressive processes in the development of the nervous system and behavior. In K. J. Connolly & H. F. R. Prechtl (Eds.), *Maturation and development: Biological and psychological perspectives* (pp. 73–108). Philadelphia, PA: International Medical Publications.

Panksepp, J. (2007). Can play diminish ADHD and facilitate the construction of the social brain? *Journal of the Canadian Academy of Child and Adolescent Psychiatry, 16*, 57–66.

Papousek, H. (1977). The development of learning ability in infancy (Entwicklung der Lernfähigkeit im Säuglingsalter). In G. Nissen (Ed.), *Intelligence, learning, and learning disabilities (Intelligenz, Lernen und Lernstörungen)*. Berlin, Germany: Springer.

Pellegrini, A. D. (2013). Play. In P. Zelazo (Ed.), *Oxford handbook of developmental psychology* (pp. 276–299). New York, NY: Oxford University Press.

Pellegrini, A. D., & Bjorklund, D. F. (2004). The ontogeny and phylogeny of children's object and fantasy play. *Human Nature, 15*, 23–43.

Pellegrini, A. D., & Smith, P. K. (Eds.). (2005). *The nature of play: Great apes and humans*. New York, NY: Guilford.

Periss, V., & Bjorklund, D. F. (2011). Trials and tribulations of childhood: An evolutionary perspective. In C. Salmon & T. Shackelford (Eds.), *Oxford handbook of evolutionary family psychology* (pp. 149–168). Oxford, England: Oxford University Press.

Piaget, J. (1983). Piaget's theory. In J. H. Flavell & E. M. Markman (Eds.), (P. H. Mussen, Gen. Ed.). *Handbook of child psychology: Vol. 1. Cognitive development* (4th ed.) (pp. 703–732). New York: Wiley.

Pierucci, J. M., O'Brien, C. T., McInnis, M. A., Gilpin, A. T., & Barber, A. B. (2014). Fantasy orientation constructs and related executive function development in preschool: Developmental benefits to executive functions by being a fantasy-oriented child. *International Journal of Behavioral Development, 38*, 62–69.

Plumert, J. M., & Schwebel, D. C. (1997). Social and temperamental influences on children's overestimation of their physical abilities: Links to accidental injuries. *Journal of Experimental Child Psychology, 67*, 317–337.

Poirier, F. E., & Smith, E. O. (1974). Socializing functions of primate play. *American Zoologist, 14*, 275–287.

Radesky, J. S., Silverstein, M., Zuckerman, B., & Christakis, D. A. (2014). Infant self-regulation and early childhood media exposure. *Pediatrics, 133*, e1172–e1178.

Ratner, H. H., Foley, M. A., & Gimpert, N. (2002). The role of collaborative planning in children's source-monitoring errors and learning. *Journal of Experimental Child Psychology, 81*, 44–73.

Reed, J., Hirsh-Pasek, K., & Golinkoff, R. M. (2012). A tale of two schools: The promise of playful learning. In B. Falk (Ed.), *Defending childhood: Keeping the promise of early education* (pp. 24–47). New York, NY: Teachers College Press.

Richert, R., Robb, M. B., Fender, J. G., & Wartella, E. (2010). Word learning from baby videos. *Achieves of Pediatric and Adolescent Medicine, 164*, 432–437.

Robb, M. B., Richert, R., & Wartella, E. (2009). Just a talking book? Word learning from watching baby videos. *British Journal of Developmental Psychology, 27*, 27–45.

Rogoff, B. (2003). *The cultural nature of human development*. New York, NY: Oxford University Press.

Ross, J., Anderson, J. R., & Campbell, R. N. (2011). I remember me: Mnemonic self-reference effects in preschool children. *Monographs of the Society for Research in Child Development, 76*(3), Serial No. 300
Roth, G., & Dicke, U. (2005). Evolution of the brain and intelligence. *Trends in Cognitive Sciences, 9*, 249–257.
Röthlisberger, M., Neuenschwander, R., Cimelia, P., Michele, E., & Roebers, C. M. (2012). Improving executive functions in 5- and 6-year-olds: Evaluation of a small group intervention in prekindergarten and kindergarten children. *Infant and Child Development, 21*, 411–429.
Rovee-Collier, C., & Shyi, C.-W. G. (1992). A functional and cognitive analysis of infant long-term retention. In M. L. Howe, C. J. Brainerd, & V. F. Reyna (Eds.), *Development of long-term retention*. New York, NY: Springer.
Rueda, M. R., & Posner, M. I. (2013). Development of attention networks. In P. D. Zelazo (Ed.), *Oxford handbook of developmental psychology* (pp. 683–705). Oxford, England: Oxford University Press.
Schneider, W. (1998). Performance prediction in young children: Effects of skill, metacognition and wishful thinking. *Developmental Science, 1*, 291–297.
Schweinhart, L. J., & Weikart, D. P. (1988). Education for young children living in poverty: Child-initiated learning or teacher-directed instruction? *The Elementary School Journal, 89*, 212–225.
Seligman, M. E. P. (1991). *Learned optimism: How to change your mind and your life*. New York, NY: Pocket Books.
Sellers, P. D., II, & Bjorklund, D. F. (2014). The development of adaptive memory. In B. L. Schwartz, M. L. Howe, M. P. Toglia, & H. Otgaar (Eds.), *What's adaptive about adaptive memory?* (pp. 286–307). New York, NY: Oxford University Press.
Shin, H.-E., Bjorklund, D. F., & Beck, E. F. (2007). The adaptive nature of children's overestimation in a strategic memory task. *Cognitive Development, 22*, 197–212.
Simpson, A., & Riggs, K. J. (2011). Three- and 4-year-olds encode modeled actions in two ways leading to immediate imitation and delayed emulation. *Developmental Psychology, 47*, 834–840.
Spinath, B., & Spinath, F. M. (2005). Development of self-perceived ability in elementary school: The role of parents' perceptions, teacher evaluations, and intelligence. *Cognitive Development, 20*, 190–204.
Stipek, D. (1984). Young children's performance expectations: Logical analysis or wishful thinking? In J. G. Nicholls (Ed.), *Advances in motivation and achievement: Vol. 3. The development of achievement motivation* (pp. 33–56). Greenwich, CT: JAI Press.
Stipek, D., & Daniels, D. (1988). Declining perceptions of competence: A consequence of changes in the child or the educational environment? *Journal of Educational Psychology, 80*, 352–356.
Stipek, D., Feiler, R., Blyer, P., Ryan, R., Milburn, S., & Salmon, J. M. (1998). Good beginnings: What difference does the program make in preparing children for school. *Journal of Applied Developmental Psychology, 19*, 41–46.
Stipek, D., Feiler, R., Daniels, D., & Milburn, S. (1995). Effects of different instructional approaches on young children's achievement and motivation. *Child Development, 66*, 209–223.
Stipek, D. J., Recchia, S., & McClintic, S. (1992). Self-evaluation in young children. *Monographs of the Society for Research in Child Development, 57*, 1–98. Serial No. 226.
Tennie, C., Walter, V., Gampe, A., Carpenter, M., & Tomasello, M. (2014). Limitations to the cultural ratchet effect in young children. *Journal of Experimental Child Psychology, 126*, 152–160.
Tomasello, M. (2000). Culture and cognitive development. *Current Directions in Psychological Science, 9*, 37–40.
Tomasello, M. (2014). *A natural history of human thinking*. Cambridge, MA: Harvard University Press.

Tomasello, M., & Carpenter, M. (2007). Shared intentionality. *Developmental Science, 10*, 121–125.
Tomasello, M., Kruger, A. C., & Ratner, H. H. (1993). Cultural learning. *Behavioral and Brain Sciences, 16*, 495–511.
Tomasello, M., & Moll, H. (2010). The gap is social: Human shared intentionality and culture. In *Mind the gap: Tracing the origins of human universals* (pp. 331–350). New York, NY: Springer.
Turkewitz, G., & Kenny, P. (1982). Limitations on input as a basis for neural organization and perceptual development: A preliminary theoretical statement. *Developmental Psychobiology, 15*, 357–368.
Vygotsky, L. S. (1962). *Thought and language*. Cambridge, MA: The MIT Press.
Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
Weisberg, D. S., Kittredge, A. K., Hirsh-Pasek, K., Golinkof, R. M., & Klahr, D. (2015). Making play work for education. *Phi Delta Kappan, 98*, 8–13.
Whiten, A., McGuigan, N., Marshall-Pescini, S., & Hopper, L. M. (2009). Emulation, imitation, over-imitation and the scope of culture for child and chimpanzee. *Philosophical Transactions of the Royal Society of London: Biological Sciences, 364*, 2417–2428.
Williamson, R. A., & Markman, E. M. (2006). Precision of imitation as a function of preschoolers' understanding of the goal of the demonstration. *Developmental Psychology, 42*, 723–731.
Williamson, R. A., & Meltzoff, A. N. (2011). Own and others' prior experiences influence children's imitation of causal acts. *Cognitive Development, 26*, 260–268.
Wood, L. A., Kendal, R. L., & Flynn, E. G. (2013). Copy me or copy you? The effect of prior experience on social learning. *Cognition, 127*, 203–213.
Zack, E., Barr, R., Gerhardstein, P., Dickerson, K., & Meltzoff, A. N. (2009). Infant imitation from television using novel touch-screen technology. *British Journal of Developmental Psychology, 27*, 13–16.
Zelazo, P. D., & Carlson, S. M. (2012). Hot and cool executive function in childhood and adolescence: Development and plasticity. *Child Development Perspectives, 6*, 354–360.
Zelazo, P. D., Carlson, S. M., & Kesek, A. (2008). The development of executive function in childhood. In C. A. Nelson & M. Luciana (Eds.), *Handbook of cognitive developmental neuroscience* (2nd ed., pp. 553–574). Cambridge, MA: MIT Press.
Zimmerman, F. J., Christakis, D. A., & Meltzoff, A. N. (2007). Associations between media viewing and language development in children under age 2 years. *The Journal of Pediatrics, 151*, 364–368.

Chapter 2
Teaching: Natural or Cultural?

David F. Lancy

An important part of the common lore of anthropology is that "other people have culture." That is, most people fail to recognize or appreciate how much of their lives are governed by habits, values, and expectations that are largely the product of history and culture. They fail to acknowledge that their own way of doing things is not necessarily universal or even widely shared. This ethnocentrism can have enormous consequences for the construction of child development theory and education. In fact, as Henrich, Heine, and Norenzayan (2010) have so brilliantly demonstrated, much of what we consider "human" psychology comes from facsimile, lab research carried out with US undergraduates—members of WEIRD (Western, Educated, Industrialized, Rich, Democratic) society. They question "whether researchers can reasonably generalize from WEIRD samples to humanity at large" (Henrich et al., 2010, p. 62). In fact, "WEIRD people are the outliers in so many key domains of the behavioral sciences; [they are] one of the worst subpopulations one could study for generalizing about Homo sapiens" (Henrich et al., 2010, p. 79).

While Henrich et al.'s (2010) identification of this problem—the tendency to overgeneralize results from WEIRD samples to the species—is quite thorough, theirs is only the latest in a very long history of such challenges. Anthropologists have been particularly critical of many "established" principles in human behavior studies. This happens so often that LeVine coined the expression the "anthropologists veto" (LeVine, 2007; see also Fouts, 2005). He has forcibly exercised this veto in his critique of the Bowlby and Ainsworth theory of infant attachment. LeVine's observations of agrarian, East African Gusii parents suggest the possibility of weak attachment and consequent blighted development. He found that while mothers respond promptly to their infant's distress signals, they ignore other vocalizations such as babbling. They rarely look at their infants or speak to them—even while breastfeeding. Later, when they do address their children, they use commands and

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threats rather than praise or interrogatives (LeVine, 2004, 2014). In spite of these obvious signs of "deficiency" on the part of Gusii mothers, LeVine and his colleagues—who have been studying Gusii villagers for decades—find no evidence of widespread emotional crippling.

Researchers in the behavioral sciences are often vulnerable to the anthropologist's veto. As noted earlier, we are largely unaware of our own culture unless we make it a practice to step outside our own ethnocentric biases. Generalizations about behavior observed in the dominant WEIRD society—especially when validated through lab research—are treated as "natural," the product of nature rather than nurture (Lancy, 2010a). This seems to be particularly true for infant studies where there is an assumption that the infant resides in a bubble that is as yet impervious to cultural influence (but see Bjorklund, 2007, for a critique). As Hunt notes: "Until the necessary cross-cultural research has been done, we have to admit the possibility that [observed patterns of behavior] are the result of experiences that are specific either to American and perhaps other post-industrial societies" (Hunt, 2007, p. 145). However, behavioral scientists rarely test the universality of their findings via a survey of the relevant ethnographic literature. For example, a recent lab study made the unqualified claim that "…early pretend play is…heavily scaffolded by adults (Rakoczy, Tomasello, & Striano, 2005, p. 70)"—in spite of a near total absence of any reference to parent–child pretend play in the ethnographic or historic records (Lancy, 2007).[1] In a representative cross-cultural study, the investigators invited rural village mothers and their educated, urban counterparts to "scaffold" their child's introduction to toys donated by the researchers.

> [Village] caregivers appeared to interpret activities such as exploring novel objects, as an appropriate context for children to play with the objects independently, not as a context for adult-child interaction or play. Thus, caregivers would let the child play independently when the novel objects were presented, while they returned to their chores. However, [WEIRD] parents…did not see the [request] for joint play with their toddlers as inappropriate (Göncü et al., 2000, p. 322).

Natural Pedagogy?

Parent–child teaching is another behavioral practice characteristic of WEIRD child-rearing that has recently been elevated to evolved, universal, or "natural" status. In the remainder of this chapter, I will interrogate this claim.

The lines in this debate are very clearly drawn (Bonawitz et al., 2011). On the one hand are scholars who argue that for successful child development and reliable transmission of culture from generation to generation, parents must teach their children skills and knowledge essential to survival and successful adaptation (Kline, 2015). A typical expression of this belief:

[1] In Peter Breughel's 1560 masterpiece "Children's Games" in the Kunsthistoriches Museum, Vienna, he portrays, in one canvas, 84 distinct children's "pass-times" or games. In none is an adult shown as a participant.

> Teaching is recognized as a universal human activity and has received much attention… reflecting…the centrality of adult teaching in educating children and in enhancing their cognitive development (Strauss & Ziv, 2004, p. 451)…teaching may be a natural cognition (Strauss & Ziv, 2004, p. 455)…all know how to teach (Strauss, Ziv, & Stein, 2002, p. 1477).

But anthropologists see a very different picture. "If selection favors teaching because it is necessary to promote learning of critical skills, it should be common within populations" (Thornton & McAuliffe, 2012, p. e8). On the contrary, cultural anthropologists and primatologists studying juveniles often draw marked attention in their ethnographic/field accounts to the almost total absence of teaching of juveniles by their parents or others.[2] Here is a sampling of anthropologists' and historians' view of the role of teaching:

> The ability to learn is older—as it is also more widespread—than is the ability to teach (Mead, 1964, p. 44).

> Everyday activity…is a more powerful source of socialization than intentional pedagogy (Lave, 1988, p. 14).

> The equation, implicit in Vygotsky's work, of culturally transmitted knowledge learned through instruction is ethnocentrically biased. In most human societies, children become competent adults without the help of…teaching…Most learning is achieved as a by-product, in the course of interactions that have other purposes (Atran & Sperber, 1991, p. 39).

> The specialized cognitive skills of children that underlie their innate ability to learn (as opposed to adults' more conscious and less reliable ability to teach) establishes the success of cultural reproduction as the child's achievement (Langdon, 2013, p. 174).

As Premack and Premack (1996) note: "The anthropology of pedagogy is largely nonexistent" (p. 315). I have conducted four successive reviews of this literature, each incorporating a greater number of cases (Lancy, 1996, 2008), the latest extending to the historic record (Lancy, 2010, 2010a, 2014a). In each review, the conclusions were that teaching was extremely rare and did not seem to map onto any inventory of critical survival skills. In parental ethnotheories of "proper" childrearing, teaching was specifically proscribed—even deemed harmful. Table 2.1 represents a very small sample of the cases that illustrate these points.

In the model embraced by contemporary child psychologists, parents, and educators, the learning and development process is dominated by a top-down transfer of knowledge (teaching) from experts/teachers to novices/pupils. By contrast, the ethnographic record portrays the development of skill and knowledge as largely a bottom-up process where the eager, self-initiating learner takes advantage of social learning opportunities to replicate (often initially in play) the observed skills and behaviors practiced by members of his/her family (Bloch, Solomon, & Carey, 2001) and community (Lancy, in press a, in press b). Geary (2007) has developed an extremely useful theory that provides a firm evolutionary foundation for the top-down, bottom-up distinction. In his theory, evolution has afforded children apanoply of cognitive skills and the motivation to master "evolutionary-significant content

[2] In another paper (Lancy, in press a) I take up the question of why evolution might favor social learning over teaching in cultural transmission.

Table 2.1 Evidence of an anti-teaching philosophy

[On Truk Island, there is no] "'training' of children in our sense" (Bollig, 1927, p. 96)
During this period, there is no formal training [among the Mbuti Pygmies], but boys and girls alike learn all there is to be learned by simple emulation and by assisting their parents and elders in various tasks (Turnbull, 1965, p. 179)
No formal instruction is practiced among the [!Kung] … learning … comes from the children's observation of the more experienced (Marshall, 1958, p. 51)
[Among the reindeer-herding Saami of Norway], "the child … is not instructed before starting a project, nor does he solicit help" (Anderson, 1978, p. 194)
[There] "is remarkably little meddling by older [Inuit] people in the learning process. Parents do not presume to teach their children what they can as easily learn on their own" (Guemple, 1979, p. 50)
In contrast to American parents, who seem to feel that knowledge is something like medicine—it's good for the child and must be crammed down his throat even if he does not like it—Rotuman parents acted as if learning were inevitable because the child *wants* to learn (Howard, 1970, p. 37, emphasis added)
Nyaka [foragers from the Lake Nyassa region of Southern India] "parents do not feel the need to 'socialize' their children and do not believe that parents' activities greatly affect their children's development" (Hewlett & Lamb 2005, p. 10). "Young [Nyaka] people learn their skills from direct experience, in the company of other children or other adults" (Bird-David, 2005, p. 96)
Kenyan Gusii "mothers … expect … their infants and toddlers to comply with their wishes … they could be harsh [and] rarely praised their infants or asked them questions, but tended to issue commands and threats in communicating with them" (LeVine, 2004, p. 156)
[Manus] "children accompany their parents and participate in adult activities that involve little skill. No attempt is made to develop skills—the emphasis is rather on the easy, pleasant identification with the activities of adults" (Mead, 1964, p. 57)
"If one asks a Chaga [from Tanzania] where he got his knowledge, in nine cases out of ten, the reply is: 'From nobody; I taught it myself!'" (Raum, 1940, pp. 246–247)
The Chewong of Malaysia believe that " … a child will grow and develop without specific parental interference" (Howell, 1988, p. 162)
To say that [Matsigenka] children learn from their parents does not imply that they receive much in the way of instruction. Children are given freedom to watch and imitate parents with minimal interference. Orna and I, in trying to learn many elemental skills like cooking over an open fire or walking on mountain trails, received virtually no advice or instruction; people watched us flounder without showing us how it is done (Johnson, 2003, p. 111)
Copying, and trial and error, rather than explicit teaching, are certainly the methods by which Duna men learn about flaked stone (White, Modjeska, & Hipuya, 1977, p. 381)

areas." These culture acquisition tools (e.g. bottom-up) are adapted for mastering "biologically *primary* domains" such as language and the ability to decode and learn from the natural environment (see, for example, Zarger, 2002). On the other hand, "academic learning involves … a suite of culture-specific, biologically *secondary* domains, such as mathematics" (Geary, 2007, p. 5). To "survive" in post-industrial society, individuals must learn material that nature has not endowed them with the ability to learn on their own initiative. To learn mathematics you must be taught—in a top-down process. For example, the Roman philosopher Quintillian asserts "it is quite clear the young student lacks the judgment to understand … what is set for him." (Langdon, 2013, p. 457).

As leaders in the "teaching is essential" contingent, Csibra, Gergely and associates go well beyond the claim that teaching is universal and argue that it is part of an evolved psychology unique to humans: "…[teaching or] natural pedagogy is a basic cognitive hominin adaptation" (Csibra & Gergely, 2009, p. 149). "Natural pedagogy was an independently selected adaptive cognitive system [rather] than…a by-product of some other human-specific adaptation, such as language" (Csibra & Gergely, 2011, p. 1149). Tomasello and colleagues also claim that only humans have evolved the capacity for teaching because "…human beings, and only human beings, are biologically adapted for participating in collaborative activities involving shared goals and socially coordinated action plans" (Tomasello, Carpenter, Call, Behne, & Moll, 2005, p. 674). Those who do field studies with great apes, on the contrary, find ample evidence for collaborative activities (hunting, for example, Boesch, 2005). Matasuzawa and colleagues describe the process whereby chimpanzee mothers facilitate their child's persistent imitation of her skilled nut cracking, including providing free access to shelled nuts and the hammer and anvil stone tool kit (Matasuzawa et al., 2001). In fact, it is striking how similar human's facilitation of children's attempts to learn tool use is to chimpanzee practice (Humle & Newton-Fisher, 2013; Lancy, in press b). Hatano and Takahashi (2005) provide the following summation of this body of work:

> Our speculation is that there is only a small, quantitative difference in many basic aspects (including sharing, intentionality) between humans and great apes, but the aggregate of a number of these small differences produces the remarkable qualitative difference [between apes and humans] (Hatano & Takahashi, 2005, p. 703).

Ethnocentrism as an Impediment to Theory Construction

I have already noted the tendency to consider the practices of our own culture as "normal" or "natural." Two cases can be cited where an ethnocentric perspective seriously undermines claims for the ubiquity of teaching. In constructing an argument about the genesis of teaching in the (universal) parent–infant relationship, Tomasello and colleagues offer this exemplar: "suppose a child and adult are building a block tower together" (Tomasello et al., 2005, p. 682). Nowhere in the entire ethnographic record of childhood have I found any instance of a parent and child building a block tower (or anything else) together; the purpose being to entertain while also instructing the child in some critical-to-the-culture skill (see Callaghan et al., 2011). Such behavior would fly in the face of widespread, core beliefs about parent–child relationships. To take a typical case, Sisala "parents regard an interest in children's play as beneath their dignity" (Grindal, 1972, p. 25). Once this ethnocentrism has been recognized and the research group has incorporated cross-cultural material in their analysis, the contrast becomes obvious.

> …due to a child-rearing philosophy focused heavily on pedagogy—parents in many Western, industrialized societies quite naturally interact with their young children in these ways, whereas parents in more traditional, small-scale societies do so much less

> often. The comprehension and use of pretense and graphic symbols therefore, is something that would seem to be quite dependent—especially in terms of early emergence—on the ways that children in different cultural settings experience these symbols (Callaghan et al., 2011, p. 109; see also Kärtner et al., 2008).

> Schooling provides a powerful model of the way information can be transmitted via language … So, we can expect more-educated parents to engage in more conversation, especially pedagogic and explanatory conversation, with their children … (Harris, 2012, p. 34).

As noted above, WEIRD society places an extremely high premium on the early development of academic knowledge and a high degree of literacy. One example of this truly urgent imperative can be found in the enormous popularity of "Baby Signs," a system of using ASL (American Sign Language) to accelerate the infant's use of language (see also Bjorklund & Beers, this volume). A typical testimonial to this innovation cheers "Hurray for Baby Signs! … Considering how slowly babies learn even easy words like ball and doggy, let alone difficult words like scared or elephant, many months are lost that could be spent having rich and rewarding interactions, both for the child and the parent" (Acredolo & Goodwyn, 2002, p. 3).

Other examples come from a growing body of research in WEIRD society that reveals parents are "teaching" children skills that they can readily learn on their own and have always done so (Shneidman & Goldin-Meadow, 2012). Prominent examples include: teaching children to speak (Clark, 2005); teaching them how to do make-believe (Vandermaas-Peeler, Nelson, von der Heide, & Kelly, 2009); teaching them how play with peers (Schütze, Kreppner, & Paulsen, 1986; Waldfogel, 2006); and teaching them how to play with toys. In another line of research, middle class parents were asked to carry out a cooking exercise (making crispy treats) with their 4-, 6- and 8-year-old children. But WEIRD parents used the cooking activity as a pretext for teaching children about literacy and basic mathematical concepts and skills.[3] The parents' overly didactic focus undermined children's enthusiasm for the exercise (Finn & Vandermaas-Peeler, 2013).[4] Gergely and associates have developed one of the more elaborated arguments for the significance and evolved character of teaching. Their *natural pedagogy* theory derives from laboratory research on infant cognition and infant–parent interaction in middle-class Hungarian society.

> Humans are adapted to spontaneously transfer … fast and efficiently (Gergely, Egyed, & Király, 2007, p. 145) … relevant cultural knowledge to conspecifics and to fast-learn the contents of such teaching through a human-specific social learning system called "pedagogy." Pedagogical knowledge transfer is triggered by specific communicative cues (such as eye-contact, contingent reactivity, the prosodic pattern of 'motherese,' and being addressed by one's own name). Infants show special sensitivity to such 'ostensive' cues that signal the teacher's communicative intention to manifest new and relevant knowledge about

[3] In a large-scale longitudinal study, the authors found that children attending heavily academic pre-school programs, had lower test scores in 3rd and 4th grade than those who had attended a more child-initiated, play-centered programs (Marcon, 2002).

[4] Fortunately, there is a growing "popular" movement to give children space to learn on their own without the constant mediation and supervision of a parent/teacher/coach/child-minder (see, as examples, Gray, 2013; Honroe, 2009; Sampson, 2015; Skenazy, 2009; Tulley & Spiegler, 2011).

> a referent object. Pedagogy offers a novel functional perspective to interpret a variety of early emerging triadic communicative interactions between adults and infants about novel objects they are jointly attending to (Gergely et al., 2007, p. 139).

Again, a thorough reading of the ethnographic record would undermine their arguments. This collection of parent–infant interaction patterns is rare beyond WEIRD or post-industrial society, particularly when applied to fathers (Brazelton, 1977). In the many societies where infants are not held *en face* as a rule, but attached to the mother's body or held facing away from the caretaker (e.g. Field & Widmayer, 1981; Jay, 1969; Ochs & Izquierdo, 2009), infants may be far "more attuned to their caregivers' postural positions than to their caregivers' gaze direction" (Akhtar & Gernsbacher, 2008, p. 61). Motherese and baby-talk are not found universally (Ochs, 1986; Pye, 1991; Solomon, 2012). Pointing and interactive communication by the infant and parent are, according to Tomasello et al. (2005), the nascent signs of later, full-blown teaching. But, like other components of "natural pedagogy," pointing by infants may be uncommon,[5] especially as others rarely respond to more than the child's basic needs. In a systematic and focused study:

> pointing (in Tzeltal and Rossel)… does not have the canonical result observed in postindustrial societies, with the adult labeling the object pointed at… On the basis of these observations, it is hard to believe that indexical pointing per se is playing a critical role in the infants' understanding that others have minds and communicative intentions of their own (Brown, 2011, p. 48).

In another recent study, middle and lower class mothers in Caracas and Chicago were recorded (90 min in total) during interaction with their 3-month-old infants. The amount of communication—verbal and gestural (e.g. pointing)—varied enormously from 0 (lower class Caracas) to 6000 (middle class Chicago) words directed at the infant. And this range was accounted for by the mother's and grandmother's education level. Those with more schooling showed greater awareness of "modern" socialization methods including the need to actively engage in "conversation" with the infant (Rowe, 2015).

Mothers with little schooling or exposure to teaching don't often engage *cognitively* with infants (Callaghan et al., 2011, p. 66; Kärtner et al., 2008). They respond quickly to their distress cues by nursing and soothing them. But they rarely gaze at them or engage in shared attention to novel objects (de León, 2011; Göncü, Mistry, & Mosier, 2000; LeVine, 2004). When Nso babies gaze at their mothers during nursing, the mother blows in their eyes so they avert their gaze and pay attention to others (Keller, 2013). Mazahua nursing mothers often display a "distracted air and pay almost no attention to the baby" (Paradise, 1996, p. 382). "Pashtu mothers rarely make eye-contact with their infants when nursing unless there's a problem" (Casimir, 2010, p. 22). In a comparative, quantitative analysis, "Euro-American adults were much more likely than Aka [foragers] or Ngandu [farmers] adults to stimulate (e.g., tickle) and vocalize to their infants (see also Whiten & Milner,

[5] Consider also that, in many societies, infants are swaddled or hidden away in cocoon-like containers, which restrict any sort of communication except distress.

1984). As a result, Euro-American infants were significantly more likely than Aka and Ngandu infants to smile, look at, and vocalize to their care providers" (Hewlett, Lamb, Leyendecker, & Schölmerich, 2000, p. 164). Akira Takada makes the point—based on his extensive observation of mother–infant interactions among Kalahari San—that the mother is engaged in a whirlwind of activity while holding or nursing her infant. This may include extensive verbal interactions with others. In short, she's much too busy to gaze at the infant or attempt to engage it in a mutual activity (Takada, 2012; see also Meehan, 2009).

The entire idea of stimulating infants cognitively and teaching them (*knowledge transfer*) is belied by practices like seclusion, swaddling, cradle-boards, and enveloping the child in a cloth attached to its mother's (or sister's) back. The most widely shared philosophy of infant care is to do everything possible to reduce stimulation so that the infant remains at rest (Howrigan, 1988). Chiga babies are kept quiet and not spoken to (Edel, 1957/1996), and traditional Chinese practice provides the infant "a tranquil and protective environment" (Bai, 2005, p. 11). Contemporary Dutch parents embrace a model of infancy in which plenty of sleep and restful, quiet waking periods are ideal. By contrast, US mothers are committed to keeping infants stimulated via physical contact, speech, and toys (Harkness & Super, 2006). Like the rest of Gergely et al.'s *communicative cues*, "being addressed by one's own name" (Gergely et al., 2007, p. 139) carries little theoretical weight because, in most societies, infants don't receive a distinctive name until their viability is assured and they are considered ready to "become persons" (Lancy, 2014). Keller and colleagues, based on extensive cross-cultural research, sum up the major difference in infant care between WEIRD society and others: "face-to-face contact is the most prominent system of parenting in urban educated middle-class families of Western societies," while elsewhere extensive bodily contact with little visual or verbal engagement is the rule (Keller, Borke, Lamm, Lohaus, & Dzeaye Yovsi, 2010, p. 234). The contrasting patterns are designed to develop the child's individuality and agency in the first case and self-regulation and conformity to group expectations, in the second.

Lastly, there is little evidence in the ethnographic literature that adults feel any urgency to transfer knowledge to children "fast and efficiently." In fact, the infant cognition studies which are the well-spring for Gergely and associates' (2007) theory are far more congenial to child-initiated acquisition of culture than adult-directed "transfer of cultural knowledge." For example, Gergely et al. conducted a study of 14-month-old infants ostensibly learning to execute a task from watching an adult model. But the infants don't faithfully copy the demonstrator, only those actions which seem relevant to completing the task. "Our results indicate that imitation of goal-directed action by preverbal infants is a selective, interpretative process, rather than a simple re-enactment of the means used by a demonstrator, as was previously thought" (Gergely, Bekkering, & Király, 2002, p. 755). Even at 14 months, infants are out in front of would-be teachers, taking the initiative to learn (Lancy, in press a).

Recent empirical studies by Rogoff and colleagues support this perspective. It would appear that children who must learn in and from the environment (as opposed to learning from teachers and books) develop characteristically different attention patterns (Gaskins & Paradise, 2010; Rogoff, Correa-Chávez, & Cotuc, 2005). Village children, as well as immigrant children whose mothers have little schooling—invited to learn to make something (e.g. Origami figures)—rely on *observing* the task as it is carried out by an expert or attempted by other children. A sample of more "schooled" individuals, on the other hand, pay little attention to the demonstration, waiting for (or soliciting) a teacher's explanation and verbal guidance (Correa-Chavez & Rogoff, 2005).

Data and Definition Issues

Even those who claim that teaching is ubiquitous and universal acknowledge that "…teaching is a slippery concept" (Strauss & Ziv, 2012, p. 187). I will review two studies in non-WEIRD societies that purportedly show evidence of parent–child instruction to illustrate this slipperiness.

In an early study of the Aka—forest foragers from central Africa—using interview data, Hewlett and Cavalli-Sforza (1986) reported on the results of a survey ($n=72$, ages 7 to adult) asking who had taught respondents a list of 50 common skills. Eighty-one percent of respondents identified a parent as their teacher. However, the authors do not clearly differentiate between adult-directed, explicit, intentional *teaching* and more informal, learner-initiated *observation* of an older role model, or the kind of *interactive* skill learning that occurs during the participatory activity described by Lave, Rogoff, and colleagues (Lave & Wenger, 1991; Rogoff et al., 2005; Tehrani & Collard, 2009; Tehrani & Riede, 2008).

In more recent reports of the same Aka community surveyed by Hewlett and Cavalli-Sforza (1986), relying on ethnographic observation rather than interviews, Hewlett and colleagues (Hewlett et al., 2011; Hewlett, 2013; Hewlett & Hewlett, 2013) present evidence of how children learn, and from whom, that is more consistent with the ethnographic record as a whole. In a report drawing on two systematic *observational* studies, Boyette—using a very broad, inclusive definition of teaching—finds teaching to be quite rare among the Aka: "observed during about two percent of all minutes of observation in both 2008 and 2010" (Boyette, 2013, p. 91).

In a comparable recent interview study conducted with 72 Fijian adults, the authors found that, depending on how the query was posed, teaching was seen as critical in the transmission of valued skills, 18–43% of the time (Kline, Boyd, & Henrich, 2013). But interview data are particularly vulnerable to response compliance. The villagers Kline queried had had over 100 years' exposure to Western schooling and missionary influence (Kline et al., 2013). In my fieldwork with Kpelle children in the early 1970s, where teaching was conspicuously absent, the village inaugurated its first school during my fieldwork. The Christian congregation was tiny and Muslims even rarer (Lancy, 1996). Little conducted a child-focused ethnography among the Asabano, a remote and relatively unacculturated Papua New Guinea (PNG) Highlands tribe. Schools and churches had arrived within the previous 15–20 years. In his observation of children and parents, he saw no teaching. Parents displayed no obligation to encourage children's learning; to manage their activity; or even to acknowledge, let alone reward, children's efforts. However, when "asked how their children learn anything, [parents] unanimously answered that they explicitly 'show' children in a step-by-step process, even though they very clearly did no such thing" (Little, 2011, p. 152). Probing further, Little discovered that the resolution to this contradiction lay in the consistent and explicit sermonizing of village pastors regarding the Christian duty of parents to instruct their children. Although parents had not actually changed their parenting behavior, they could parrot the credo and apply it to their own culture (Little, 2011).

In summary, it is my recommendation that for a phenomenon as "slippery" as teaching, one would be on much firmer ground if the data were triangulated: ethnographic study to provide cultural *and* historical context and meaning (Odden, 2007; Little & Lancy, in press.); systematic observation (e.g. Boyette, 2013); and informed, open-ended interviews with both experts and learners (Lancy, 1996).

An equally challenging problem is the lack of consensus on a definition of what teaching (or pedagogy) is. Kline (2015, p. 1) notes "there is wide disagreement about how to define teaching, and how to interpret the empirical evidence for teaching across cultures and species." She defines "teaching as *behavior that evolved to facilitate learning in others*" (emphasis in original). But this definition presumes the acceptance of a hypothesis that has yet to be tested. To do so, Kline must identify behaviors that facilitate learning in others; then determine that those behaviors are uniquely associated with teaching and not some other purpose(s); and lastly, establish that the behaviors are ubiquitous and critically important among humans, but absent in close relatives such as apes. But such is clearly not the case: "If teaching is defined very broadly to include any behavior of one animal that serves to assist another animal's learning, teaching is relatively common in the animal kingdom" (Boesch & Tomasello, 1998, p. 602).

But Kline does not develop a stringent definition of teaching suitable for testing the theory that it has evolved separately from other behaviors that might assist learners. Instead, she offers a very catholic and inclusive catalog of behaviors that she would count as fitting her definition of "teaching." But, as other evolutionary scholars interested in teaching have noted: "We feel that moving away from a clearly delineated and testable definition risks creating confusion and eroding standards of evidence in this nascent field" (Thornton & McAuliffe, 2012, p. e7). I see enormous difficulties in unequivocally identifying the named behaviors as reflecting structures evolved to facilitate learning in others. For example, one type of teaching behavior is *opportunity provisioning* where the "teacher" provides the child access to objects or settings from which they can learn (Kline, 2015, p. 7). This would include the frequent accounts of the provision of knives to young children. For example, a Pirahã child:

> was playing with a sharp knife … swinging the knife blade around him, often coming close to his eyes, his chest, his arm … when he dropped the knife, his mother-talking to someone else—reached backward nonchalantly … picked up the knife and handed it back to the toddler (Everett, 2008, p. 89).

And from Taiwan:

> Parents were surprised and amused when questions such as 'How do you teach children …' were put to them. 'We don't teach them; why they just learn themselves,' was the usual answer… A 2-year-old girl was seen imitating her mother by attempting to whittle off pieces of bamboo with a large 12-inch blade bushknife… Sickles and knives are used expertly by many 6-year-olds. Bandaged fingers and numerous little scars are evidences of learning and experimentation (Maretzki & Maretzki, 1963, pp. 510–511).

I would use these examples of "opportunity provisioning" as prima facie evidence of parents' *aversion* to teaching coupled with the widespread belief (Lancy, in press b) that learning how to use knives is children's business (e.g., Willerslev, 2007).

Evaluative feedback is another type of teaching discussed by Kline (2015, p. 8). A normative reading of the ethnographic record would stress the rarity of feedback—especially praise—from adults (Hilger, 1957; Metge, 1984). Even in the West, providing positive feedback or praise was, until fairly recently, rejected as a child-rearing or pedagogical technique because of the danger of "spoiling" the child (LeVine & Norman, 2001). Not surprisingly, in the bottom-up model of culture acquisition that predominated until very recently, evaluative feedback is provided to the learner automatically during the learning process (Paradise, 1998). The learner doesn't need an adult to tell them whether or not they're successful; the *results* of their efforts will provide all the feedback necessary. Indeed, one of the most important contemporary research programs in educational psychology has been the de-mythologizing of excessive teacher-donated praise (Mueller & Dweck, 1998). On the other hand, corporal punishment (Ember & Ember, 2005; Hsiung, 2005) and frightening the child are certainly common instances of "evaluative feedback" (these commonly employed elements of "natural pedagogy" are conspicuously absent from the major evolutionary-based theories, e.g. Kruger & Tomasello, 1996). But of course, it isn't clear that the intent is to *teach*. Verbal and corporal punishment or denial of food is usually aimed at a child who has failed to do a chore or run an errand—tasks she/he has already mastered. "Evaluative feedback" is largely used to manage the child's behavior, rather than to transmit the culture.

In crafting a broad, inclusive definition of teaching, in order to counter the argument that teaching is rare and unlikely to play a role in human evolution, Kline et al. (2013) make it near impossible to differentiate teaching from other behaviors. This quandary is easily illustrated (Köhler, 2012). When a mother tolerates the presence of her 4-year-old daughter while sitting in the shade of her house working clay into pots, is she teaching (yes, according to Kline)? Or, is she "child minding?" When she donates a ball of clay to the daughter (without any verbal instruction), is she teaching (also yes in Kline's theory)? Or, is she keeping the child occupied so she'll not be a bother? If she donates a ball of clay to her sister who drops by, is she teaching or displaying reciprocal altruism? Obviously, many behaviors displayed by one party can "facilitate learning" in another party. But crediting such behaviors as "teaching" is merely a hypothesis which is difficult, if not impossible, to support.

To take another "slippery" example, the Aka may take their 10–12-month old infants along on net-hunting expeditions. A mother will assemble, in a basket, a miniature or toy tool kit (axes, digging sticks, spears). When the hunting party stops

Table 2.2 Components of a definition of teaching

The teacher must incur costs (taking time away from their work or using non-recoverable materials) and these "costs to teachers of facilitating learning are outweighed by the long-term fitness benefits they accrue once pupils have learned" (Thornton & Raihani, 2008, p. 1823)
Teaching will not occur, or is unlikely, where the learner is able to acquire the requisite knowledge or skill in the absence of teaching (Thornton & Raihani, 2008)
Teaching involves the intent of the teacher to alter/enhance the knowledge or competence of the learner. The learner is aware of the teacher's intention and engages with or attends to the "lesson" (Olson, 2009)
Teachers explicitly monitor the progress of the learner and modify teaching activity accordingly (Kruger & Tomasello, 1996)

to rest, the mother empties the basket of tools whose contents keep the toddler happily chopping, cutting and, digging. This activity distracts the child, lessens the likelihood he'll wander off into the bush, and is patently entertaining for the adults. It reflects an understanding of children's deep interest in objects, their desire to achieve greater competence using them, and also reflects an Aka "core cultural value"—respect of the child's autonomy (Hewlett & Hewlett, 2013). Although this seems the most straightforward rationale for the mother's tool/toy basket, the authors claim a pedagogical intent on the part of parents. But these are 10–12-month-olds—hardly the most propitious age for beginning "training" in the use of tools. Further, they report no evidence that the occasional on-the-spot teaching is part of a program of systematic instruction in which the parent takes responsibility for developing the child's mastery of tool use (Hewlett et al. 2011).

A Working Definition of Teaching

I believe that a definition of teaching that is robust enough to survive the rigors of evolutionary theory must meet the criteria noted in Table 2.2. For most of the village curriculum, children are capable of learning socially or individually. They do not require the services of a teacher. Even when they seek the assistance of a teacher, they may well be rebuffed if the expert feels that this is unnecessary (they'll learn on their own) or a waste of his/her time (Lancy, in press b). That is, teaching incurs costs to the teacher. These costs must be offset by clear fitness gains for the teacher; most obviously that the lesson is critical to the child's (or other close kin) learning skills which are vital to survival and eventual reproduction. The teacher may also increase his/her fitness directly—a successful lesson will increase the child's work output, unburdening the parent/teacher—or indirectly, where the skills taught will lead to some future surplus output that can be donated to the teacher. We can imagine any number of hypothetical scenarios that would meet these criteria. However, in the real world, the necessity for teaching is mediated by the child's ability to learn without the aid of a teacher. We have overwhelming evidence from both field and laboratory studies that children are self-starters, getting about the business of learning critical skills without the intervention of a teacher (Geary, 1995), *and* parallel evidence of deep-seated pro-social tendencies which compel them to apply their newly learned skills in the service of family (Haun, van Leeuwen, & Edelson, 2013). Why should an expert invest time, materials, and energy instructing a novice who will learn just fine on her own and likely enhance relative fitness in the long term? (Trivers, 1972)

Criterion three and four in Table 2.2 point to the necessity of finding signs that a "lesson" is underway. Without these indicators, as I've mentioned earlier, it is nigh impossible to distinguish a behavior or suite of behaviors as teaching, rather than altruism, punishment, child-minding, and so on (Thornton & Raihani, 2008). If you argue for the *survival* value of the skills or information being taught, and you argue that they are *opaque* and can't be learned without teaching (Csibra & Gergely, 2011), there should be *lessons*. That is, you should see/hear a parent say something like, "I will now teach Goma to make traps; he is ready to learn it." It should be obvious to an observer that a lesson is underway. One should see demonstration, verbal explanation, and correction. There should be decision rules, for example: when to change teaching tactics to get Goma over any obstacles, or when to stop and declare him trained. You can't claim that teaching is ephemeral, fleeting, and casual, that it is not matched up in any specific ways with the developing child and the local skill set, while also claiming that culture and individuals would not survive without it (Csibra & Gergely, 2011). If a baby isn't fed, it dies. Csibra and Gergely's assertions re: teaching MUST be supported by life or death examples.

Teaching in the Village

To this point, the reader may well assume that I am arguing that teaching does not exist outside WEIRD society. On the contrary, it certainly does exist and I will discuss these specific cases in this section. My argument rather is that the extreme rarity of teaching, its seemingly random variety and distribution, and the very evident aversion to and disapproval of teaching in most situations fatally weaken arguments for the ubiquity, importance, and evolutionarily shaped nature of teaching. In actuality, when we seek out instances of teaching, we see situations suggestive of Lévi-Strauss (1966) famed *bricoleur*.

In the ethnographic record, teaching tends to cluster around certain bodies of knowledge and skill. In a handful of societies infants are "taught" to sit and/or walk. The purpose is clearly not to ensure that children will master sitting and walking—they'll obviously learn on their own eventually. But, in high fertility societies, the infant's independence and separation from its mother is accelerated via early weaning from the breast and the back and accelerated walking to free up the mother to attend to the next birth. According to the definition outlined earlier, these examples can't be classified as teaching because the child can learn entirely on their own, so I have chosen to characterize these behaviors as "acceleration" rather than teaching (Lancy, 2014, 2015).

I have characterized a second cluster of behaviors as "learning manners." Extremely common in Oceania (Lancy, 2014, 2015)—but much rarer elsewhere—we find families systematically teaching the skills needed for full acceptance as a human being—a "true" Tongan, for example. That is, most societies differentiate between not-fully-human infants and children who are considered human (but still of little importance). In the Pacific Islands, issues of rank, speech, and etiquette are so important that families feel that their not-fully-human children are a source of embarrassment and loss of status (Fajans, 1997). To remedy these deficits, lessons are constructed (and administered by all family members from about age 5) to teach polite speech, appropriate terms of address, and social etiquette.

A limited number of societies intervene early to promote sharing (Lancy, 2014, 2015). For example, Papel infants are given something desirable, such as a snack, then immediately told to pass it on to another, particularly a sibling (Einarsdóttir, 2004). Generosity is demanded of even small Ngoni children both directly—forcing them to donate prized resources to peers—and indirectly, through proverbs lauding generosity and condemning meanness (Read, 1960). A !Kung grandmother most often takes on the task of teaching *hxaro*, their formal system of exchange and mutual support. The very young child is given beads and told which kinsmen to pass them on to (Bakeman, Adamson, Konner, & Barr, 1990).[6] It is certainly the case that sharing—especially of food—is a core value in most societies (Mauss, 1967) and children are hastened into compliance. But a related goal in "humanizing the child" is to make him/her as attractive as possible to alloparents or foster parents.

Once again this behavior falls short of the criteria I have outlined that define teaching. There's considerable evidence that children will learn the appropriate pro-social behaviors with time (d'Andrade, 1984; Fehr, Bernhard, & Rockenbach, 2008),[7] including proper kin terms (Beverly & Whittemore, 1993). For example, on Samoa (where rank and etiquette are important):

> Children as young as six … begin to pick up the distinctive features characterizing people of rank and authority without any explicit instruction. This was particularly the case for distinctive behavioral aspects of common ritual events associated with chiefs that children could readily witness (Odden & Rochat, 2004, p. 46).

So there's a cluster of teaching or quasi-teaching practices that are designed to accelerate the child's independence from mother's care and ensure that the child is tolerated and given alloparental care by other family and community members. A second cluster relates to a critical element in Gergely and associates' theory. Csibra & Gergely (2011) argue that there is a great deal of the culture that is opaque. They give the following example:

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[6] Like other hunter-gatherers, the !Kung are "fierce egalitarians." They "consider refusal to share as the 'ultimate sin'" (Howell, 2010, p. 194).

[7] Recent laboratory studies underscore that human children exhibit pro-social behavior spontaneously from the age of three or earlier and are more readily pro-social than juvenile chimps (House, Henrich, Brosnan, & Silk, 2012).

> Imagine that you…observe a man as he turns a bottle upside down, twists its cap three times to the left and then another time to the right, turns it upside again, then opens it and drinks its content. (Csibra & Gergely, 2011, p. 1149).

They argue that social learning alone would be insufficient, or at least inefficient, in figuring out the bottle-opening sequence. But what can we learn from their example? First, Csibra & Gergely seem to be ignoring the work by Keil and colleagues (Keil, 2006; see also Ruiz & Santos, 2014) with WEIRD subjects that reveal the obvious fact that opacity per se is no obstacle to learning to *use* a myriad of common devices from locks to zippers. In the bottle opening example, all the learner must do is carefully observe the procedure then replicate it. No explicit, conscious instructional *demonstration* is required. Nor would a lecture on the procedure and its necessity unless the whole exercise is a case of "functionless pedantry" (Mead, 1964). Second, in the real world of the village, completely opaque processes that are essential for children to learn are almost nonexistent. In both ethnographic and historical accounts, we see children gaining virtually complete access to all aspects of the society. Children are not prohibited from "dangerous" situations. They may eavesdrop on adult conversation and interaction, including sex. In a butchering party, a 5-year-old has his hands buried in the guts of the animal. Children are ubiquitous as spectators at court, funerals, rituals, marital conflicts, etc. Further, when one inventories the tools and processes involved in each society's adaptation to their environment, this technology is inevitably quite uncomplicated and easily broken down into visible and comprehensible components (Oswalt, 1976; Whiten & Milner, 1984). After all, villagers don't use multi-part food processors in meal preparation, combines to harvest their crops, or magnetic resonance imaging to diagnose their illnesses. Far from being opaque, pre-modern societies are characterized by transparency. This is in stark contrast to post-industrial society where "Multiple surveys of children's understanding of work shows great naiveté and ignorance. Because they have little opportunity to observe different kinds of work, the whole subject is opaque" (Dunn, 1988, p. 309).

Lastly, the twist-off bottle cap is a modern, WEIRD artifact, hardly the sort of tool found in the Paleolithic tool kit and, hence a very poor example.

On the other hand, Gergely and associates are certainly correct in linking opacity to instruction. I have found only a few cases in the ethnographic literature of this necessity. The best known is the explicit, lesson-based instruction necessary to train a long-distance navigator in the Puluwat Islands. So complex and opaque is their navigation system that it must be explicitly taught to the novice by an expert. But note that on the entire island there are only a very few expert navigators, so an outsider might well live on Puluwat several years without actually witnessing such training. Further, on Puluwat, short-distance navigation and outrigger canoe construction are so completely transparent, no instruction is necessary (Gladwin, 1970). Among the Yoruba, and undoubtedly many other societies, the skills and knowledge of ritual practitioners, such as Ifá diviners, are hidden and only taught to a *select*, gifted few (Bascom, 1969; see also the Kogi priesthood, cf. Reichel-Dolmatoff, 1976). This is a pretty paltry sample to build a case for the evolutionary imperative of teaching. These few cases of teaching certainly illustrate the human capacity to create lessons, but they leave open the following critical questions:

Is it possible to analytically extract some "teaching essence" that is only deployed during a lesson? Or to put it differently, is the conduct of lessons dependent on some key skill or behavior that is not used in other interactional settings (e.g. speech, shared intentionality) nor routinely displayed in non-human primates. If this challenge proves impossible, then we're left without the empirical tools (e.g. operational definition) to even begin a test of teaching as an evolved suite of unique skills.

Another essential set of components implied by a proposed evolutionary theory would relate to fitness. We should expect to see teaching occurring where there is a body of knowledge and/or specific skills which children cannot acquire on their own and where, lacking them, their fitness (survivorship, reproduction) is severely impaired. No proponent of teaching as the engine of culture transmission has even raised this question, let alone tested it. From my extensive survey of the literature, this hypothesis cannot be sustained. I have found only one prototypical case. The Fort Norman Slave band of Inuit hunts during severe winter weather and must traverse ice-fields. Fathers "instruct" sons about this dangerous environment (which comprises 13 kinds of ice and multiple modes of travel) via a game-like quiz (Basso, 1972). But one can find similar examples of apparently opaque knowledge—Siberian hunters' mastery of their challenging environment—where teaching is not considered useful because "to be a hunter you must know everything yourself" (Willerslev, 2007, p. 160). In other words, despite the challenges of navigating the arctic landscape, not all societies that must do so consider it essential to teach (Geary, 2000) their novices such as hunters and reindeer herders (Istomin & Dwyer, 2009).

Given the theory, one can speculate on where we might find critical skills that are, because of complexity and opaqueness, candidates for deliberate instruction. Prime candidates would be hunting and fishing. Here is a suite of skills that improve both individual fitness and that of one's family and community. A "good" hunter/fisher who shares his bounty of scarce protein is considered an excellent "mate," and empirical studies have demonstrated that more successful hunters have increased opportunities for extra-marital mating, thereby increasing their inclusive fitness (Hawkes, 1991). From the theory ("a basic cognitive *hominin* adaptation," Csibra & Gergely, 2009, p. 149), one might expect that virtually all boys in a society where hunting or fishing contributed to the diet would be "taught" to hunt and/or fish.

A very thorough review of the ethnographic record shows the near total absence of "lessons" in which fathers/adults teach young boys to hunt. "Much of the [young Penan's] expertise will be gained through trial and error experience in play or while actually hunting, not by direct instruction" (Puri, 2005, p. 281). "Ju/wasi hunters maintain that hunting is not something that one teaches… You have to teach yourself" (Liebenberg, 1990, p. 70). In fact, unlike other forms of work where social learning from adults is the norm, with hunting (and fishing in some cases as well, e.g., Lancy, 2014, 2015), boys are prevented from accompanying hunters, so opportunities to observe experts' hunting skills and acquire knowledge of prey are limited. Children are left behind on the hunt because they are noisy, slow, and impatient (Martu—Bird & Bliege Bird, 2005; !Kung—Howell, 2010; Penan—Puri, 2005; Yora—Sugiyama & Chacon, 2005). Aka boys rarely are in the company of men hunting (their primary contribution to subsistence) because hunting is best done solo (Boyette, 2013). Among the Huaorani, "hunting is performed more efficiently alone" (Rival, 2002, p. 102).

Nevertheless, on their own or with peers, boys can begin to learn hunting/trapping quite early—targeting small creatures (which would be spurned by adult hunters) and practicing their tracking and capture skills for hours each day (Apache—Goodwin & Goodwin, 1942; Baka—Higgens, 1985; Hadza—Crittenden, Conklin-Brittain, Zes, Schoeninger, & Marlowe, 2013; !Kung—Shostak, 1981; Asbano—Little, 2011). While adult role models may not be available, older brothers seem quite happy to show off their skills to impress their juniors (Little, 2011; Biyaka—Neuwelt-Truntzer, 1981; Puri, 2005). There is an extremely relevant body of research that supports the notion that children are "natural" foragers and do not need to be taught or even shown how it's done (Chipeniuk, 1995; Heth & Cornell, 1985; Hunn, 2002; Piel, 2012; Zarger, 2002). And boys are free to listen and learn as "real" hunters recount their experiences back in the village after the hunt (Liebenberg, 1990; Tayanin & Lindell, 1991). Nevertheless, the hunters have no pedantic intent and make no adjustment for the rudimentary knowledge of the aspirant hunters (Yukaghir—Willerslev, 2007).

A parallel could easily be drawn between girls and craftwork. If certain crafts (weaving, pottery, basketry) provide essential community needs, and if competence in those crafts marks a young woman as "ready" to assume the responsibilities of wife and mother, then teaching should be essential to ensure that all achieve the necessary level of competence. But again we find many more cases of children becoming competent crafts-persons without the aid of instruction than the reverse (Lancy, 2015; Crown, 2002). Perhaps even more common are societies where "pathways to learning vary significantly"—some less expert crafts-persons seeking and getting assistance from those more expert while others progress without seeking assistance (Puri, 2013, p. 293). The Shipbo-Conibo people of the Amazon Basin are a good case in point. The socialization (including teaching) of young potters leads to a "bewildering variety of… designs" (DeBoer, 1990, p. 88). So, contrary to the assertion made by Kline (2015) and others that teaching is essential to the "faithful" transmission of culture, clear evidence of teaching of Shipbo-Conibo novice potters does not result in the faithful and conservative transmission of culture. In addition to stylistic variation, skill levels vary widely, suggesting that mothers do not carry out lessons designed reliably to bring the novice to a state of mastery or at least clear competence. Indeed, "there are scandalous cases of Shipbo-Conibo women who never become good, or even adequate artists" (DeBoer, 1990, p. 88).

In short, proponents have argued that teaching evolved as a unique cognitive adaptation to ensure that critical, fitness-enhancing skills—which could not be acquired solely through social learning—would be learned by aspirant practitioners. Proponents must, therefore, be able to identify prototypical domains or a suite of skills that would be very likely to provoke a teaching response. I have supplied two prototypes for them—hunting and craftwork—and showed (see also Lancy, 2015, in press b) that, by and large, boys learn to hunt without the benefit of a teacher or even an adult role model, and boys and girls typically master critical craft production without direct instruction. This scattered and scarce distribution of culturally sanctioned and routinized applications of instruction in the rearing of children fatally undermines any claim that there is an evolutionary imperative for "natural pedagogy."

"Good" Teachers, "Good" Pupils?

If teaching is vital and universal, we should find the majority of adults considered "good" teachers and children "good" pupils. Assuming, for the sake of argument, that everyone is born with a suite of cognitive traits and the explicit motivation and determination "*to facilitate learning in others*" (Kline, 2015, p. 6, emphasis in original), we might expect to see the majority of the adult population acting eagerly and willingly as teachers.[8] On average, they should be "good at it." By the same token, children should gravitate readily to the role of pupil and automatically display appropriate behaviors in order to benefit from the lessons. Again, the majority should exhibit considerable native ability to learn from an instructor.

On the subject of "natural teachers," cases that illustrate careful, informed, systematic Vygotskian-style scaffolded instruction are virtually nonexistent before the modern era. Even in formal apprenticeship, one isn't likely to see much teaching—by anyone's definition (Lancy, 2012). In fact, there are probably more descriptions in the ethnographic record of experts spurning overtures from would-be novices/pupils than of the reverse (Edwards, 2005; Gladwin & Sarason, 1953; Hill & Plath, 1998; Krause, 1985; Lancy, 1996; Reichard, 1934). Even more common in the ethnographic record are broader, normative statements made by both adults and children that assert the absence of teaching in cultural transmission; its superfluity; even its capacity to harm and undermine a child's self-initiated learning—a finding affirmed in recent experimental psychological research (Bonawitz et al., 2011). A sample of such statements can be found in Table 2.1.

When observing the junior member of the teacher/pupil partnership, the picture is similar. Camilla Morelli (2011, 2012) has been a recent participant observer—with a focus on children—in a transitional community of Matses Indians in the Peruvian Amazon. She marvels at how facile and active the Matses children are in the natural environment compared to her own feelings of ineptitude. She is cowed by 3- and 4-year-olds who competently paddle and maneuver canoes on the wide river. She observes young boys nimbly catching and handling enormous catfish. And then she is struck by the painful contrast between the children's mastery of their natural surroundings while displaying great discomfort and incompetence in

[8] One piece of contrafactual evidence for this statement is the frequency with which ethnographers complain about their informants' unwillingness to assist them in learning the culture–subsistence skills in particular. Indeed, villagers see the inept attempts of the ethnographer and his/her social faux pas as occasions for hilarity and entertainment, not instruction (Henze, 1992; Nicolaisen, 1988).

the classroom. She summarizes the dilemma as "learning to sit still." Somehow, Matses children must suppress their spontaneous inclinations, which serve them well in learning their culture, and adopt a pattern of behavior and cognitive engagement that is completely novel. Matses children are active, hands-on learners; their role models are other children, not their parents. The learning process is profoundly physical rather than verbal. When free to learn on their own, they are contented; constrained to learn from a teacher, they are restless and frustrated.

Natural Pedagogy in the Classroom

"Natural pedagogy" should also have been in full view as schools were introduced to rural communities that had never encountered formal education—assuming of course that Gergely and associates acknowledge that natural pedagogy should apply in the school as well as in the home. But, in a well-known series of monographs sponsored by the anthropology of education program at Stanford (Spindler & Spindler, 1983), ethnographers portrayed village classroom scenes that were painful to observe. Children were treated cruelly. For instance, in the schools in the Chiapas Highlands of Mexico, students were beaten and made to kneel on pebbles or fruit pits to drive lessons home. It is no wonder that "Indian parents did all they could to save their children from the terrible fate of attending school" (Modiano, 1973, p. 87). In the 1960s, John Gay, Michael Cole (Gay & Cole, 1967), and I (Lancy, 1975) observed Kpelle village classrooms where teachers behaved like automatons, completely unable to adapt the to-be-learned material to the skill level, language, prior knowledge, or comprehension of the students. The most frequently used "instructional aide" was some form of physical punishment or verbal chastisement (Rival, 2002) [9] and these pedagogical tactics may be endorsed by parents in some societies (Wolf, 1972). Students weren't learning much from the constant rounds of rote memorization and repetition of the teacher's words and ended up leaving school long before they'd learned enough to use schooling as a passport into salaried employment. Mead refers to "functionless pedantry" (Mead, 1964) where the learner is subjected to teaching not for the content or skill transmitted, but to assert the "teacher's" dominant status.[10] Rural schools have been a colossal failure on a world-wide scale, at least in part because the principal players don't know how to enact the roles of teacher and student.

Aside from seeking evidence of natural pedagogy in the behavior of classroom teachers, the theory should predict that children or novices will take on the role of pupil easily. They should demonstrate a willingness to comply with the teacher and

[9] In rural Morocco, beating as a form of "instruction" is still accepted at home and in school (Nutter-El Ouardani, 2013, p. 115).

[10] For a review of "functionless pedantry" in adolescent initiation rites, see (Lancy, 2014, pp. 334–336). Similarly, "the Romans used education … to reproduce social hierarchies within their own society … the political function of pedagogy is … easily disguised … " (Corbeill, 2001: 282).

Table 2.3 How novices are expected to behave

In a Mayan community … children are taught to avoid challenging an adult with a display of greater knowledge by telling them something (Rogoff, 1990, p. 60)
On an Indian Reservation in the US, children are viewed as being inattentive because they don't gaze at the teacher when she is speaking; yet averting one's gaze in the presence of adults is "proper" behavior in the village (Phillips, 1983)
West African Wolof parents never quiz their kids by asking known-answer questions (Irvine, 1978)
Fijian children are never encouraged to address adults or even to make eye contact. Rather, their demeanor should express timidity and self-effacement (Toren, 1990)
Were the Mazahua children to ask questions it would be considered immature and rude (Paradise & Rogoff, 2009; see also Penn, 2001)
Because Inuit children are present in many multi-age situations, they are exposed to a great deal of talk by older people. Yet, it became apparent in this study that they were neither expected to participate nor to ask questions of adults who were speaking together. If they did ask questions, the adults ignored them, leaving their questions unanswered (Crago, 1992, p. 494)
In a Tongan classroom, teachers may well expect students to volunteer information, ask questions, or eagerly answer the teacher's academic questions. This doesn't happen though because, in a Tongan village, children are to learn through observation alone (Morton, 1996)
In a four-culture (Samoa, Caribbean, Nepal, Kenya) comparative study, children very rarely asked information-seeking questions. Parents did not engage in dialog with their children to exchange information. They were to be obedient, respectful, and responsible (Gauvain & Munroe, 2013)
Tizard and Hughes (1984) showed that middle class preschoolers asked more questions than lower class. Middle class parents consistently asked and received more questions/answers than lower class. Middle class parents are more likely to take up, repeat, or expand what the child has just said. Parents who didn't pose or solicit questions were much more likely to use commands or directives with children

collaborate to the extent, for example, of asking questions of the teacher when they can't understand the lesson. But we see precisely the opposite. We see "pupils" in classrooms fretting at the inactivity (Morelli, 2011) and at having to focus on listening to a teacher (Paradise & de Haan, 2009) when they're accustomed to learning through doing. "The child keeps on doing and doing, and then gets used to it [is an expression] very often used [by Tapajós Indians] to talk about the learning process" (Medaets, 2011, p. 4). Yukaghir (Siberian foragers) model of knowledge transferal could be described as "doing is learning and learning is doing" (Willerslev, 2007, p. 162). With respect to the pupil asking questions of the teacher, the descriptions in Table 2.3 are representative[11]:

These village norms have real consequences in terms of the mindset children bring to the classroom, as demonstrated in an ingenious experiment. Mayan children were compared with middle-class American counterparts in an origami-folding task. The village-reared children were much more attentive to the demonstration

[11] In my study of Kpelle childhood (Lancy, 1996), my best informant was a child who was not at all intimidated by me, was very talkative and articulate, and quite perceptive. I was repeatedly warned by adults to keep my distance from this child as he was a rascal and "not a proper Kpelle child."

and to the activities of others in the setting, especially adults. Unlike the Anglo children, they did not seek additional information to aid them in completing the task (Correa-Chavez & Rogoff, 2005).[12] Parallel results were observed in a study comparing native Hawaiian and Haole (Anglo) students where the latter were much more likely to request adult assistance, and consequently, were more successful at the task (Gallimore, Howard, & Jordan, 1969).

The First Schools

There is little evidence that schooling in the village has changed a great deal in the intervening 50 years since the anthropology of education field was launched (Shepler, 2014). In fact, when West African education authorities attempt to "modernize" (e.g., to abandon "natural" pedagogy) teaching methods in village classrooms, they are met with resistance on the part of teachers and parents (Anderson-Levitt & Diallo, 2003; Moore, 2006). Specifically with respect to corporal punishment, teachers in Guinea echo a widely expressed view: "*Il faut suffrir pour apprendre*" = "to learn one must suffer" (Anderson-Levitt, 2005, p. 988).

To check any tendency the reader might have to find some bias or inaccuracy in this portrait of teaching, a review of the historical record will readily show that what is today considered effective pedagogy was also absent from the first few millennia of formal education.

"Literate and numerate education, characteristic of the Eastern Palace cultures [dating] to 3200 BCE [was] developed to train a scribal class in service to a centralized monarchy" (Langdon, 2013, p. 446). The oldest known classroom and pedagogical material were found in Mesopotamia. The *edduba* (Tablet House) from the third millennium BCE, excavated at Mari, had two rows of benches for the students and many discarded clay tablets. The clay tablet facilitated instruction because it could be easily erased and reused and was much less costly than the writing media used elsewhere in antiquity. Sumerian scholar Samuel Kramer notes—from a reading of the ancient texts—that the schools were "uninviting," the lessons were dull, and discipline was harsh (1963, p. 243). One poor novice describes his experience: "My headmaster read my tablet, said: 'There is something missing,' caned[13] me. 'Why didn't you speak Sumerian,' caned me. My teacher said: 'Your hand is unsatisfactory,' caned me. And so I began to hate the scribal art" (Kramer, 1963, pp. 238–239).

[12] In a parallel study in the US, groups of children whose immigrant mothers were relatively well or poorly educated, behaved differently when shown how to make origami figures. The latter group relied solely on observation whereas the former sought additional information through questioning the teacher (Mejia-Arauz et al., 2005).

[13] The specific cuneiform sign for "caned" is an amalgam of the signs for stick and flesh (Kramer, 1963, p. 237).

This unpromising regimen changes little through the ages (Chiappetta, 1953). And evidence of the conflict between top-down teaching and bottom-up learners is not hard to find. "Graffiti at Pompeii reveals the children … mocking their school learning" (Bloomer, 2013, p. 453). And, "a common writing exercise had the student write 'work hard lest you be beaten'" (Bloomer, 2013, p. 455). In Britain, the master is depicted perched at his elevated desk "grasping the birch—a bundle of twigs—that formed his badge of office" and used "to punish indiscipline and inability to answer" (Orme, 2006, p. 144). A teacher in the 1590s "laments that children are afraid to come to school and wish to leave as soon as possible because of the severity and frequency of the whippings" (Durantini, 1983, p. 125). These practices grew out of the belief that children would not naturally accept the role of pupil. In Holland in the seventeenth century, children's resistance to pedagogical practices was so widely acknowledged that it spawned an entire genre of painting—"unruly school scenes" (Durantini, 1983, pp. 152–154).

Teaching in the Present and Future

Ironically, even in WEIRD society, where parental teaching is practically a sacred duty, parents and professionally trained teachers aren't necessarily very good at it. In a study of WEIRD parents teaching their children the game Chutes and Ladders, some parents used effective techniques, other were quite ineffective (Bjorklund, 2007; see also Bergin, Lancy, & Draper, 1994). In a recent massive study in the US (Robinson & Harris, 2014), the level of parents' academic involvement did not predict children's grades. In fact, "helping with homework" had a negative impact because parents lacked appropriate knowledge and/or teaching skills and students were more successful on their own. The main thrust of this study is that the "parent involvement" mantra is based on the myth that all parents are effective teachers. But in fact, from the earliest teachers in the first schools to the unhelpful homework tutors, a common element is the employment of controlling teaching techniques, such as commands and corrections—shown to negatively affect a number of child learning outcomes including conceptual understanding and task performance.

The parent involvement campaign has, as a primary goal, the recruiting of parents—typically lower or working class—as auxiliary teachers. But these parents, historically, disavow any interest in teaching their children or taking responsibility for their successful schooling. These aren't neglectful parents, but modern adherents of the village-based socialization model. For example, Lareau (see also Kusserow, 2004) found that working class children "have more autonomy from adults than their middle-class counterparts" (Lareau, 2003, p. 151).

The linguistic anthropologist Shirley Brice Heath conducted a long-term ethnographic project with families in the Piedmont region of the US in the 1970s. Her goal was to understand how different communities interact with literacy, especially where children were concerned. In a poor, African-American community, "Tracton," use of books (other than the Bible) and printed material was limited, and parents did not engage in elaborate conversations or other "joint activity" with their young children, nor did they see it as their responsibility to act as the child's first teacher. She recorded sentiments that echo those recorded by anthropologists in villages throughout the world.

> He [her grandson] gotta learn to know 'bout dis world, can't nobody tell 'im. Now just how crazy is dat? White folks uh hear dey kids say sump'n, dey say it back to 'em, dey aks 'em 'gain 'n 'gain 'bout things … He just gotta be keen, keep his eyes open … Gotta watch hisself by watchin' other folks. Ain't no use me tellin' 'im: "learn dis, learn dat" … He just gotta learn … he see one thing one place one time, he know how it go, see sump'n like it again, maybe it be same, maybe it won't. He hafta try it out (Heath, 1983, p. 84).

The very same philosophy was displayed in Dickens' (1836) classic The Pickwick Papers. The Pickwickians had taken on Sam Weller as general manager and all-around assistant to support their peregrinations through England. When Pickwick meets Sam's father, they have this interchange:

> Beg your pardon, sir," said Mr. Weller senior, taking off his hat, "I hope you're no fault to find with Sammy sir?" "None whatsoever," said Mr. Pickwick. "Why very glad to hear it, sir," replied the old man; "I took a good deal o' pains with his eddication, sir; let him run in the streets when he was very young, and shift for hisself. It's the only way to make a boy sharp, sir. (p. 306 in 1964 edition).

Lareau's cross-class comparative ethnography identifies similar attitudes in a typical US working-class community. For instance, Mrs. Morris, a mother from Colton, saw her son Tommy's education beginning when she "turned over responsibility" for him to the school. Afterwards, she remained largely in ignorance of his progress and was surprised to be called to the school and informed that he was doing poorly (Lareau, 1989). Each of these studies of contemporary parenting practices outside WEIRD society reinforces my argument that teaching by parents is cultural, not natural. And further, the skills involved are not learned easily (Geary, 1995).

If teaching was rare and patchy in the past and across cultures, then what has led to the unquestioned dominance of teaching as the essential means of child rearing and cultural transmission?

> The requirement of out-of-context, or context-independent, learning makes formal schooling an evolutionarily novel and "unnatural" experience … Children did not evolve to sit quietly at desks in age-segregated classrooms being instructed by unrelated and unfamiliar adults. Yet such procedures, to varying degrees, are necessary. They are necessary because the demands of modern culture required that children master basic technological skills, the most important of which are reading and writing, and mathematics, as well as knowledge in a broad realm of domains (Bjorklund, 2007, p. 120).

In pre-modern, face-to-face communities, skills and knowledge that are both critical and opaque are rare to nonexistent. In post-industrial societies, opaque material that is essential for young learners to acquire fills entire libraries. The sheer volume is enormous and growing exponentially. An entire system of instruction has been invented over years to handle this massive challenge in cultural transmission

Berch (2013). In WEIRD society, infants are subject to early lessons from conscientious and attendant parents and, not surprisingly, they become precocious teachers themselves[14] (Strauss & Ziv, 2012). Nevertheless, despite spending billions on developing curricula, methods, and teacher training, the schooling process, at least across much of the US, seems, by many measures, seriously deficient. There seems to be very little that is "natural" about effective pedagogy. On the contrary, promoting successful pedagogy seems like an engineering challenge comparable to sending humans to the moon.

Conclusion

I would propose that the arguments which attempt to elevate teaching to a privileged place in human evolutionary theory are doomed to fail. I believe that a far more fruitful discussion might center on reconsidering the degree to which childhood should be considered a period of dependency (Kramer, 2014). I believe that contemporary thinking across the social sciences and biology may over-estimate the degree of dependency during the subadult period. Thinking is colored by three factors. First: the pervasive effects of living in a Neontocracy (Lancy, 1996, 2014a, 2014b) where youth are almost totally dependent on others well into adolescence. Second: the early !Kung reports which initially defined the "ancestral" analog. But !Kung children are unable to contribute much to subsistence—which is highly unusual. And third: the very evident dependency of infants who are truly helpless. Once we open this debate, we might begin to entertain the idea that, while children do learn from others, especially parents, they are the active and leading partners in this enterprise; and that parents are passive and even reluctant partners (see Gray, this volume; Toub et al., this volume). If this view prevails, "teaching" might be placed in the marginal position in theory that it occupies in reality.

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References

Acredolo, L., & Goodwyn, S. (2002). *Baby signs: How to talk with your baby before your baby can talk*. Chicago, IL: Contemporary Books.

Akhtar, N., & Gernsbacher, M. A. (2008). On privileging the role of gaze in infant social cognition. *Child Development Perspectives, 2*, 59–65.

Anderson, M. (1978). *Saami ethnoecology: Resource management in Norwegian Lapland*. Ann Arbor, MI: University Microfilms International.

[14] My daughter Nadia is nearly 2-years older than her younger sibling Sonia. For years, but especially before they started school, there was a constant running conflict between Nadia's felt "need" to "teach" her sister and Sonia's personal imperative to learn on her own.

Anderson-Levitt, K. M., & Diallo, B. B. (2003). Teaching by the book in Guinea. In K. M. Anderson-Levitt (Ed.), *Local meanings, global schooling: Anthropology and world culture theory* (pp. 75–97). Basingstone, England: Palgrave Macmillan.

Anderson-Levitt, K. M. (2005). The schoolyard gate: Schooling and childhood in global perspective. *Journal of Social History, 38*(4), 987–1006.

Atran, S., & Sperber, D. (1991). Learning without teaching: Its place in culture. In L. T. Landsmann (Ed.), *Culture, schooling and psychological development* (pp. 39–55). Norwood, NJ: Ablex.

Bai, L. (2005). *Shaping the ideal child: Children and their primers in late Imperial China*. Hong Kong, China: The Chinese University Press.

Bakeman, R., Adamson, L. B., Konner, M., & Barr, R. G. (1990). !Kung infancy: The social context of object exploration. *Child Development, 61*, 794–809.

Bascom, W. (1969). *The Yoruba of Southwest Nigeria*. New York, NY: Holt, Rinehart, and Winston.

Basso, K. H. (1972). Ice and travel among Fort Norman Slave: Folk taxonomies and cultural rules. *Language in Society, 1*, 31–49.

Berch, D. (2013). *Evolutionary theory can inform the intelligent design of educational policy and practice*. The Evolution Institute Online, Retrieved from March 27, 2015 from https://evolution-institute.org/project/education/evolutionary-theory-can-inform-the-intelligent-design-of-educational-policy-and-practice/

Bergin, C., Lancy, D. F., & Draper, K. D. (1994). Parents' interactions with beginning readers. In D. F. Lancy (Ed.), *Children's emergent literacy: From research to practice* (pp. 53–78). Westport, CT: Praeger.

Beverly, E. A., & Whittemore, R. D. (1993). Mandinka children and the geography of well-being. *Ethos, 21*, 235–272.

Bird, D. W., & Bliege Bird, R. (2005). Martu children's hunting strategies in the western desert, Australia. In B. S. Hewlett & M. E. Lamb (Eds.), *Hunter gatherer childhoods: Evolutionary, developmental, and cultural perspectives* (pp. 129–146). New Brunswick, NJ: Aldine/Transaction.

Bird-David, N. (2005). Studying children in "hunter-gatherer" societies: Reflections from a Nayaka perspective. In B. S. Hewlett & M. E. Lamb (Eds.), *Hunter gatherer childhoods: Evolutionary, developmental, and cultural perspectives* (pp. 92–101). New Brunswick, NJ: AldineTransaction.

Bjorklund, D. F. (2007). *Why youth is not wasted on the young*. Malden, MA: Blackwell.

Bloch, M. E. F., Solomon, G. E. A., & Carey, S. (2001). Zafmaniry: An understanding of what is passed on from parents to children: A cross-cultural investigation. *Journal of Cognition and Culture, 1*, 43–68.

Bloomer, W. M. (2013). The ancient child in school. In J. E. Grubbs, T. Parkin, & R. Bell (Eds.), *The Oxford handbook of childhood and education in the classical world* (pp. 444–461). Oxford, England: Oxford University Press.

Boesch, C. (2005). Joint cooperative hunting among wild chimpanzees: Taking natural observations seriously. *Behavioral and Brain Sciences, 28*, 692–693.

Boesch, C., & Tomasello, M. (1998). Chimpanzee and human cultures. *Current Anthropology, 39*, 591–614.

Bollig, L. (1927). *The inhabitants of the Truk Islands: Religion, life and a short grammar of a Micronesian people*. Munster, Germany: Aschendorff.

Bonawitz, E., Shafto, P., Gweon, H., Goodman, N. D., Spelke, E., & Schultz, L. (2011). The double-edged sword of pedagogy: Instruction limits spontaneous exploration and discovery. *Cognition, 120*, 322–330.

Boyette, A. H. (2013). *Social learning during middle childhood among Aka foragers and Ngandu farmers of the Central African Republic* (Unpublished Ph.D. Dissertation), Washington State University, Pullman, WA

Brazelton, T. B. (1977). Implications of infant development among the Mayan Indians of Mexico. In P. Herbert Leiderman, S. R. Tulkin, & A. Rosenfeld (Eds.), *Culture and infancy: Variations in the human experience* (pp. 151–187). New York, NY: Academic Press.

Brown, P. (2011). The cultural organization of attention. In A. Duranti, E. Ochs, & B. B. Schieffelin (Eds.), *The handbook of language socialization* (1st ed.). London, England: Blackwell.
Callaghan, T., Holl, H., Rakoczy, H., Warnkekn, F., Liszkowski, U., Behne, T., & Tomasello, M. (2011). Early social cognition in three cultural contexts. *Monographs of the Society for Research in Child Development, 76*(2)
Casimir, M. J. (2010). *Growing up in a pastoral society: Socialization among Pashtu nomads. Kölner Ethnologische Beiträge*. Köln, Germany: Druck and Bindung.
Chiappetta, M. (1953). Historiography and Roman education. *History of Education Journal, 4*, 149–156.
Chipeniuk, R. (1995). Childhood foraging as a means of acquiring competent human cognition about biodiversity. *Environment and Behavior, 27*, 490–512.
Clark, E. V. (2005). *First language acquisition*. Cambridge, England: Cambridge University Press.
Corbeill, A. (2001). Education in the Roman Republic: Creating traditions. In Y. L. Too (Ed.), *Education in Greek and Roman Antiquity* (pp. 261–287). Boston, MA: Brill.
Correa-Chavez, M., & Rogoff, B. (2005). Cultural research has transformed our ideas of cognitive development. *International Society for the Study of Behavioral Development Newsletter, 47*, 7–10.
Crago, M. B. (1992). Communicative interaction and second language acquisition: An Inuit example. *TESOL Quarterly, 26*, 487–505.
Crittenden, A. N., Conklin-Brittain, N. L., Zes, D. A., Schoeninger, M. J., & Marlowe, F. W. (2013). Juvenile foraging among the Hadza: Implications for human life history. *Evolution and Human Behavior, 34*, 299–304.
Crown, P. L. (2002). Learning and teaching in the prehispanic American Southwest. In K. A. Kamp (Ed.), *Children in the prehistoric Puebloan Southwest* (pp. 108–124). Salt Lake City, UT: The University of Utah Press.
Csibra, G., & Gergely, G. (2009). Natural pedagogy. *Trends in Cognitive Sciences, 13*, 148–153.
Csibra, G., & Gergely, G. (2011). Natural pedagogy as evolutionary adaptation. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 366*, 1149–1157.
d'Andrade, R. G. (1984). Cultural meaning systems. In R. A. Shweder & R. A. LeVine (Eds.), *Culture theory: Essays on mind, self, and emotion* (pp. 88–119). Cambridge, England: Cambridge University Press.
DeBoer, W. R. (1990). Interaction, imitation and communication as expressed in style: The Ucayali experience. In M. W. Conkey & C. Hastorf (Eds.), *The uses of style in archaeology* (pp. 82–104). Cambridge, England: Cambridge University Press.
de León, L. (2011). Language socialization and multiparty participation frameworks. In A. Duranti, E. Ochs, & B. B. Schieffelin (Eds.), *The handbook of language socialization* (pp. 81–111). Oxford, MA: Blackwell.
Dickens, C. (1836). *The Pickwick Papers* (1964th ed.). New York, NY: New American Library.
Dunn, J. (1988). *The beginnings of social understanding*. Cambridge, MA: Harvard.
Durantini, M. F. (1983). *The child in seventeenth-century Dutch painting*. Ann Arbor, MI: UMI Research Press.
Edel, M. M. (1996). *The Chiga of Uganda* (2nd ed.). New Brunswick, NJ: Transaction Publishers (Original work published 1957).
Edwards, C. P. (2005). Children's play in cross-cultural perspective: A new look at the Six Culture Study. In F. F. McMahon, D. E. Lytle, & B. S. Smith (Eds.), *Play: An interdisciplinary synthesis* (pp. 81–96). Lanham, MD: University Press of America.
Einarsdóttir, J. (2004). *Tired of weeping: Mother love, child death, and poverty in Guinea-Bissau*. Madison, WI: University of Wisconsin Press.
Ember, C. R., & Ember, M. (2005). Explaining corporal punishment of children: A cross-cultural study. *American Anthropologist, 107*, 609–619.
Everett, D. L. (2008). *Don't sleep there are snakes: Life and language in the Amazonian Jungle*. New York, NY: Pantheon Books.
Fajans, J. (1997). *They make themselves: Work and play among the Baining of Papua New Guinea*. Chicago, IL: University of Chicago Press.

Fehr, E., Bernhard, H., & Rockenbach, B. (2008). Egalitarianism in young children. *Nature, 454*, 1079–1084.
Field, T. M., & Widmayer, S. M. (1981). Mother-infant interaction among lower SES Black, Cuban, Puerto Rican and South American immigrants. In T. M. Field, A. M. Sostek, P. Vietze, & P. Herbert Leiderman (Eds.), *Culture and early interactions* (pp. 41–62). Hillsdale, NJ: LEA.
Finn, L., & Vandermaas-Peeler, M. (2013). Young children's engagement and learning opportunities in a cooking activity with parents and older siblings. *Early Childhood Research and Practice, 15*, Retrieved March 23, 2015 from http://ecrp.uiuc.edu/v15n1/finn.html
Fouts, H. (2005). Families in Central Africa: A comparison of Bofi farmer and forager families. In J. L. Roopnarine & U. P. Gielen (Eds.), *Families in global perspective* (pp. 347–363). Boston, MA: Allyn & Bacon.
Gallimore, R., Howard, A., & Jordan, C. (1969). Independence training among Hawaiians: A cross cultural study. In H. C. Lindgren (Ed.), *Contemporary research in social psychology* (pp. 392–397). New York, NY: John Wiley.
Gaskins, S., & Paradise, R. (2010). Learning through observation in daily life. In D. F. Lancy, S. Gaskins, & J. Bock (Eds.), *The anthropology of learning in childhood* (pp. 85–117). Lanham, MD: AltaMira Press.
Gauvain, M., & Munroe, R. L. (2013). Children's questions in cross-cultural perspective: A four-culture study. *Journal of Cross-Cultural Psychology, 44*, 1148–1165.
Gay, J., & Cole, M. (1967). *The new mathematics and an old culture: A study of learning among the Kpelle*. New York, NY: Holt, Rinehart and Winston.
Geary, D. C. (1995). Reflections of evolution and culture in children's cognition: Implications for mathematical development and instruction. *American Psychologist, 50*, 24–37.
Geary, D. C. (2000). Evolution and proximate expression of human paternal investment. *Psychological Bulletin, 126*, 55–77.
Geary, D. C. (2007). Educating the evolved mind. In J. S. Carlson & J. R. Levin (Eds.), *Educating the evolved mind* (pp. 1–99). Charlotte, NC: Information Age.
Gergely, G., Bekkering, H., & Király, I. (2002). Rational imitation in preverbal infants. *Nature, 415*, 755.
Gergely, G., Egyed, K., & Király, I. (2007). On pedagogy. *Developmental Science, 10*, 139–146.
Gladwin, T. (1970). *East is a big bird: Navigation and logic on Puluwat Atoll*. Cambridge, MA: Harvard University Press.
Gladwin, T., & Sarason, S. B. (1953). *Truk: Man in paradise*. New York, NY: Wenner-Gren Foundation.
Goodwin, G., & Goodwin, J. T. (1942). *The social organization of the Western Apache*. Chicago, IL: University of Chicago Press.
Göncü, A., Mistry, J., & Mosier, C. (2000). Cultural variations in the play of toddlers. *International Journal of Behavioral Development, 24*, 321–329.
Gray, P. O. (2013). *Freedom to learn*. New York, NY: Basic Books.
Grindal, B. T. (1972). *Growing up in two worlds: Education and transition among the Sisala of Northern Ghana*. New York, NY: Holt, Rinehart, and Winston.
Guemple, D. L. (1979). Inuit socialization: A study of children as social actors in an Eskimo community. In I. Karigoudar (Ed.), *Childhood and adolescence in Canada* (pp. 39–71). Toronto, ON, Canada: McGraw-Hill Ryerson.
Harkness, S., & Super, C. (2006). Themes and variations: Parental ethnotheories in Western cultures. In K. H. Rubin, O. B. Chung, & O. Boon (Eds.), *Parenting beliefs, behaviors, and parent-child relations: A cross-cultural perspective* (pp. 61–79). New York, NY: Psychology Press.
Harris, P. (2012). *Trusting what you're told: How children learn from others*. Cambridge, MA: Belknap Press.
Hatano, G., & Takahashi, K. (2005). Is shared intentionality widespread among and unique to humans? *Behavioral and Brain Sciences, 28*, 703.
Haun, D. B. M., van Leeuwen, E. J. C., & Edelson, M. G. (2013). Majority influence in children and other animals. *Developmental Cognitive Neuroscience, 3*, 61–71.

Hawkes, K. (1991). Showing off: Tests of another hypothesis about men's foraging goals. *Ethology and Sociobiology, 11*, 29–54.
Heath, S. B. (1983). *Ways with words*. Cambridge, England: Cambridge University Press.
Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioural and Brain Sciences, 33*, 61–81.
Henze, R. C. (1992). *Informal teaching and learning*. Hillsdale, NJ: LEA.
Heth, C. D., & Cornell, E. H. (1985). A comparative description of representation and processing during search. In H. M. Wellman (Ed.), *Children's searching: The development of search skill and spatial representation* (pp. 215–249). Hillsdale, NJ: Erlbaum.
Hewlett, B. L. (2013). *Listen, here is a story*. New York, NY: Oxford University Press.
Hewlett, B. S., & Cavalli-Sforza, L. L. (1986). Cultural transmission among Aka Pygmies. *American Anthropologist, 88*, 922–934.
Hewlett, B. S., Fouts, H. N., Boyette, A. H., & Hewlett, B. L. (2011). Social learning among Congo Basin hunter–gatherers. *Philosophical Transactions of the Royal Society: Biology, 366*, 1168–1178.
Hewlett, B. L., & Hewlett, B. S. (2013). Hunter-gatherer adolescence. In B. L. Hewlett (Ed.), *Adolescent identity* (pp. 73–101). New York, NY: Routledge.
Hewlett, B. S., & Lamb, M. E. (Eds.). (2005). *Hunter gatherer childhoods: Evolutionary, developmental, and cultural perspectives*. New Brunswick, NJ: Aldine Transaction.
Hewlett, B. S., Lamb, M. E., Leyendecker, B., & Schölmerich, A. (2000). Parental investment strategies among Aka foragers, Ngandu farmers, and Euro-American urban-industrialists. In C. Lee, N. Chagnon, & W. Irons (Eds.), *Adaptation and human behavior: An anthropological perspective* (pp. 155–178). New York, NY: Aldine de Gruyter.
Higgens, K. (1985). Ritual and symbol in Baka life history. *Anthropology and Humanism Quarterly, 10*, 100–106.
Hilger, M. I. (1957). Araucanian child life and cultural background. In *Smithsonian miscellaneous collections* (Vol. 133, pp. 5–6). Washington, DC: Smithsonian Institution.
Hill, J. F., & Plath, D. W. (1998). Moneyed knowledge: How women become commercial shellfish divers. In J. Singleton (Ed.), *Learning in likely places: Varieties of apprenticeship in Japan* (pp. 211–225). Cambridge, NY: Cambridge University Press.
Honroe, C. (2009). *Under pressure: Rescuing our children from the culture of hyper-parenting*. New York, NY: Harper Collins.
House, B. R., Henrich, J., Brosnan, S. F., & Silk, J. B. (2012). The ontogeny of human prosociality: Behavioral experiments with children aged 3 to 8. *Evolution and Human Behavior, 33*, 291–308.
Howard, A. (1970). *Learning to be Rotuman*. New York, NY: Teachers College Press.
Howell, S. (1988). From child to human: Chewong concepts of self. In G. Jahoda & I. M. Lewis (Eds.), *Acquiring culture: Cross cultural studies in child development* (pp. 147–168). London, England: Croom Helm.
Howell, N. (2010). *Life histories of the Dobe !Kung: Food, fatness, and well-being over the life span*. Berkeley, CA: University of California Press.
Howrigan, G. A. (1988). Fertility, infant feeding, and change in Yucatan. In R. A. LeVine, P. M. Miller, & M. M. West (Eds.), *Parental behavior in diverse societies* (New directions for child development, Vol. 40, pp. 37–50).
Hsiung, P. (2005). *A tender voyage: Children and childhood in late imperial China*. Stanford, CA: Stanford University Press.
Humle, T., & Newton-Fisher, N. E. (2013). Culture in non-human primates. In R. Ellen, S. J. Lycett, & S. E. Johns (Eds.), *Understanding cultural transmission in anthropology* (pp. 80–101). Oxford, NY: Berghahn.
Hunn, E. S. (2002). Evidence for the precocious acquisition of plant knowledge by Zapotec children. In J. R. Stepp, F. S. Wyndham, & R. K. Zarger (Eds.), *Ethnobiology and biocultural diversity: Proceedings of the seventh international congress of ethnobiology* (pp. 604–613). Athens, GA: University of Georgia Press.

Hunt, E. (2007). What is the meaning of evolutionary psychology for education? In J. S. Carlson & J. R. Levin (Eds.), *Educating the evolved mind* (pp. 141–154). Charlotte, NC: Information Age.

Irvine, J. T. (1978). Wolof "magical thinking": Culture and conservation revisited. *Journal of Cross-Cultural Psychology, 9*, 300–310.

Istomin, K. V., & Dwyer, M. J. (2009). Finding the way: A critical discussion of anthropological theories of human spatial orientation with reference to reindeer herders of northeastern Europe and western Siberia. *Current Anthropology, 50*, 29–49.

Jay, R. R. (1969). *Javanese villagers: Social relations in rural Modjokuto*. Cambridge, MA: MIT Press.

Johnson, A. (2003). *Families of the forest*. Berkeley, CA: University of California Press.

Kärtner, J., Keller, H., Lamm, B., Abels, M., Yovsi, R., Chaudhary, R., et al. (2008). Similarities and differences in contingency experiences of 3-month-olds across sociocultural contexts. *Infant Behavior and Development, 31*, 488–500.

Keil, F. C. (2006). Explanation and understanding. *Annual Review of Psychology, 57*, 227–254.

Keller, H. (2013). Attachment and culture. *Journal of Cross-Cultural Psychology, 44*, 175–194.

Keller, H., Borke, J., Lamm, B., Lohaus, A., & Dzeaye Yovsi, R. (2010). Developing patterns of parenting in two cultural communities. *International Journal of Behavioral Development, 35*, 233–245.

Kline, M. A. (2015). How to learn about teaching: An evolutionary framework for the study of teaching behavior in humans and other animals. *Behavioral and Brain Sciences, 38*, e31. doi:10.1017/S0140525X14000090.

Kline, M. A., Boyd, R., & Henrich, J. (2013). Teaching and the life history of cultural transmission in Fijian villages. *Human Nature, 24*, 351–374.

Köhler, I. (2012). Learning and children's work in a pottery-making environment in Northern Côte d'Ivoire. In G. Spittler & M. Bourdillon (Eds.), *In African children at work: Working and learning in growing up* (pp. 113–141). Berlin, Germany: LitVerlag.

Kramer, S. N. (1963). *The Sumerians: Their history, culture and character*. Chicago, IL: University of Chicago Press.

Kramer, K. L. (2014). Why what juveniles do matters in the evolution of cooperative breeding. *Human Nature, 25*, 49–65.

Krause, R. A. (1985). *The clay sleeps: An ethnoarchaeological study of three African potters*. Birmingham, AL: The University of Alabama Press.

Kruger, A. C., & Tomasello, M. (1996). Cultural learning and learning culture. In D. R. Olson & N. Torrance (Eds.), *Handbook of education and human development: New models of learning, teaching, and schooling* (pp. 369–387). Cambridge, England: Blackwell.

Kusserow, A. S. (2004). *American individualisms: Child rearing and social class in three neighborhoods*. New York, NY: Palgrave Macmillan.

Lancy, D. F. (1975). The social organization of learning: Initiation rituals and public schools. *Human Organization, 34*, 371–380.

Lancy, D. F. (1996). *Playing on the mother ground: Cultural routines for children's development*. New York, NY: Guilford.

Lancy, D. F. (2007). Accounting for the presence/absence of mother-child play. *American Anthropologist, 109*, 273–284.

Lancy, D. F. (2008). *The anthropology of childhood: Cherubs, chattel, changelings* (1st ed.). Cambridge, MA: Cambridge University Press.

Lancy, D. F. (2010). Learning "from nobody:" The limited role of teaching in folk models of children's development. *Childhood in the Past, 3*, 79–106.

Lancy, D. F. (2010a). When nurture becomes nature: Ethnocentrism in studies of human development. *Behavioral and Brain Sciences, 33*, 99–100.

Lancy, D. F. (2012). "First you must master pain:" The nature and purpose of apprenticeship. *Society for the Anthropology of Work Review, 33*, 113–126.

Lancy, D. F. (2014). *The anthropology of childhood: Cherubs, chattel, changelings* (2nd ed.). Cambridge, NY: Cambridge University Press.

Lancy, D. F. (2015). "Babies aren't persons:" A survey of delayed personhood. In H. Otto & H. Keller (Eds.), *Different faces of attachment: Cultural variations of a universal human need* (pp. 66–109). Cambridge, England: Cambridge University Press.

Lancy, D. F. (in press a). Ethnographic perspectives on culture acquisition. In C. L. Mehan & A. Crittenden (Eds.), *Childhood: Origins, evolution, and implications*. Albuquerque, NM: University of New Mexico Press.

Lancy, D. F. (in press b). Playing with knives: The socialization of self-initiated learners. *Child Development*

Langdon, S. (2013). Children as early learners and producers in early Greece. In J. E. Grubbs, T. Parkin, & R. Bell (Eds.), *The Oxford handbook of childhood and education in the classical world* (pp. 172–194). Oxford, NY: Oxford University Press.

Lareau, A. (1989). *Home advantage: Social class and parental intervention in elementary education*. New York, NY: Falmer.

Lareau, A. (2003). *Unequal childhoods: Class, race, and family life*. Berkley, CA: University of California Press.

Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life*. Cambridge, England: Cambridge University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, England: Cambridge University Press.

LeVine, R. A. (2004). Challenging expert knowledge: Findings from an African study of infant care and development. In U. P. Gielen & J. L. Roopnarine (Eds.), *Childhood and adolescence: Cross-cultural perspectives and applications* (pp. 149–165). Westport, CT: Praeger.

LeVine, R. A. (2007). Ethnographic studies of childhood: A historical overview. *American Anthropologist, 109*, 247–260.

LeVine, R. A. (2014). Attachment Theory as Cultural Ideology. In Heidi Keller and Hiltrud Otto (Eds.), *Different faces of attachment: Cultural variations of a universal human need* (pp. 50–65). Cambridge: Cambridge University Press.

LeVine, R. A., & Norman, K. (2001). The infant's acquisition of culture: Early attachment re-examined in anthropological perspective. In H. Mathews & C. Moore (Eds.), *The psychology of cultural experience* (pp. 83–104). New York, NY: Cambridge University Press.

Lévi-Strauss, C. (1966). *The savage mind*. Chicago, IL: University of Chicago Press.

Liebenberg, L. (1990). *The art of tracking*. Cape Town, South Africa: Creda Press.

Little, C. A. J. L. (2011). How Asabano children learn; or, formal schooling amongst informal learners. *Oceania, 81*, 146–166.

Little, C. A. J. & Lancy, D. F. (in prep.). Interviews, history and ethnography in the study of cultural transmission: Lessons from the Asabano. *Ethos*

Marcon, R. A. (2002). Moving up the grades: Relationship between preschool model and later school success. *Early Childhood Research & Practice, 4*(1). Retrieved from http://ecrp.uiuc.edu/v4n1/marcon.html.

Maretzki, T. W., & Maretzki, H. (1963). Taira: An Okinawan village. In B. B. Whiting (Ed.), *Six cultures: Studies of child rearing* (pp. 362–539). Cambridge, MA: Harvard University Press.

Marshall, J. (1958). Man as a hunter. *Natural History, 67*, 276–395.

Matasuzawa, T., Biro, D., Humle, T., Inoue-Nakamura, N., Tonooka, R., & Yamakoshi, G. (2001). Emergence of culture in wild chimpanzees: Education by master-apprenticeship. In T. Matsuzawa (Ed.), *Primate origins of human cognition and behavior* (pp. 557–574). New York, NY: Springer.

Mauss, M. (1967). *The gift: Forms and functions of exchanges in archaic societies*. New York, NY: W.W. Norton.

Mead, M. (1964). *Continuities in cultural evolution*. New Haven, CT: Yale University Press.

Medaets, C. V. (2011, October). *"Tu garante?" Reflections on the transmission practices and learning in the Lower Tapajós, Brazilian Amazon*. Paper presented at 34th Annual Meeting of ANPEd (Brazilian Educational Research and Post-Graduate Association)

Meehan, C. L. (2009). Maternal time allocation in two cooperative childrearing societies. *Human Nature, 20*, 375–393.

Mejia-Arauz, R., Rogoff, B., & Paradise, R. (2005). Cultural variation in children's observation during a demonstration. *International Journal of Behavioral Development, 29*, 282–291.
Metge, J. (1984). *Learning and teaching: He Tikanga Maori*. Wellington, New Zealand: NZ Ministry of Education.
Modiano, N. (1973). *Indian education in the Chiapas highlands*. New York, NY: Holt, Rinehart, and Winston.
Moore, L. C. (2006). Learning by heart in Qur'anic and public schools in northern Cameroon. *Social Analysis: The International Journal of Cultural and Social Practice, 50*, 109–126.
Morelli, C. (2011, December). *Learning to sit still: The physical implications of schooling for Matses children in the Peruvian Amazon*. Paper presented at a workshop: "Schooling in anthropology: Learning the 'modern way,'" Brunel University.
Morelli, C. (2012). Teaching in the rainforest: Exploring Matses children's affective engagement and multisensory experiences in the classroom environment. *Teaching Anthropology, 2*, 53–65.
Morton, H. (1996). *Becoming Tongan: An ethnography of childhood*. Honolulu, HI: University of Hawai'i Press.
Mueller, C. M., & Dweck, C. S. (1998). Praise for intelligence can undermine children's motivation and performance. *Journal of Personality and Social Psychology, 75*, 33–52.
Neuwelt-Truntzer, S. (1981). *Ecological influences on the physical, behavioral, and cognitive development of Pygmy children* (Unpublished Ph.D. Dissertation), University of Chicago, Chicago, IL
Nicolaisen, I. (1988). Concepts and learning among the Punan Bah of Sarawak. In G. Jahoda & I. M. Lewis (Eds.), *Acquiring culture* (pp. 193–222). London, England: Croom Helm.
Ochs, E. (1986). Introduction. In B. B. Schieffelin & E. Ochs (Eds.), *Language socialization across cultures* (pp. 1–13). Cambridge, England: Cambridge University Press.
Ochs, E., & Izquierdo, C. (2009). Responsibility in childhood: Three developmental trajectories. *Ethos, 37*, 391–413.
Odden, H. L. (2007). *The acquisition of cultural knowledge of hierarchy by Samoan children* (Unpublished Ph.D. dissertation), Emory University, Atlanta, GA
Odden, H., & Rochat, P. (2004). Observational learning and enculturation. *Educational and Child Psychology, 21*, 39–50.
Olson, D. R. (2009). Some preliminaries to the natural history of pedagogy. In D. Berliner & H. Kupermintz (Eds.), *Fostering change in institutions, environments and people* (pp. 1–13). New York, NY: Routledge.
Orme, N. (2006). *Medieval schools: From Roman Britain to Renaissance England*. London, England: Yale University Press.
Oswalt, W. H. (1976). *An anthropological analysis of food-getting technology*. New York, NY: Wiley.
Nutter (El Ouardani), C. (2013). *Discipline and development: Negotiating childhood and authority in rural Morocco* (Unpublished Ph.D. dissertation). University of Chicago, Chicago, IL
Paradise, R. (1996). Passivity or tacit collaboration: Mazahua interaction in cultural context. *Learning and Instruction, 6*, 379–389.
Paradise, R. (1998). What's different about learning in schools as compared to family and community settings? *Human Development, 41*, 270–278.
Paradise, R., & de Haan, M. (2009). Responsibility and reciprocity: Social organization of Mazahua learning practices. *Anthropology and Education Quarterly, 40*, 187–204.
Paradise, R., & Rogoff, B. (2009). Side by side: Learning by observing and pitching in. *Ethos, 37*, 102–138.
Penn, H. (2001). Culture and childhood in pastoralist communities: The example of Outer Mongolia. In L. Alanen & B. Mayall (Eds.), *Conceptualizing child-adult relations* (pp. 86–98). Abington, England: Routledge.
Phillips, S. U. (1983). *Invisible culture: Communication in classroom and community on the Warm Springs Indian Reservation*. White Plains, NY: Longman.
Piel, L. H. (2012). Food rationing and children's self-reliance in Japan, 1942–1952. *Journal of the History Childhood and Youth, 5*, 393–418.

Premack, D., & Premack, A. J. (1996). Why animals lack pedagogy and some cultures have more of it than others. In D. R. Olson & N. Rottance (Eds.), *The handbook of education and human development* (pp. 302–323). Cambridge, England: Blackwell.
Puri, R. K. (2005). *Deadly dances in the Bornean rainforest: Hunting knowledge of the Punan Benalui*. Leiden, Netherlands: KITLV Press.
Puri, R. K. (2013). Transmitting Penan basketry knowledge and practice. In R. Ellen, S. J. Lycett, & S. E. Johns (Eds.), *Understanding cultural transmission: a critical anthropological synthesis* (pp. 266–299). Oxford, NY: Berghahn Books.
Pye, C. (1991). The acquisition of K'iché (Maya). In D. I. Slobin (Ed.), *The cross-linguistic study of language acquisition* (pp. 221–308). Hillsdale, NJ: Erlbaum.
Rakoczy, H., Tomasello, M., & Striano, T. (2005). On tools and toys: How children learn to act on and pretend with 'virgin objects'. *Developmental Science, 8*, 57–73.
Raum, O. F. (1940). *Chaga childhood*. Oxford, England: Oxford University Press.
Read, M. (1960). *Children of their fathers: Growing up among the Ngoni of Malawi*. New Haven, CT: Yale University Press.
Reichard, G. (1934). *Spider woman: A story of Navaho weavers and chanters*. New York, NY: Macmillan.
Reichel-Dolmatoff, G. (1976). Training for the priesthood among the Kogi of Columbia. In J. Wilbert (Ed.), *Enculturation in Latin America* (pp. 265–288). Los Angeles, CA: UCLA Latin American Center Publications.
Rival, L. M. (2002). *Treking through history: The Hauorani of Amazonian Ecuador*. New York, NY: Columbia University Press.
Robinson, K., & Harris, A. L. (2014). *The broken compass: Parental involvement with children's education*. Cambridge, MA: Harvard University Press.
Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York, NY: Oxford University Press.
Rogoff, B., Correa-Chávez, M., & Cotuc, M. N. (2005). A cultural/historical view of schooling in human development. In D. B. Pillemer & S. H. White (Eds.), *Developmental psychology and social change: Research, history, and policy* (pp. 225–263). Cambridge, NY: Cambridge University Press.
Rowe, M. (2015, April). *Language development in context*. Paper presented at the Society for Psychological Anthropology Biennial Meeting, Boston
Ruiz, A. M., & Santos, L. R. (2014). Understanding differences in the way human and non-human primates represent tools: The role of teleological-intentional information. In C. M. Sanz, J. Call, & C. Boesch (Eds.), *Tool use in animal: Cognition and ecology* (pp. 119–133). New York, NY: Cambridge University Press.
Sampson, S. D. (2015). *How to raise a wild child: The art and science of falling in love with nature*. Boston, MA: Houghton-Mifflin.
Schütze, Y., Kreppner, K., & Paulsen, S. (1986). The social construction of the sibling relationship. In J. Cook-Gumperz, W. A. Corsaro, & J. Streek (Eds.), *Children's worlds and children's language* (pp. 128–145). Berlin, Germany: Mouton de Gruyter.
Shepler, S. (2014). *Childhood deployed: Remaking child soldiers in Sierra Leone*. New York, NY: New York University Press.
Shneidman, L. A., & Goldin-Meadow, S. (2012). Language input and acquisition in a Mayan village: How important is directed speech? *Developmental Science, 15*, 659–673.
Shostak, M. (1981). *Nisa: The life and words of a !Kung woman*. New York, NY: Vintage Books.
Skenazy, L. (2009). *Free-range kids: Giving our children the freedom we had without going nuts with worry*. Danvers, MA: Jossey-Bass.
Solomon, O. (2012). Rethinking baby talk. In A. Duranti, E. Ochs, & B. B. Schieffelin (Eds.), *The handbook of language socialization* (pp. 121–149). West Sussex, England: Wiley Blackwell.
Spindler, G., & Spindler, L. (1983). Review essay: The case studies in education and culture from cradle to grave. *Anthropology and Education Quarterly, 14*, 73–80.
Strauss, S., & Ziv, M. (2004). Teaching: Ontogenesis, culture, and education. *Cognitive Development, 19*, 451–456.

Strauss, S., & Ziv, M. (2012). Teaching is a natural cognitive ability for humans. *Mind, Brain and Education, 6*, 186–196.

Strauss, S., Ziv, M., & Stein, A. (2002). Teaching as a natural cognition and its relations to preschoolers' developing theory of mind. *Cognitive Development, 17*, 1473–1787.

Sugiyama, L. S., & Chacon, R. (2005). Juvenile responses to household ecology among the Yora of Peruvian Amazonia. In B. S. Hewlett & M. E. Lamb (Eds.), *Hunter gatherer childhoods: Evolutionary, developmental, and cultural perspectives* (pp. 237–261). New Brunswick, NJ: Aldine Transaction.

Takada, A. (2012). Preverbal infant-caregiver interaction. In A. Duranti, E. Ochs, & B. B. Schieffelin (Eds.), *The handbook of language socialization* (pp. 56–80). West Sussex, England: Wiley Blackwell.

Tayanin, D., & Lindell, K. (1991). *Hunting and fishing in a Kammu village* (Studies in Asian topics, Vol. 14). Copenhagen, Denmark: Curzon Press.

Tehrani, J. J., & Collard, M. (2009). On the relationship between interindividual cultural transmission and population-level cultural diversity: A case study of weaving in Iranian tribal populations. *Evolution and Human Behavior, 30*, 286–300.

Tehrani, J. J., & Riede, F. (2008). Towards an archaeology of pedagogy: Learning, teaching and the generation of material culture traditions. *World Archaeology, 40*, 316–331.

Thornton, A., & McAuliffe, K. (2012). Teaching can teach us a lot. *Animal Behaviour, 83*, e6–e9.

Thornton, A., & Raihani, N. J. (2008). The evolution of teaching. *Animal Behaviour, 75*, 1823–1836.

Tizard, B., & Hughes, M. (1984). *Young children learning*. London, England: Fontana.

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences, 28*, 675–735.

Toren, C. (1990). *Making sense of hierarchy: Cognition as social process in Fiji*. Houndsmills, England: Palgrave-Macmillan.

Trivers, R. L. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), *Sexual selection and the descent of man* (pp. 136–179). Chicago, IL: Aldine.

Tulley, G., & Spiegler, J. (2011). *50 dangerous things you should let your children do*. New York, NY: New American Library.

Turnbull, C. M. (1965). *The Mbuti Pygmies: An ethnographic survey*. New York, NY: American Museum of Natural History.

Vandermaas-Peeler, M., Nelson, J., von der Heide, M., & Kelly, E. (2009). Parental guidance with four-year-olds in literacy and play activities at home. In D. Kuschner (Ed.), *From children to red hatters* (pp. 93–112). Lanham, MD: University Press of America.

Waldfogel, J. (2006). *What children need*. Cambridge, MA: Harvard University Press.

White, J. P., Modjeska, N., & Hipuya, I. (1977). Group definitions and mental templates. In R. V. S. Wright (Ed.), *Stone tools as cultural markers: Change, evolution and complexity* (pp. 380–390). Atlantic Highland, NJ: Humanities Press.

Whiten, A., & Milner, P. (1984). The educational experiences of Nigerian infants. In H. Valerie Curran (Ed.), *Nigerian children: Developmental perspectives* (pp. 34–73). London, England: Routledge & Kegan Paul.

Willerslev, R. (2007). *Soul hunters: Hunting, animism, and personhood among the Siberian Yukaghirs*. Berkley, CA: University of California Press.

Wolf, M. (1972). *Woman and the family in rural Taiwan*. Palo Alto, CA: Stanford University Press.

Zarger, R. K. (2002). Acquisition and transmission of subsistence knowledge by Q'equchi' Maya in Belize. In J. R. Stepp, F. S. Wyndham, & R. K. Zarger (Eds.), *Ethnobiology and biocultural diversity* (pp. 593–603). Athens, GA: University of Georgia Press.

Chapter 3
Children's Natural Ways of Educating Themselves Still Work: Even for the Three Rs

Peter Gray

We live in an era of education gone amok. Over the past several decades, children in the US have been subjected to ever-increasing amounts of schooling, in ever more rigid forms, aimed at improving scores on standardized tests. Even out of school, children are increasingly placed into adult-directed, school-like activities, driven partly by parents' beliefs that childhood is a time of résumé building, toward getting into a prestigious college, rather than a time of free play (see also Bjorklund & Beer, this volume; Toub et al., this volume). Over the same decades that children's freedom to play and explore has been declining, researchers have documented dramatic increases in anxiety and depression, and decreases in internal locus of control and creativity among young people (Gray, 2011a; Kim, 2011; Newsom, Archer, Trumbetta, & Gottesman, 2003; Twenge et al., 2010; Twenge, Zhang, & Im, 2004). Elsewhere, I have given reasons for believing that the decline of children's freedom is a cause of these deleterious changes in their mental well-being (Gray, 2011a; Gray, 2013).

The mania for increased instruction, with consequent decreases in play, has even struck our kindergartens and preschools. Teachers in these settings are increasingly required to forego playful, creative, and enjoyable activities, so they can spend more time on worksheets and test preparation (Lynch, 2015). This is despite repeated studies showing that the immediate academic gains of such training wash out within 2 or 3 years (Carlsson-Paige, Almon, & McLaughlin, 2015; Darling-Hammond & Snyder, 1992; Katz, 2015). Indeed, in some well-controlled studies, students from academic-based preschools and kindergartens performed *worse*, by fourth grade and beyond, on measures of reading, math, social maturity, and emotional control than otherwise comparable children from play-based preschools and kindergartens (Goldbeck, 2001; Marcon, 2002; Schweinhart & Weikart, 1997).

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The dominant assumption of education policy makers is that increased academic instruction is necessary for success in our culture. It may not be pleasant, but, like bad-tasting medicine, it is a necessary means to overcome a malady, in this case the malady of ignorance. There seems also to be the assumption that, for this medicine, more is always better. If a certain amount of instruction doesn't produce the results we want, then the solution must be to provide more of it. Blindly we continue on this track, with little thought about possible harmful effects of overdose.

The Origin of Modern Schools

In truth, schools as we know them have never been very effective in promoting what most liberal-minded people today would like to think of as education. Schools are not products of scientific knowledge about how children become educated. They are products of history. They arose to serve religious and political ends that are incompatible with ends that many enlightened thinkers today view as the ideal goals of education.

If a chief architect of our system of schooling were to be named, it would be August Hermann Francke, the Pietist leader who established the world's first large-scale system of compulsory schooling, in Prussia, beginning in the seventeenth century (Melton, 1988). He established the type of classroom in which children sit in rows, all supposed to be learning the same things, in the same way, at the same time, directed by the schoolmaster. He developed a standardized curriculum (consisting then mostly of religious catechisms) and a method of training and certifying teachers to teach that curriculum. He arranged to have hourglasses installed in classrooms, so everyone would follow the same pre-determined schedule, dictated by time.

Francke was very clear in his writings about the purposes of his schools. Reading was taught, so children would be able to read the Bible. Religious doctrine was taught in a manner that prevented any questioning of it. But the larger, clearly stated purpose was to break children's wills and make them obedient—obedient to schoolmasters, parents, lords, and ultimately God. In his instructions to schoolmasters, Francke wrote, "Above all, it is necessary to break the natural willfulness of the child. While the schoolmaster who seeks to make the child more learned is to be commended for cultivating the child's understanding, he has not done enough. He has forgotten his most important task, namely that of making the will obedient." (Melton, 1988, p. 43). He believed that the most effective way to break children's wills was through constant monitoring and supervision. He wrote, "Youth do not know how to regulate their lives, and are naturally inclined toward idle and sinful behavior when left to their own devices. For this reason, it is a rule in this institution that a pupil never be allowed out of the presence of a supervisor. The supervisor's presence will stifle the pupil's inclination to sinful behavior, and slowly weaken his willfulness." (Melton, 1988, pp. 43–44.)

Francke's methods were transported throughout Europe and to the colonies in America. Ultimately, as religious influence waned and the power of states increased, the schools were taken over by states and curricula were altered to serve secular ends, but the methods were largely unchanged. Today, many educators wish that schools would promote curiosity, creativity, critical thinking, self-direction, and love of learning. But because our schools are essentially still the same as those designed by Francke, they are structurally incapable of such ends. Those ends all involve respecting children's wills. The method of requiring all children to attend to the same lessons, all at the same time, necessarily requires the suppression of, if not the breaking of, children's wills.

In times past, schools were never very successful at breaking wills, despite their best efforts, because school was only a small part of children's lives. Most of life was outside of school, where children were not always under adult surveillance. That was true even when I was a child, in the 1950s. Today, however, school is a huge part of children's lives, and even out of school many children are regularly in settings where adults monitor and govern their behavior. Counting homework, school today is for many the equivalent of what for an adult would be a full-time job—a very unpleasant sedentary full-time job, with a micromanaging boss, where one's work is constantly evaluated and compared with that of co-workers, where talking with co-workers is largely forbidden, and where permission is needed to leave one's workstation even to go to the bathroom. Research on employment satisfaction indicates that this would be an extreme example of the kind of job that most adults would rate as highly unpleasant and stressful (Galinsky, Bond, & Friedman, 1993). The well-documented recent increases among young people in depression and anxiety, and decreases in creativity and internal locus of control, may, indeed, reflect the successful breaking of wills.

A Biological View of Education

It is common today to equate education with schooling. But, for a meaningful discussion of education from a biological perspective, we must distinguish between the two. *Schooling* is the deliberate use of special procedures to teach a specific, preselected set of skills, concepts, beliefs, lore, and (or) values (a curriculum) to students. *Education,* in contrast, is the entire set of processes by which each new generation of human beings acquires any or all of the skills, concepts, beliefs, lore, and values—in short, the culture—of the previous generation. Education is cultural transmission. From a biological perspective, schooling is new, but education is as old as our genus. It is part of our biological makeup. While schooling takes place in special settings, under the direction of specially appointed teachers or masters, education takes place during every waking hour of every person's life, though it occurs most rapidly and significantly during childhood and adolescence (Lancy, this volume).

Beginning at least 2 million years ago, our ancestors began moving along an evolutionary track that made us ever more dependent on education. We developed means of hunting, gathering, processing foods, protecting ourselves from predators, birthing, caring for infants, navigating our environment, and combating diseases that depended on accumulated knowledge, theories, and skills passed from generation to generation. We also came to depend on increasing levels of cooperation within and across groups, which required the cultural transmission of social mores, rules, rituals, stories, and shared beliefs and values that served to hold groups together and permit cooperation.

In any human group, children who failed to acquire crucial aspects of their culture would be at a serious disadvantage for survival and reproduction in adulthood. They would not know how to perform economically essential tasks, secure the cooperation of others, or attract a mate for reproduction. Natural selection, then, would strongly favor characteristics that promoted young people's desires and abilities to acquire the culture. Today, in the minds of most people, the onus for education lies with adults, who have the responsibility to make children acquire aspects of the culture, whether the children want to or not. But throughout history, the real onus for education has always been with children, and it still is today, despite our schools (see Geary & Berch, this volume; Sweller, this volume). Natural selection has ensured that children come into the world with instinctive drives to educate themselves—to learn what they must to become effective members of the society into which they are born.

Near the turn of the nineteenth to the twentieth century, about 40 years after Darwin's *Origin of Species*, the naturalist and philosopher Karl Groos wrote two books in which he developed a Darwinian theory of play. In the first, *The Play of Animals* (1898), he noted that play, superficially viewed, seems wasteful and maladaptive from an evolutionary perspective. It uses energy, for no immediate survival end. It is often noisy and can attract predators. It sometimes involves risky behaviors that can result in injury or even death. Play would surely have been selected out, by natural selection, if it didn't have significant compensatory advantages (see also, Bjorklund & Beers, this volume). On the basis of his own and others' observations, Groos proposed that play is the means by which animals practice and hone the skills that they must in order to survive to and through adulthood.

Groos's *practice theory of play* is widely accepted today by researchers who study play in nonhuman animals. It explains why young animals play more than do older ones (they have more to learn) and why animals that depend least on rigid instincts, and most on learning, play the most. It also explains differences among species in forms of play. One can predict, quite well, what animals will play at by knowing the chief constraints on their survival. For example, predatory animals play at chasing, or creeping and pouncing, while prey animals play at fleeing, dodging, and escaping.

In his second book, *The Play of Man* (1902), Groos extended his theory to humans. He pointed out that, consistent with his theory, humans, who have far more to learn than do other species, play far more, and over a longer duration of life, than do other species. He also pointed out a major difference between human play and that of other animals. Other animals play at species-specific skills—skills that characterize their way of life no matter where they live. Humans, too, play at species-specific skills (such as two-legged walking and talking), but also play at culture-specific skills—skills that may be unique to the culture in which they are developing. He suggested that human children come into the world designed to attend to what people in their culture do and to incorporate those activities into their play. Groos referred to his theory as a theory of play, but I view it as more than that. It is a theory of education, or at least the foundation for such a theory.

Education in Hunter-Gatherer Bands

One way by which I have attempted to test and build on Groos's (1902) theory has been to examine children's play and education in hunter-gatherer cultures (see also Lancy, this volume). Until roughly 10,000 years ago, all humans were hunter-gatherers. The hunter-gatherer way of life is now almost completely extinguished, pushed out by modern influences. But as recently as the 1960s and 1970s, and to some degree even later, anthropologists could trek out into isolated parts of the world and find hunter-gatherers who were relatively unaffected by modern ways. Each culture that they found had its own unique characteristics—its own language, ways of hunting and gathering, stories, rituals, and art forms. Yet, in certain basic ways they were remarkably similar to one another, whether they were found in Africa, Asia, South America, or elsewhere, and whether in rainforests or deserts (Lee & Daly, 1999). To be clear, I should note that by "hunter gatherers," I am referring to groups that might more precisely be called *band* hunter-gatherers. I am not including the so-called *collector societies*, such as the Kwakiutl of the American northwest coast or the Ainu of Japan, which defended rich fishing grounds and were in many ways more similar to early agricultural societies than to band hunter-gatherers. In describing these cultures, I have chosen to use the past tense, to indicate that I am referring to practices that existed at the time they were studied, but may or may not exist today.

Wherever they were found, hunter-gatherers lived in bands of about 15–40 people, which moved from place to place within large but circumscribed areas to follow the available game and edible vegetation. Their most striking social characteristic, to Western eyes, was their extraordinary egalitarianism (Boehm, 1999; Gray, 2014; Ingold, 1999; Lee, 1988). They had no chiefs or big men, nor any obvious hierarchy of power. They made group decisions by consensus, often after long discussions. They shared food and material goods readily within the band and, less often, across bands. Part and parcel of their egalitarian ethos was an extraordinary degree of respect for individual autonomy. They didn't tell one another what to do, and, most remarkably, they applied this to children as well as adults.

I have never lived in or directly observed a hunter-gatherer society. My information comes from what others have observed and reported and from a survey that Jonathan Ogas (then my graduate student) and I conducted of ten anthropologists who, among them, had lived in seven different hunter-gatherer cultures—four in various parts of Africa, one in the Philippines, one in Malaysia, and one in New Guinea (Gray, 2009). In the survey, we asked each observer questions about the lives of children in the culture they observed. The literature review and survey led to three main conclusions concerning children's lives and education in such cultures.

The first conclusion is that hunter-gatherer children had to learn an enormous amount to become effective adults. The hunter-gatherer way of life was highly knowledge-intensive and skill-intensive. Moreover, because of the lack of occupational specialization, each child had to acquire nearly the whole culture, or at least that part of it appropriate to his or her gender. To become hunters, boys had to learn how to identify and track the many dozens of different species of mammals and birds that their group hunted. Liebenberg (1990) has presented a compelling argument that tracking by pre-agricultural hunters marked the origin of scientific reasoning. Hunters used scant marks in the sand, mud, or foliage as clues, which they combined with their accumulated knowledge from past experience, to develop and test hypotheses about the state of the animal they were tracking. As one anthropologist (Wannenburgh, 1979, p. 41) put it, "Everything is noticed, considered, and discussed. The kink in a trodden grass blade, the direction of the pull that broke a twig from a bush, the depth, size, shape, and disposition of the tracks themselves, all reveal information about the condition of the animal, the direction it is moving in, the rate of travel, and what its future movements are likely to be." They also had to develop great skill at crafting and using the tools of hunting, such as bows and arrows, blowguns and darts, or snares and nets, depending on the culture.

To become gatherers, girls—and boys also, to the degree that men also gathered—had to learn which of the countless varieties of roots, nuts, seeds, fruits, and greens were edible and nutritious; when and where to find them; how to extract the edible portions; and how to process them. These abilities included physical skills, honed by years of practice, as well as the capacity to remember, use, add to, and modify an enormous store of culturally shared verbal knowledge (Bock, 2005; Kaplan, Hill, Lancaster, & Hurtado, 2000). In addition, hunter-gatherer children had to learn to build huts, make fires, cook, fend off predators, predict weather changes, navigate their hunting and gathering grounds, treat wounds and diseases, assist births, care for infants, maintain harmony in the group, negotiate with neighboring groups, tell stories, make music, and engage in the various dances and rituals of their culture.

The second conclusion is that hunter-gatherer adults were extraordinarily non-directive and trusting in their relationships with children. The spirit of equality and autonomy characterized adult hunter-gatherers' interactions with children, just as it applied to their interactions with other adults. The central tenet of their parenting and educational philosophy seemed to be that children's instincts and judgments could be trusted, that children who were allowed to follow their own wills would learn what they needed to learn and would begin naturally to contribute to the band's economy when they had the skills and maturity to do so (see also Lancy, this volume). Illustrating this attitude, one set of researchers (Gosso, Otta, de Lima, Ribeiro, & Bussab, 2005, p. 218) wrote: "Hunter-gatherers do not give orders to their children; for example, no adult announces bedtime… Adults do not interfere with their children's lives. They never beat, scold, or behave aggressively with them, physically or verbally, nor do they offer praise or keep track of their development." Another (Hewlett, Fouts, Boyette, & Hewlett, 2011, p. 1173) wrote, "Foragers value autonomy and egalitarianism, so parents, older children or other adults are not likely to think and feel that they know what is best or better for the child and are generally unlikely to initiate, direct, or intervene in a child's social learning."

The third conclusion is that hunter-gatherer children educated themselves through their self-directed exploration and play. Given hunter-gatherers' trustful approach to parenting, it is not surprising that children spent most of their time playing and exploring, without adult direction. To our question, "How much free time did children in the group you studied have for play?," all of the respondents to our survey said, essentially, that they were free to play all day or almost all day, every day, from the age of about 4, when they were weaned and began to move away from their mothers, on into their teenage years, when they began taking on some adult responsibilities (Gray, 2009). As one respondent (Karen Endicott, who studied the Batek) put it, "Children were free to play nearly all the time; no one expected children to do serious work until they were in their late teens." In a study of people with mixed hunter-gatherer and agricultural subsistence, in Botswana, Bock and Johnson (2004) found that the more a family was involved in hunting and gathering, and the less they were involved in agriculture, the more time children had to play.

In our survey, we also asked about the ways in which children played. The responses confirmed Groos's theory that children naturally incorporate culture-specific skills into their play. All of the respondents told us that the boys played endlessly at tracking and hunting. They would playfully follow animal tracks and track one another. With small bows and arrows, little children would shoot at such "game" as butterflies, toads, and small rodents. The two respondents who studied that Agta, a Philippine culture in which women as well as men hunt, said that girls as well as boys played at hunting in the groups they observed. Among the other play activities that the respondents listed were caring for infants, climbing trees, building vine ladders, building huts, using knives and other tools, making tools, carrying heavy loads, building rafts, making fires, defending against attacks from pretend predators, imitating animals (a means of identifying animals and learning their habits), making musical instruments, making music, dancing, and storytelling. The specific lists varied from culture to culture in ways that were consistent with variations in the adult activities (Gray, 2009). Several hunter-gatherer researchers have written that the children grew up in a play culture that paralleled and mimicked the larger culture within which it was embedded (Gosso et al., 2005; Shostak, 1981; Turnbull, 1961).

Although hunter-gatherer adults did not direct children's activities and rarely taught explicitly, they recognized that children learn by watching, listening, and participating, so they did not exclude children from adult activities. By all accounts, they were enormously tolerant of children's interruptions, and they allowed children into their workspaces even when that meant that the work would go slower. On their own initiatives, children often joined their mothers on gathering trips, where they learned by watching and sometimes helping. By their early teens, boys who were eager to do so were allowed to join men on big-game hunting expeditions, so they could watch and learn. By the time they were in their middle to late teens, they might be actively contributing to, rather than detracting from, the success of such trips. In camp, children often crowded around adults, and young ones climbed onto adults' laps, to watch or "help" them cook, or make hunting weapons and other tools, or play musical instruments, and the adults rarely shooed them away (Draper, 1976).

Adults also helped children learn by responding to their requests. As one group of researchers (Hewlett et al., 2011, p. 1173) put it, "Sharing and giving are core forager values, so what an individual knows is open and available to everyone; if a child wants to learn something, others are obliged to share the knowledge or skill." An adult might show a child the best way to swing an axe, or point out the difference between the footprints of closely related animals. Usually such help came only when requested, but occasionally, especially when it could make a life-or-death difference, adults took the initiative in offering information, for example, about differences between edible and poisonous mushrooms (Hewlett et al., 2011).

Self-Education in Today's World: Democratic Schooling and Unschooling

Would the hunter-gatherer mode of education work in our society today? It's not hard to think of reasons why it might not. For starters, we have reading, writing, and arithmetic—skills that were foreign to hunter-gatherers, as they did not have written languages and their ways of life required little if any numerical calculations. One might plausibly argue, as Geary (2008) has, that the three Rs, and perhaps some of the scientific ways of thinking that we value today, are sufficiently different from the skills that hunter-gatherers had to acquire that children would not learn through their natural exploration and play, no matter how prevalent and valuable the skills are in the society in which they are developing (also Geary & Berch, this volume; Sinatra & Danielson, this volume; Sweller, this volume). Another obvious difference is that children in our society cannot observe, in their daily experiences, all of the ways that adults make a living. Our society is much more complex and less available to children than a hunter-gatherer society.

Without empirical evidence, claims that children's natural means of educating themselves would not suffice today are, of course, just speculation. It is equally easy to speculate in the opposite direction. Although hunter-gatherer cultures were no doubt more similar to one another than any of them are to ours, the basic kinds of skills needed for success in our culture may not be extraordinarily different from those in hunter-gatherer cultures. The written word is simply an alternative way of representing words, so learning to read and write might piggyback onto whatever evolved cognitive mechanisms we have for learning to understand and produce oral speech. Mathematics and science involve a variety of thinking that may not be fundamentally different from the thinking that hunter-gatherers engaged in regularly as they made and tested hypotheses about the movements of animals based on scant tracks, or the probable locations of tubers hidden underground during the dry season, or compass directions based on positions of stars. It also seems quite plausible that our innate learning mechanisms are far more adaptable and flexible than has been proposed by those evolutionary psychologists (e.g., Tooby & Cosmides, 1992) who conceive of the human brain as a set of task-specific modules that came about to serve specific survival purposes.

The problem of how children become exposed to adult activities in our culture is, actually, not one that our compulsory school system has addressed. Children in school see what teachers do, but generally that's the only profession they witness first-hand. Children probably gain more of a sense of what adults in our culture do from watching television. Our children may be drawn to television partly for the same reason that hunter-gatherer children are drawn to adult activities in their culture. Children don't necessarily need to witness all professions first-hand, but it is useful for them to experience a good sample of the sorts of skills that are represented in the adult work world.

What would happen to children in our culture if we did not subject them to coercive schooling, but provided them with educational settings that are, for our time and place, the equivalent of a hunter-gatherer band? In other words, what if we provided them with a setting in which they are free to play and explore all day in their own chosen ways, where they can freely mix with other children over a broad range of ages, where they can witness and take part in a broad range of culturally valued activities, and where the adults are helpful but do not direct children's activities or evaluate their progress? Over many years, I've observed learning in just such a place—the Sudbury Valley School.

The school was founded in 1968, so it's been in operation now for almost half a century. It's a private day school, in Framingham, Massachusetts, open to students aged four through high-school age. It admits students without regard to any measures of academic performance and operates at a per-pupil cost about half that of the surrounding public schools. The school currently has approximately 160 students and eight adult staff members. It is housed in a large Victorian farmhouse and remodeled barn, on ten acres of land in a semi-rural area.

The school is, fundamentally, a democratic community. The founders' primary goal was to create a setting where children would experience the rights and responsibilities of democratic citizenship. In one-person-one-vote fashion, at weekly school meetings, the students and staff together create all of the school's rules, make decisions about school purchases, establish committees to oversee the school's day-to-day operation, and hire and fire staff members. All staff members are on 1-year contracts, which must be renewed each year through a process that involves a secret-ballot election. Those who survive this process and are reelected year after year are, necessarily, those who are admired by the students. They are people who are kind, ethical, competent, and who contribute significantly and positively to the school's environment. They are adults that the students may wish in some ways to emulate.

The school's rules are enforced by the Judicial Committee, which changes regularly in membership, but always includes one staff member and a set of students representing the full range of ages at the school. When a student or staff member is charged by another school member with violating one of the school's democratically made rules, the accuser and the accused must appear before the Judicial Committee, which judges innocence and guilt and, in the latter case, decides on an appropriate sentence. The rules have to do with maintaining peace and order, protecting individuals' rights, and protecting the school, not with education.

The educational philosophy of the school is essentially the same as that of a hunter-gatherer band. The assumption is that if young people have ample opportunity to play, explore, and follow their own interests, in an environment rich in educational opportunities, they will learn what they must for success in their culture. The school gives no tests and does not in any way evaluate students' progress. There is no curriculum and no attempt by staff members to motivate learning. Courses occur only when a group of students take the initiative to organize one, and then the course lasts only as long as the students want it to last. Many students never join a course.

The staff members at the school do not consider themselves to be "teachers." They are, instead, the adult members of the community. They are the more mature and often more persuasive voices at school meetings, the people that students go to with problems that other students can't help them with, and the interface between the school and the larger community. Most of their "teaching," if one calls it that, is of the same variety as can be found in any human setting. It involves presenting ideas in the context of naturally occurring conversations and responding naturally to questions and requests for help. We might think of the staff at Sudbury Valley as in some ways the equivalent of the older and often wiser members of a hunter-gatherer band.

Except when they serve on the Judicial Committee, students are free all day, every day, to pursue their own interests. They are not divided into groups by the school nor assigned to specific spaces. They can interact with whom they please and go anywhere in the school buildings or grounds. The school has equipment for a wide variety of activities—including computers, a fully equipped kitchen, a woodworking shop, an art room, playground equipment, toys, games, and many books. Students also have access to a pond, a field, and a nearby forest for outdoor play and exploration. The most valuable educational resource at the school, for most students, is other students, who among them manifest an enormous range of interests and abilities.

Much of the students' exploration at the school, especially that of the older students, takes place through conversation. Students talk about everything imaginable, with each other and with staff members, and are thereby exposed to a huge range of ideas and arguments. Because nobody is an official authority, everything that is said and heard in conversation is understood as something to think about, not dogma to memorize or feed back on a test. Conversation, unlike memorizing material for a test, stimulates the intellect. Vygotsky (1962) argued, long ago, that conversation is the root of higher thought; and my observations of students at Sudbury Valley convince me that he was largely right. Thought is internalized conversation; actual conversations with other people get it started.

Many years ago, in collaboration with a part-time staff member at the school, I conducted a follow-up study of the school's graduates (Gray & Chanoff, 1986). The school was smaller then and had existed for only 15 years, but there were already 82 graduates who met our criteria—they had been students at the school for at least 2 years and had left at age 16 or older with no plans for further secondary schooling. We were able to locate 76 of these graduates, and 69 of them completed our rather extensive questionnaire—a response rate of 91 % of those who could be located, or 84 % of all the graduates. We found that those who had pursued higher education (about 75 % of the total) reported no particular difficulty getting into the schools of their choice and doing well there. Some, including a few who had never previously taken a formal course or an academic test (other than the SAT required for college admission), had gone on successfully to highly prestigious colleges and universities. As a group, regardless of whether or not they had pursued higher education, they were remarkably successful in finding employment that they enjoyed and earned them a living. They were pursuing a wide variety of occupations, including business, arts, science, medicine, other service professions, and skilled trades. Their success is perhaps especially remarkable, given that many of them came to the school because they were failing or doing poorly in the local public schools.

Many of the graduates had gone on successfully in careers that were direct extensions of passionate interests they had developed in play at the school. Here are a few examples: A woman who was captain of a cruise ship had played extensively with little boats on the school's pond as a young girl, and as a teenager had used the school's off-campus policy to apprentice herself to a ship caption on Cape Cod. A man who was a machinist and inventor had been "obsessed" with constructive play as a child. He would, among other things, make whole cities and factories from plasticine, with everything measured to scale. A woman who was a pattern maker in the high fashion industry had made doll clothes as a little girl and had then gone on, as a teenager, to making clothes for herself and her friends before apprenticing herself to a pattern maker. A man who became a mathematics professor had developed a strong interest in theoretical physics, and then math, as a teenager, from his passion for science fiction. Graduates who were successful artists, musicians, and computer specialists had all developed their interests and skills in free play at the school.

Most of the graduates said that a major benefit of their Sudbury Valley education was that they had acquired a sense of personal responsibility and self-control that served them well in all aspects of their lives. None said, in response to our question, that they regretted having gone to such an unusual school instead of a more traditional school. More recently, two larger studies of graduates, conducted by the school and published as books (Greenberg & Sadofsky, 1992; Greenberg, Sadofsky, & Lempka, 2005), resulted in similar conclusions. At least two dozen schools in the United States and roughly another dozen in other countries have been modeled after Sudbury Valley.

Another population of children and adolescents directing their own education in our society are those involved in the rapidly growing *unschooling* movement. These are young people who don't attend school at all. They are usually officially registered as homeschoolers, but are not subjected to any curriculum or tests at home because their parents subscribe to the philosophy that children learn best when they pursue their own interests in their own chosen ways. Gina Riley and I have conducted two survey studies of unschoolers. The first was a survey of 232 unschooling parents, which included questions about why they had chosen that educational route and what role they played in their children's education (Gray & Riley, 2013). According to their own reports, most parents actively helped to connect their children with the broader community, so they could learn from sources outside of the family as well as inside. The second study was a survey of 75 adults who had been unschooled during what would have been their K-12 school years (Gray & Riley, 2015; Riley & Gray, 2015). Our findings were quite similar to the previous findings concerning Sudbury Valley graduates. The great majority had no regrets about having been unschooled. They believed that they were more self-directed, more responsible, and more motivated to continue learning than they would have been had they been schooled. Those who had gone on to higher education had no particular difficulties getting into colleges and universities or doing well there. They had gone on to a wide variety of careers, which in many cases were direct extensions of their childhood play.

Conditions that Optimize Children's Abilities to Educate Themselves: How Sudbury Valley Is Like a Hunter-Gatherer Band

Earlier, I suggested that Sudbury Valley is in some ways the educational equivalent, for our time and place, of a hunter-gatherer band. Here I will expand on that by describing six conditions, common to both settings, that appear to optimize children's abilities to educate themselves. These conditions also appear to characterize the environments of the most satisfied unschoolers (Gray & Riley, 2013, 2015). None of them are present in our standard schools.

The social expectation (and reality) that education is children's responsibility. When children know they are responsible for their own education, they assume that responsibility. We would not have survived as a species if that were not true. When we adults act as if we educate children, as we do in our conventional schools, we take that responsibility away from children. We convince them that their own curiosity and questions don't count, that play is trivial, and that their education depends on doing what they are told rather than their own initiative. Beliefs become self-fulfilling prophecies. Staff members at Sudbury Valley School and parents in unschooling families, like adults in hunter-gatherer cultures, do nothing to diminish children's natural assumptions that they are in charge of their own education.

Unlimited freedom to play, explore, and pursue one's own interests. To educate themselves, children need great amounts of free time—to make friends, explore, play, get bored, and overcome boredom. They need time for fleeting interests and to immerse themselves deeply in activities that engage their passions. They also need space—to roam, explore, get away, and experience the sense of independence and power that can only occur for children when no adult is watching.

Opportunity to play with the tools of the culture. Much of education has to do with learning to use the culture's tools. The way to master any tool fully is to play with it, that is, to be creative with it, impose your will on it, and make it do what you want it to do. Hunter-gatherer adults recognize this, and so they allow even little children to play with the real tools of their culture, including those that could cause injury, such as fire, knives, and bows and arrows (Gray, 2009; Lancy, this volume). At Sudbury Valley, children play with the tools of our modern culture, including books, woodworking equipment, cooking utensils, and sporting equipment. Not surprisingly, the tool they play with most these days is the computer. Every child who looks around can see that the computer is by far the most valuable tool of our time, so it is no wonder that our children are drawn to computers as strongly as hunter-gatherer children are drawn to bows and arrows and digging sticks. They know in their bones that this is a tool they must master for success in the world in which they are growing.

Access to a variety of caring adults, who are helpers, not judges. In hunter-gatherer bands, the children's world is not segregated off from that of adults. Children see what adults do and incorporate that into their play. They also hear the adults' stories, discussions, and debates, and they learn from what they hear. When they need adult help, they can go to any of the adults in the band (Hewlett et al., 2011). At Sudbury Valley, too, adults and children mingle freely. There is no place in the school where staff members can go but students cannot. Students can listen to any adult discussions, observe whatever the adults are doing, and join if they wish. Students who need help can go to whichever staff member they think can best help them. Unschooling, too, appears to work best when children have regular access to multiple adults beyond just their own parents.

Adults can help best when they are not judges of the children, and adults in hunter-gatherer bands, the Sudbury Valley School, and unschooling families deliberately avoid the role of judge. None of us, regardless of age, can be fully honest with—fully willing to show our vulnerability to and ask for help from—people whose business it is to evaluate us. When we think we are being evaluated, we go into impression-management mode, in which we show off what we know and can do well and avoid what we don't know or can't do well. Evaluation also induces anxiety, which interferes with learning. Impression management and anxiety are antithetical to education, yet they are characteristics that our standard schools are well-designed to promote.

Free age mixing among children and adolescents. Hunter-gatherer children necessarily play in age-mixed groups, as there aren't enough children for age-segregated play (Konner, 1975). At Sudbury Valley, there are enough children that they could play just with others close in age, but they don't. By their own choices, they regularly play across large age ranges. In one quantitative study, we found that a quarter of all of the naturally occurring interactions among students involved students who spanned an age range of more than 4 years (Gray & Feldman, 1997). Daniel Greenberg, one of the founders of Sudbury Valley and the primary exponent of the school's philosophy, has long claimed that free age mixing is the secret to the school's educational success, and my research at the school tends strongly to confirm that view (Gray, 2011b; Gray & Feldman, 2004).

Vygotsky (1978) coined the term *zone of proximal development* to refer to the set of activities that a child cannot do alone or just with others of the same ability, but can do in collaboration with others who are more skilled. He suggested that children develop new skills and understanding largely by collaborating with others within their zones of proximal development. Extending that idea, Jerome Bruner and his colleagues (Sylva, Bruner, & Genova, 1976) introduced the term *scaffolding* as a metaphor for the means by which skilled participants enable novices to engage in a shared activity. The scaffolds consist of the reminders, hints, boosts, and other forms of help that elevate the child to a higher form of activity. In observational research at Sudbury Valley, Jay Feldman and I have documented many examples of such scaffolding (Gray & Feldman, 2004). We saw scaffolding in nearly all instances of play among children who differed considerably in age.

For example, we observed young children playing rather complicated board games and card games with older children. Generally, though there are exceptions, children under about age 9 can't play such games with age-mates. They lose track of rules, their attention wanders, and the game, if it ever gets started, quickly disintegrates. But we often observed children younger than that play such games with older children and adolescents. The older players reminded the younger ones what to do: "Hold your cards up." "Pay attention." "Try to remember what cards have been played." "Think ahead." Paying attention, remembering, and thinking ahead are the elements of intelligence. In keeping the younger players on task in order to keep the game going, the older players were, in effect, scaffolding the younger players' intelligence.

Age mixing benefits the older children as well as the younger ones, as it allows them to practice leading, guiding, and caring. We observed countless instances in which older children went out of their way to help much younger ones (Gray & Feldman, 2004). Teenagers seem to be drawn especially to the very youngest children. Evolutionarily, this makes sense, as they may be practicing for parenthood. We also observed many scenes in which older children explained concepts to younger ones, such as rules of games, rules of the school, or how to search for lost items. Explaining a concept to others is often the best way to stretch and consolidate one's own understanding of it. In an age-mixed environment, all children have the opportunity to learn through teaching.

Children learn from older and younger children even when they are not directly interacting with them. Younger children learn new words and concepts by overhearing the conversations of older ones, and they are inspired to try new activities by watching the older ones. At Sudbury Valley, young students become interested in such activities as reading, tree climbing, cooking, and playing musical instruments because they see older students enjoying these activities. Just as younger children are attracted to the more sophisticated activities of older ones, older children are attracted to the creative and imaginative activities of younger ones. At Sudbury Valley, we have frequently observed teenagers playing with paints, clay, or blocks, or playing make-believe games, often with younger children—activities that most teenagers elsewhere in our culture would have abandoned. Through such play, many become excellent artists, builders, storytellers, and creative thinkers.

Immersion in a stable, moral, democratic community. Hunter-gatherer bands and Sudbury Valley School are, in different ways, democracies. Hunter-gatherers made all group decisions through group discussion aimed at consensus. Whether or not children took part in those discussions, they witnessed them and knew they would play ever-greater roles in such decisions as they grew older. The children were treated with the same respect as the adults, so they grew up respecting others. Sudbury Valley is administered through a formal democratic process, involving discussions at the School Meeting, where each student and staff member has an equal vote. Unschooling families also tend to operate democratically, at least to the degree that they respect and take into account children's opinions and ideas in family decisions. In all of these settings, children are exposed, in everyday life, to the moral principles of the community in which they are immersed. In such an environment, children learn to be responsible not just for themselves but also for others and the community as a whole.

Learning to Read Without Formal Instruction

Assumptions of our standard school system are that learning to read is difficult, children won't learn it on their own, and, therefore, reading must be deliberately taught by professionals who know how to teach it. Indeed, familiarity with the slow, often painful process through which children commonly learn to read in school can lead one to see the origins of these assumptions. Vast amounts of research have gone toward trying to figure out the scientifically best way to teach reading, much of it centering on the debate, sometimes dubbed "the reading wars," between those who believe that most emphasis should be on phonics, right from the beginning, and those who favor a "whole language" approach, in which children start off reading for meaning, with phonics coming later. The debate is centuries old. Noah Webster, who created the first series of books designed to teach reading and spelling in secular schools, was an early warrior for phonics, while Horace Mann, the first secretary of education in any state in the union (Massachusetts), championed whole-language (Lemann, 1997). In recent decades, many controlled experiments have compared the two approaches, and the consensus of most reviewers is that phonics-first is the clear winner (Kim, 2008).

To me, it is no surprise that phonics-first would work better than whole-language in school classrooms. The classroom is all about training, which is the process of getting reluctant organisms to do or learn what the trainer wants them to do or learn. Under these conditions, a focus on the mechanical processes underlying reading, especially the conversion of sights to sounds, works better than attempts to promote reading through meaning, which require that students care about meaning, which require that they be able to follow their own interests, which is generally not possible in classrooms. The common classroom methods of direct instruction and drill can be applied to teaching phonics, but not to whole-language reading.

Experiments on reading are essentially always carried out in classrooms. Classrooms lend themselves to experiments. Researchers there have captive participants, who are used to doing what they are told and to taking tests on demand. It is easy to set up conditions in which students in some classes are taught in one way, those in others are taught in another way, and all are given the same test to see which method worked best. This is the kind of evidence supporting phonics-first instruction. In contrast, research on natural learning, outside of classrooms, requires non-experimental observational and survey methods, which tend to be scorned by hard-nosed researchers. It is useful to remember, however, that many of the greatest advances in science have come from multiple, converging observations. A prime example is Darwin's development of the concept of evolution by natural selection. In what follows I describe some systematic observations concerned with how children learn to read, on their own initiative, outside of classrooms.

Studies of Precocious Readers

Roughly one percent of US children, referred to as *precocious readers*, read fluently by age 4, before they have experienced any reading instruction in preschool, kindergarten, or first grade (Olson, Evans, & Keckler, 2006). Researchers have conducted systematic case studies of precocious readers, through interviews of parents, and have compared them with other children to see if they are unique in any other ways (Forester, 1977; Margrain, 2005; Olson et al., 2006). The results indicate that precocious reading does not depend on an unusually high IQ or any particular personality trait and is not consistently linked to socioeconomic class, but does depend on growing up in a setting where reading is a common and valued activity. Parents of precocious readers most often report that they or an older sibling often read to the child, but did not in any deliberate way attempt to teach reading. In the typical case, the parents at some point discovered, to their surprise, that their child was reading, at least in a preliminary way, and then they fostered that reading by providing appropriate reading materials and answering the child's questions about words. In essentially no cases did they provide anything like the systematic training in either phonics or word recognition that occurs in school.

In sum, precocious readers appear to be children who grow up in a literate home and, for some unknown reason, unlike even their siblings in the same home, develop an intense early interest in reading. Interest, not unusual brain development, is apparently what distinguishes them from others. Because of their strong motivation, they use whatever cues are available to figure out the meanings of printed words and sentences, and, along the way, with or without help, consciously or unconsciously, they infer the underlying phonetic code and use it to read new words. For them, reading for meaning always precedes phonics. In the words of one set of researchers (Olson et al., 2006, p. 215), "The precocious readers were not taught the prerequisite skills of reading such as phoneme-grapheme correspondence or letter-naming skills but, instead, learned to read familiar, meaningful sight vocabulary; the rules of reading were not explicitly taught but apparently inferred over time."

The fact that even a small percentage of children learn to read by the age of four without formal instruction, and the evidence that most of these children are not unusually advanced in other respects, suggests that learning to reading may not be the extraordinarily difficult task that it appears to be in school. I can't resist a small anecdote here. I first became interested in precocious reading when my son began reading independently at age 3. One of the first signs of his reading occurred when we were visiting the town square of a New England village and he came over to me and said, "Why would men fight and die to save an onion?" The question confused me until I realized that he had just read the inscription on a Civil War monument and had pronounced the word "union" phonetically. My son's story fits well with the findings of research on precocious reading. He saw me spending much time reading, as I was a graduate student; his mother read to him frequently; and he often asked us to pronounce words that he saw on signs, cereal boxes, and such; but neither of us had tried to teach him reading. In particular, neither of us had explained the relationship between letters and sounds; he apparently figured that out on his own.

How Sudbury Valley Students and Unschoolers Learn to Read

Would children other than precocious readers learn to read without deliberate instruction, if they were immersed in a literary environment and were allowed to engage themselves with reading whenever they wished? At Sudbury Valley, there are no formal reading classes and no adult-imposed pressures to learn to read. Yet, according to long-time staff members, all of the students, in their own time, learn to read.

In my study of Sudbury Valley graduates, two of the respondents told me, independently, that they had come to the school as teenagers unable to read. Both had been passed along from grade to grade, in public school, with a diagnosis of dyslexia. Both told me that they learned to read within a few months after enrolling at Sudbury Valley. When I asked why they could learn there what they had been unable to learn before, they both told me, in effect, that for the first time in their lives nobody cared if they could read. The pressure was off. Now, in a relaxed way, they could concentrate on reading. They didn't have to hide behind a label. Both went on to college, with no designation of dyslexia or any other learning disability, and performed well there. Staff members at Sudbury Valley claim that they have never seen a case of real dyslexia at the school.

A few years after my study of Sudbury Valley graduates, two of my undergraduate students collected a set of 16 case histories of learning to read at Sudbury Valley. They identified students who had learned to read after enrolling at the school, and then they interviewed those students, the students' parents, and staff members to find out what they could about when each student learned to read, over what length of time the process took, why the student learned, and, to the degree that it was known, how the student learned. More recently, I recruited a group of unschooling parents to address these same questions about their children's learning to read and thereby received 21 more case stories. My informal qualitative analysis of the total set of 37 cases led me to identify what I refer to as *seven principles of learning to read without formal instruction* (Gray, 2010b). Here they are.

There is no critical period for learning to read. For children in standard, graded schools, it is important to learn to read on time, to avoid being labeled as a failure and to move on from "learning to read" in the early grades to "reading to learn" in later grades. But the story is entirely different for Sudbury Valley students and unschoolers. The median age for learning to read (becoming a fluent reader) in the cases I examined was 7, but the range for most was from age 4 to 11, with one outlier not learning until age 14. There was no evidence that those who had learned earlier were better readers, at the time of the study, than those who learned later. One of the unschooling mothers, for example, noted that one of her daughters learned to read at age 5 and another not until age 8, but that the late-reading daughter, then age 14, "reads hundreds of books a year, has written a novel, and has won numerous poetry awards." A general claim of most of these parents was that their children love to read, regardless of the age at which they learned, precisely because they were never forced to read.

Motivated children can go from apparent non-reading to fluent reading very quickly. Some of the children progressed from non-reading to reading in what seemed to be a flash. For example, one unschooling mother wrote: "Our second child … didn't learn to read until he was 7. For years, he could either figure out what he needed to know from pictorial cues, or if stuck, would get his older brother to read to him. I remember the day he started reading. He had asked his older brother to read something to him on the computer and his brother replied, 'I have better things to do than to read to you all day,' and walked away. Within days he was reading quite well." Such step-like progressions in overt reading ability may occur at least partly because earlier, more covert stages of learning are not noticed by observers and may not even be noticed consciously by the learners.

Attempts to push reading can backfire. Three unschooling mothers noted that at some point they became impatient with their child's delayed reading and therefore attempted to teach reading, against their child's will and contrary to their own unschooling philosophy. All three reported that the attempt had a negative effect. For example, one mother wrote, "By age 9 … reading became a regular battle. He resisted it and found it boring and was distracted, so finally I got over my own schooly head … I said that I would never make him read again or even suggest it … Over the next months he quietly went to his room and taught himself to read."

Children learn to read when reading becomes, to them, a means to some valued end or ends. This principle is illustrated by most, if not all, of the reading case histories. For example, one of the Sudbury Valley students reported that he learned to read when he became jealous of other students who were reading and talking about the books they read. He said, "I wanted to join that club." An unschooling mother said that the first evidence she saw of her daughter's reading occurred when the daughter wanted to make brownies and nobody was willing to take the time to read the recipe to her. Another wrote that her daughter, who didn't begin reading until age 11, was able to satisfy her love of stories by being read to, watching movies, and checking out CDs and books on tape from the library. She finally began reading because there was no other way for her to satisfy her interest in video games and magna books, which require reading that nobody was willing to do for her.

Reading, like many other skills, is learned socially, through shared participation. Vygotsky's idea that development occurs when children collaborate with more skilled others applies well to reading. For example, at Sudbury Valley non-readers and readers often play games together, including computer games, which involve written words. To keep the game going, the readers read the words aloud and the non-readers pick them up. Nearly all of the stories from unschooling parents included examples of shared participation in reading. One mother, for example, noted that her daughter, who learned to read at age 5, became interested in reading because of the family's regular Bible reading time. Before she could read she insisted on having her turn at Bible reading, "and she would just make up words as her turn!" The most common examples of shared participation are those in which readers read stories to nonreaders. The readers might be teenagers at Sudbury Valley, or parents or older siblings in unschooling families. Nonreaders look on, at the words as well as the pictures, and pick up some of the words; or they memorize books that have been read to them repeatedly, and then later they pretend to read the books while actually attending to some of the words. Pretend reading gradually becomes real reading.

Some children become interested in writing before reading, and they learn to read as they learn to write. Seven of the unschooling parents said that their child was interested in writing, or typing, either before or simultaneously with their initial interest in reading. For example, one wrote, of her 7-year-old son, "He is an artist and spends hours drawing things, especially stories and inventions. So naturally he wished to make his pictures 'talk' with captions, titles, instructions, and quotations.… There was a lot of 'MOM? How do you spell Superdog wants to go home?' I would spell out the sentence and five minutes later, 'MOM? How do you spell Superdog sees his house?'" This boy learned to read, at least partly, by reading the sentences that he, himself, had written.

There is no predictable course through which children learn to read. Every story of learning to read is unique. In natural learning, there is no right or wrong way. Many of our respondents expressed surprise at the sequence that their child went through in learning to read. Some children learned to read exotic words—like *hippopotamus* or *Tyrannosaurus Rex*—before they learned simpler words. Some, as I said, learned to write before they could read. Some seemed to be learning rapidly and then stopped for a year or more before progressing further. Most seemed to develop a large sight-reading vocabulary before they became aware of phonics, but a few seemed to become fascinated by the sounds of letters early in their learning. The best lesson we can draw from these varied stories is one of humility. We can enjoy watching children learn to read as long as we remember that it isn't our responsibility to push it along or modify the way it occurs. We're just observers and sometimes tools that children use for their own chosen ends.

Learning Math Without Formal Instruction

The question of how to teach mathematics has generated controversy rivaling that of how to teach reading. Numerous revolutions in math teaching have been tried, with little success. The one constant is that, however it has been taught, mathematics courses in our standard schools in the US have generated far more loathing of math than love of it and very little understanding of it. Math phobia is a major problem in colleges and universities, leading many, if not most, students to avoid mathematics courses when possible (Ashcraft, 2002). One expert on math phobia (Burns, 1998) contends, "More than two-thirds of American adults fear and loathe mathematics."

An Experiment in Which Less Teaching Resulted in More Learning

A fascinating, but little known, experiment on mathematics teaching was conducted in the 1930s by Louis Benezet (1935/1936), who at the time was superintendent of schools in Manchester, New Hampshire. In the introduction to his report on the study, he wrote, "For some years I had noted that the effect of the early introduction of arithmetic had been to dull and almost chloroform the child's reasoning facilities." All that drill, he claimed, had divorced the whole realm of numbers and arithmetic, in the children's minds, from common sense, with the result that they could do the calculations as taught to them, but didn't understand what they were doing and couldn't apply the calculations to real-life problems.

As a result of this observation, Benezet proposed an experiment that even in the 1930s seemed outrageous and would probably be impossible today. He asked the principals and teachers in some classrooms, in schools located in the poorest neighborhoods of Manchester, to drop arithmetic from the curriculum of grades 1 through 5. The children in those classrooms would be given no lessons adding, subtracting, multiplying, and dividing until they reached sixth grade. Children in the other classrooms would start such training in 3rd grade. He chose schools in the poorest neighborhoods because he knew that if he tried to do this in wealthier neighborhoods, where the parents were high school or college graduates, the parents would rebel.

As part of the plan, he asked the teachers to devote the time that they would normally spend on arithmetic to class discussions, in which the students would be encouraged to share and talk about any topics that interested them—anything that would lead to genuine, lively communication. This, he thought, would improve their abilities to reason and communicate logically. He also asked the teachers to give their pupils some practice in measuring and counting things, to assure that they would have some practical experience with numbers.

In order to evaluate the experiment, Benezet arranged for a graduate student from Boston University to test the Manchester children at various times in the sixth grade.

The results were remarkable. At the beginning of sixth grade, the children in the experimental classes, who had not been taught any arithmetic, performed much better than those in the traditional classes on story problems that could be solved by common sense and a general understanding of numbers and measurement. They were better not only than were the children in traditional classes in the poor-neighborhood schools, but also better than those in the wealthy-neighborhood schools. Of course, at the beginning of sixth grade, those in the experimental classes performed worse on standard school arithmetic tests, where the problems were set up in the usual school manner and could be solved by applying the rote-learned algorithms. But, by the end of sixth grade, according to Benezet, those in the experimental group had completely caught up on this and were still far ahead on story problems.

In sum, Benezet showed that children who received just 1 year of arithmetic, in sixth grade, performed as well on standard school calculations and much better on story problems than children who had received several years of arithmetic training. Today, whenever we find that instruction doesn't work well we conclude that therefore we need *more* of it and we need to start it *earlier*. Benezet showed that, at least for elementary school arithmetic, the apparent best practice is to teach *less* of it and to start it *later*! I suspect that a major reason for Benezet's results is that children naturally learn much about numbers in everyday life, so by sixth grade they have an understanding of real-world uses of numbers that allows them to learn calculations in ways that make sense and are not just rote.

Learning SAT Math at Sudbury Valley

Here's an observation about minimal math teaching that tops even Benezet's, though it's not the result of an experiment. At Sudbury Valley School, nearly every year, a group of students who plan to apply to competitive colleges approach a particular staff member for help in preparing for the mathematics portion of the SAT. In an interview, this staff member told me that the students who approach him are generally those who have the least previous experience with mathematics and the least long-term interest in it, but who know that they must perform well to be admitted into the college of their choice. Some have never previously studied mathematics in any formal way. Yet, they have acquired an understanding of such concepts as adding, subtracting, multiplying, dividing, fractions, decimals, percentages, and the like through everyday life experiences.

Beginning with their understanding of those concepts, the staff member efficiently leads them through all of the further background math that they need in order to read and understand the math SAT prep books, from which they complete their preparation on their own. Because the students have acquired basic numerical concepts in real life, and because they are motivated to do well on the SAT and are therefore attentive, they don't need to do hundreds of each type of problem. The staff member explains the rationale for solving each type of problem, the students solve a few samples of it, and they've got it. Typically, he meets with the students for 60–90 min per week, for 6–10 weeks, and the students spend another 60–90 min on homework between meetings. That amounts to a range of about 12–30 h, total, of math study for students who may never before have taken a math lesson. The usual result, according to the staff member, is a math SAT score that is good enough for admission to the college the student wants to attend.

How Children Acquire Basic Mathematical Concepts in Play and Life

How do children acquire mathematical concepts without formal teaching? To address that, I conducted a survey of unschooling parents in which I asked them to tell me about any observations they might have made about how their children acquired such concepts. I received responses from 61 parents. In my informal qualitative analysis of the stories, I distinguished between *playful math* and *instrumental math* based on the child's motivation for learning (Gray, 2010a).

Playful math might also be called pure math; it is math for its own sake, motivated by the joy of discovery rather than a need to solve some practical problem. Playful math is to numbers what poetry is to words, or music is to sounds, or art is to visual perception. Four-year-olds are natural poets, musicians, and artists when they play with words, sounds, and colors and shapes; and they are natural mathematicians when they play with numbers. Playful math involves the discovery or production of patterns in numbers, just as poetry, music, and art involve the discovery or production of patterns in words, music, and visual space.

The earliest math play typically entails the discoveries that numbers come in a fixed sequence, that the sequence repeats itself in a regular (base-ten) way, and that once you understand the pattern of repetition there's no end to how high you can count. Many of the unschooling parents wrote of their young children's fascination with counting. For example, one wrote, "When [my 4½-year-old] found out about connect-the-dot drawings, it started to click for him how numbers proceed in order. He started counting aloud all the time… morning, noon and night… He is now at 5068. And when I tell people he is counting to one million, he says, 'No, ten million.' I hope I can survive it!"

In their continued math play, young children often discover the basic concepts of adding, subtracting, multiplying, dividing, and more. Here, for example, is a quotation about a child discovering the meaning of addition: "My younger son [age 5] was building with Legos while I was in another room, and he called out to me with a smile on his face, while jumping on the couch, 'Mom! What is 4 plus 4 plus 4 plus 4?' I said, '16.' He smiled and said, 'What is 8 plus 8?' I said, '16.' He smiled more and said, 'What is 2 plus 2 plus 2… ' and he got exactly the right number of 2's to go to 16. It was clear that he knew the answers to these questions before he asked. These were not memorized from having been taught, but concepts that he figured out from working with Legos and playing around with the numbers in his head and on his fingers. And he was thrilled to manipulate the numbers, all on his own. To him, it was a game."

Here's another quote, about a child discovering multiplication: "When he was 3 or 4, one day he went into our living room where we have a large window and noticed that there were four rows of seven panes. 'So,' he said, 'if I count to seven four times then it's 28.' I don't think we'd ever talked about multiplication at that point, but he'd essentially figured out how it worked and how to do it on his own from looking at the arrangement of squares. He began experimenting with it on his own, [putting] buttons in rows arrayed like the panes of glass. He still had to count up most of his answers because he hadn't committed them to memory, but he understood how it worked and what it meant."

And here's a story about a child discovering the concept of a square number: "One evening, at age 7, he had brought home a pack of Skittles. Like many kids, he likes to put them on a plate, sort them by color and play with them. On this day he had nine left and arranged them into three rows of three. He said, 'you know, the number nine is a square.' I told him that's what it's called, a square number, and that he could also make a square with four rows of four. He ended up making bigger and bigger squares… When it became impractical to keep making squares with skittles (too big), or perhaps because he was just getting bored with doing that, he used a calculator to find more square numbers and wrote them down."

Instrumental math is math used as an instrument (tool) for some practical purpose. Most of the math stories sent to me included at least some account of instrumental math. One unschooling mother listed a set of practical contexts in which her children learned to calculate: "All five kids learned to make measurements and read recipes, how to divide and how to double or triple a recipe's ingredients. They read maps and figured out the mileage. They all played various card games and board games that use numbers and/or reasoning skills—Uno, Skip-bo, Pinochle, etc. As they became involved in local sports, they learned how to keep the scorebook and figure out averages. One son learned how to make a spreadsheet to keep track of his team's batting averages. They all kept their own ledgers in their bank savings accounts."

Many of the stories that I classified as instrumental math were stories about play, in which the math was used as a tool (e.g., to keep score) and was not the primary subject of play. Here's a quotation from a mother whose children attended a school modeled after Sudbury Valley: "My kids have spent a lot of time playing online games. Real games, not those stupid educational ones. My 11-year-old son plays MapleStory and has figured out complex mathematical structures to play the game. 'If I want to buy this helmet for this amount, how many hours do I have to play making this amount per hour? If I sell this item in the market and the fee to sell is a certain percentage, how much will I have left after the fee? If I have this percentage of experience and I make a certain percentage per hour of experience, how many hours will it take to level up?' … Plus in the game you work with three different currencies and have to be able to translate back and forth among them regularly. Put these problems isolated from the game context to a bunch of 5th graders in 'real' school and ask them to show their work and see what you get."

Stories such as these explain well why unschoolers and Sudbury students have little difficulty learning the formal math they need for SAT or ACT college admissions tests, when the time and desire comes for them to learn it. They are growing up in a world of numbers. They naturally play with numbers and use numbers in many aspects of their lives, and they thereby acquire basic mathematical concepts in contexts that make them real. Because this is all part of natural life, not forced and not judged, they learn math joyfully. They do not learn to fear and loathe it as so often happens with children in standard schools.

Conclusion

In an influential article entitled "An Evolutionarily Informed Education Science," Geary (2008, p. 187) concluded, "If our goal is universal education that encompasses a variety of evolutionarily novel academic domains (e.g., mathematics) and abilities (e.g., phonetic decoding as related to reading), then we cannot assume that an inherent curiosity or motivation to learn will be sufficient for most children and adolescents." My own conclusion, based on research examining education among children who do not attend conventional schools, is quite different. When children grow up in a literate and numerate environment, in which they regularly experience the written word and numbers and interact with people who read and use numbers, they indeed do learn to read, write, and calculate through their inherent curiosity and motivation to learn. Of course, those who choose to pursue, for example, mathematics at a higher level—beyond that needed for everyday life—may well do so by seeking formal instruction. There is nothing wrong with instruction, as long as it is self-chosen and not coerced.

One of the great strengths of an evolutionary perspective, at least in principle, is that it expands our frame of reference beyond the parochial here-and-now. It leads us to ask questions about human possibilities, not just about what happens given the constraints most people experience today. In our society today, it is rare for children not to attend schools where their natural ways of learning are deliberately shut off and, instead, they experience forced academic training according to a curriculum they did not choose. My research shows that, when we don't send children to conventional schools, but allow their curiosity and playfulness to continue to bloom, in an environment rich in self-educational opportunities, children learn to read, write, and perform numerical calculations without deliberate training, in their own ways and in their own time. They also discover their interests and passions, develop specialized skills in those realms, and often go on to successful careers that make use of those skills. The powerful educational instincts that evolved to meet the needs of our pre-agricultural ancestors still function beautifully today, if we provide young people with the conditions that allow those instincts to operate optimally.

References

Ashcraft, M. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*, 181–185.

Benezet, L. (1936). The teaching of arithmetic: The story of an experiment. *Journal of the National Education Association in three parts, 24*(8), 241–244. 24(9), 301–303; 25(1), 7–8 (Original work published 1935).

Bock, J. (2005). What makes a competent adult forager? In B. S. Hewlett & M. E. Lamb (Eds.), *Hunter-gatherer childhoods: Evolutionary, developmental, and cultural perspectives* (pp. 109–128). New Brunswick, NJ: Transaction.

Bock, J., & Johnson, S. (2004). Subsistence ecology and play among the Okavango Delta peoples of Botswana. *Human Nature, 15*, 63–81.

Boehm, C. (1999). *Hierarchy in the forest: The evolution of egalitarian behavior*. Cambridge, MA: Harvard University Press.

Burns, M. (1998). *Math: Facing an American phobia*. Sausalito, CA: Math Solutions.

Carlsson-Paige, N., Almon, J., & McLaughlin, G. (2015). *Reading instruction in kindergarten: Little to gain and much to lose*. Boston, MA: Defending the Early Years. Retrieved from https://www.sarahlawrence.edu/cdi/media/pdf/ReadinginKindergartenreport.pdf.

Darling-Hammond, L., & Snyder, J. (1992). Curriculum studies and the traditions of inquiry: The scientific tradition. In P. W. Jackson (Ed.), *Handbook of research on curriculum* (pp. 41–78). New York, NY: Macmillan.

Draper, P. (1976). Social and economic constraints on child life among the !Kung. In R. B. Lee & I. DeVore (Eds.), *Kalahari hunter-gatherers: Studies of the !Kung San and their neighbors* (pp. 199–217). Cambridge, MA: Harvard University Press.

Forester, A. (1977). What teachers can learn from "natural readers". *Reading Teacher, 31*, 160–166.

Galinsky, E., Bond, J., & Friedman, D. (1993). *The changing workforce: Highlights of the national study*. New York, NY: Families and Work Institute.

Geary, D. (2008). An evolutionarily informed education science. *Educational Psychologist, 43*, 179–195.

Goldbeck, S. (2001). Instructional models for early childhood. In S. Goldbeck (Ed.), *Psychological perspectives on early childhood education. Reframing dilemmas in research and practice* (pp. 3–31). Mahwah, NJ: Erlbaum.

Gosso, Y., Otta, E., de Lima, M., Ribeiro, F., & Bussab, V. (2005). Play in hunter-gatherer societies. In A. D. Pellegrini & P. K. Smith (Eds.), *The nature of play: Great apes and humans* (pp. 213–253). New York, NY: Guilford.

Gray, P. (2009). Play as the foundation for hunter-gatherer social existence. *American Journal of Play, 1*, 476–522.

Gray, P. (2010a). Kids learn math easily when they control their own learning. Freedom to Learn blog, Psychology Today. Retrieved April 15, 2010 from http://www.psychologytoday.com/blog/freedom-learn

Gray, P. (2010b). Unschoolers' accounts of how children learn to read. Freedom to Learn blog, Psychology Today. Retrieved February 24, 2010 from http://www.psychologytoday.com/blog/freedom-learn

Gray, P. (2011a). The decline of play and the rise of psychopathology in childhood and adolescence. *American Journal of Play, 3*, 443–463.

Gray, P. (2011b). The special value of age-mixed play. *American Journal of Play, 3*, 500–522.

Gray, P. (2013). *Free to learn: Why releasing the instinct to play will make our children happier, more self-reliant, and better students for life*. New York, NY: Basic Books.

Gray, P. (2014). The play theory of hunter-gatherer egalitarianism. In D. Narvaez, K. Valentino, A. Fuentes, J. McKenna, & P. Gray (Eds.), *Ancestral landscapes in human evolution: culture, childrearing and social wellbeing* (pp. 190–213). New York, NY: Oxford University Press.

Gray, P., & Chanoff, D. (1986). Democratic schooling: What happens to young people who have charge of their own education? *American Journal of Education, 94*, 182–213.

Gray, P., & Feldman, J. (1997). Patterns of age mixing and gender mixing among children and adolescents at an ungraded democratic school. *Merrill-Palmer Quarterly, 43*, 67–86.

Gray, P., & Feldman, J. (2004). Playing in the zone of proximal development: Qualities of self-directed age mixing between adolescents and young children at a democratic school. *American Journal of Education, 110*, 108–145.

Gray, P., & Riley, G. (2013). The challenges and benefits of unschooling according to 232 families who have chosen that route. *Journal of Unschooling and Alternative Learning, 7*, 1–27.

Gray, P., & Riley, G. (2015). Grown unschoolers' evaluations of their unschooling experiences: Report I on a survey of 75 unschooled adults. *Other Education, 4 (2)*, 8–32.

Greenberg, D., & Sadofsky, M. (1992). *Legacy of trust: Life after the Sudbury Valley School experience*. Framingham, MA: Sudbury Valley School Press.

Greenberg, D., Sadofsky, M., & Lempka, J. (2005). *The pursuit of happiness: The lives of Sudbury Valley alumni*. Framingham, MA: Sudbury Valley School Press.

Hewlett, B., Fouts, H., Boyette, A., & Hewlett, B. L. (2011). Social learning among Congo Basin hunter-gatherers. *Philosophical Transactions of the Royal Society B, 366*, 1168–1178.

Ingold, T. (1999). On the social relations of the hunter-gatherer band. In R. B. Lee & R. H. Daly (Eds.), *The Cambridge encyclopedia of hunters and gatherers* (pp. 399–410). Cambridge, England: Cambridge University Press.

Kaplan, H., Hill, K., Lancaster, J., & Hurtado, A. (2000). A theory of human life history evolution: Diet, intelligence, and longevity. *Evolutionary Anthropology, 9*, 156–185.

Katz, L. G. (2015). *Lively minds: Distinctions between academic versus intellectual goals for young children*. Boston, MA: Defending the Early Years. Retrieved from https://deyproject.files.wordpress.com/2015/04/dey-lively-minds-4-8-15.pdf.

Kim, J. (2008). Research and the reading wars. In F. M. Hess (Ed.), *When research matters: How scholarship influences education policy* (pp. 89–111). Cambridge, MA: Harvard Education Press.

Kim, K. (2011). The creativity crisis: The decrease in creative thinking scores on the Torrance Tests of Creative Thinking. *Creativity Research Journal, 23*, 285–295.

Konner, M. (1975). Relations among infants and juveniles in comparative perspective. In M. Lewis & L. A. Rosenblum (Eds.), *The origins of behavior* (Friendship and peer relations, Vol. 4, pp. 99–129). New York, NY: Wiley.

Lee, R. (1988). Reflections on primitive communism. In T. Ingold, D. Riches, & J. Woodburn (Eds.), *Hunters and gatherers* (Vol. 1, pp. 252–268). Oxford, England: Berg.

Lee, R., & Daly, R. (1999). *The Cambridge encyclopedia of hunters and gatherers*. Cambridge, England: Cambridge University Press.

Lemann, N. (1997). The reading wars. *The Atlantic Monthly, 280*(5), 128–134.

Liebenberg, L. (1990). *The art of tracking: The origin of science*. Claremont, South Africa: Philip.

Lynch, M. (2015). More play, please: The perspective of kindergarten teachers on play in the classroom. *American Journal of Play, 7*, 347–370.

Marcon, R. (2002). Moving up the grades: Relationship between preschool model and later school success. *Early Childhood Research & Practice, 4*, 1–20.

Margrain, V. (2005). Precocious readers: Case studies of spontaneous learning, self-regulation and social support in the early years. Doctoral dissertation, Victoria University of Wellington, School of Education, New Zealand

Melton, J. (1988). *Absolutism and the eighteenth-century origins of compulsory schooling in Prussia and Austria*. Cambridge, England: Cambridge University Press.

Newsom, C., Archer, R., Trumbetta, S., & Gottesman, I. (2003). Changes in adolescent response patterns on the MMPI/MMPI-A across four decades. *Journal of Personality Assessment, 81*, 74–84.

Olson, L., Evans, J., & Keckler, W. (2006). Precocious readers: Past, present, and future. *Journal for the Education of the Gifted, 30*, 205–235.

Riley, G., & Gray, P. (2015). Grown unschoolers' experiences with higher education and employment: Report II on a survey of 75 unschooled adults. *Other Education, 4(2)*, 33–53.

Schweinhart, L., & Weikart, D. (1997). The high/scope preschool curriculum comparison study through age 23. *Early Childhood Research Quarterly, 12*, 117–143.
Shostak, M. (1981). *Nisa: The life and words of a !Kung woman*. Cambridge, MA: Harvard University Press.
Sylva, K., Bruner, J., & Genova, P. (1976). The role of play in the problem solving of children 3–5 years old. In J. Bruner, A. Jolly, & K. Sylva (Eds.), *Play* (pp. 244–257). New York, NY: Basic Books.
Tooby, J., & Cosmides, L. (1992). The psychological foundations of culture. In J. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 19–136). Oxford, England: Oxford University Press.
Turnbull, C. (1961). *The forest people*. New York, NY: Simon & Schuster.
Twenge, J., Gentile, B., DeWall, C., Ma, D., Lacefield, K., & Schurtz, D. (2010). Birth cohort increase in psychopathology among young Americans, 1938–2007: A cross-temporal meta-analysis of the MMPI. *Clinical Psychology Review, 30*, 145–154.
Twenge, J., Zhang, L., & Im, C. (2004). It's beyond my control: A cross-temporal meta-analysis of increasing externality in locus of control, 1960–2002. *Personality and Social Psychology Review, 8*, 308–319.
Vygotsky, L. (1962). In E. Hoffman & G. Vaker (Eds. & Trans.), *Thought and language*. Cambridge, MA: MIT Press.
Vygotsky, L. (1978). Interaction between learning and development. In M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.), *Mind and society: The development of higher psychological processes* (pp. 79–91). Cambridge, MA: Harvard University Press.
Wannenburgh, A. (1979). *The bushmen*. New York, NY: Mayflower Books.

Chapter 4
Object Use in Childhood: Development and Possible Functions

Anthony D. Pellegrini

The various ways that objects are used by children have been subjected to a considerable amount of theoretical and empirical attention across a number of different disciplines, from anthropology (e.g., Bock, 2005; Boyd & Richerson, 1985), through developmental psychology, (e.g., Bjorklund & Gardiner, 2011; Pellegrini & Hou, 2011; Piaget, 1952; Power, 2000), to zoology (Amant & Horton, 2003; Beck, 1980). Perhaps most centrally, Piaget (1952, 1970) proposed that children's cognitive development is rooted in their sensorimotor interactions with objects. However, much of what developmental psychologists know about children's object use, especially during infancy and early childhood, is often subsumed under the misleading labels "object play" and "construction". These labels have been used so loosely that it is very difficult to chart ontogenetic or functional courses for the diverse ways in which children use objects. A basic premise of this chapter is that behavior categories should be induced through empirical observation, not pre-selected and untested assumptions. From this position, hypothesis testing (i.e., deduction) should proceed only after empirically identified categories, based on direct observations (i.e., induction) have been derived (Blurton Jones, 1972; Tinbergen, 1963).

Further, the importance of social interaction around object uses in early cognitive development, especially in Piaget's theory, has been ignored. This view persisted even though there were numerous observations, especially involving young children, that interactions with objects take place in a social contexts, and that children spend considerable time observing others using objects (see Haight & Miller, 1992; Pellegrini & Hou, 2011; Tomasello, 1999; Tomasello & Call, 1997). Unfortunately, however, the extant child developmental literature on object uses pays only limited attention to the ways that different types of object are used in a variety of social as well as nonsocial contexts (though see Flynn & Whiten, 2008 and Pellegrini & Hou, 2011).

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My goal is to first describe the different forms of object use (i.e., exploration, construction, play, tool use, and toolmaking) for boys and girls in childhood. This is an important exercise given the variety of labels used to describe the different ways that children interact with objects. Correspondingly, I will establish time budgets for each type of object uses and then make functional inferences about each and the social context in which each is embedded.

Different Forms of Object Use in Childhood

Perhaps most commonly, in the child development literature, where efforts have been made to address the different types of object use and play exhibited by children, researchers have often conflated object play with different forms of objects use. Specifically, much of the study of children's interactions with objects during childhood has been influenced by Smilansky's (1968) rather inaccurate (Smith, Takhvar, Gore, & Volstedt, 1986) adaptation of Piaget's (1962) theory of play and the ways that she categorized behaviors directed at objects. In her influential monograph, she included "constructive play" as a category to account for children's interactions with objects. Constructive play for Smilansky was an ends-oriented activity with objects where something was built. Piaget, in contrast, did not consider construction to be play because of its ends, not means, orientation. I discuss each form of object use, in the order in which they occur in ontogeny.

Exploration

Exploration is the behavior exhibited when individuals first encounter unfamiliar objects; they manipulate or explore their properties and attributes (Hutt, 1966; West, 1977). Through exploration, children find out that objects, for example, are flat or rounded, long or short, used for drinking or for covering one's head. While often conflated with play with objects (defined below), they differ behaviorally and ontogenetically (Hutt, 1966; McCall, 1974; West, 1977). Specifically, exploration, relative to play, is characterized by elevated heart rate, low distractibility, and negative/flat affect. By contrast, children playing with objects have lower heart rates, are highly distractible, and display positive affect (Hutt, 1966).

Further, exploration precedes other forms of object use, including play in human ontogeny (Belsky & Most, 1981; McCall, 1974), as well in other animals (e.g., West, 1977). In a study of children from 7.5 to 21 months of age, Belsky and most found that exploration of toys was the predominant activity of the youngest children (7.5–10.5 months), with no instances of pretend play with objects. From around 9 to 10.5 months, children named objects as they manipulated them. At 12 months, pretend play with objects appeared, co-occurring with exploration and naming of the objects, and then pretend displaced exploration. And, like Hutt (1966) and West (1977), Belsky and most noted that exploration of an object precedes play with that object. These trends are consistent with a view that the processes involved in exploring are necessary for object play.

By the time children are of preschool age, exploration accounts for a relatively small portion of their object time budgets, between 2 and 15 % of children's totally observed behavior (Pellegrini & Gustafson, 2005; Pellegrini & Hou, 2011). In the case of the high end of the range, exploration spikes when children are exposed to novel objects, such as when they return to their preschool classrooms after a holiday. Given the relative infrequency of exploration during the preschool years, there are few documented age differences for directly observed exploration (Pellegrini & Gustafson, 2005), though differences do appear when the construct is widened to include such behaviors as asking questions and other elicited behaviors (Henderson & Moore, 1979).

There are reported sex differences in exploration, where boys exhibit more than girls (Bornstein, Haynes, O'Reilly, & Painter, 1996; Pellegrini & Hou, 2011), though experimental study of infants' and preschoolers' exploration does not consistently test for sex differences (e.g., Belsky & Most, 1981; Hughes, 1978; Ross, Rheingold, & Eckerman, 1972).

Exploration of objects occurs in both social and solitary contexts. Piaget (1967) described how solitary infants, especially, as well as young children explored objects, yet children's exploration can be facilitated by adults, such as parental presence (Rheingold & Eckerman, 1970) and involvement (Belsky, Goode, & Most, 1980) (but see Lancy, this volume). Adult facilitation continues through early childhood (~5.5 years of age), where adult encouragement significantly increases exploration (Henderson, 1984). However, we find that when children explore objects in preschool classrooms, they tend to do so in solitary contexts (Pellegrini, unpublished data). Correspondingly, preschool children's exploration does not attract their peers' attention (Pellegrini & Hou, 2011).

In short, exploration tends to be a solitary behavior, though its frequency and level of sophistication can be increased by adult support. It may be that children are aroused when exploring objects and may not seek out peers until they have thoroughly explored the object and it is no longer novel. Further, and more central to the purpose of this paper, exploration is an empirically verifiable construct that is distinct from play (Belsky et al., 1980; Hutt, 1966; McCall, 1974; Weisler & McCall, 1976), a construct with which it is often confounded with play.

Play with Objects

Play, generally and following the definition advanced by Burghardt (2005), should be defined categorically, not continuously, and must meet all of the following criteria: It must be voluntary, observed in a "relaxed field," not completely functional in the immediately observed context, and have elements that are exaggerated, segmented, and non-sequential in relation to the functional behavior (see also Bjorklund &

Beer, this volume). A relaxed field is one in which the individual, typically a juvenile, is well-provisioned, safe, and healthy. Further, the child voluntarily chooses to engage in an activity that is not completely functional. The nature and sequence of these behaviors should not resemble those in a functional context. For example, a child could approach a peer with a "play face," take an exaggerated swipe at his peer, fall to the ground, and then switch roles, so his peers can hit at him. Distilling Burghardt's definition, I suggest that the most important criteria are the emphases on means over ends and incompletely functional behavior in the immediate context because they are probably antecedents, and sufficient conditions, for children generating novel behaviors associated with objects. That is, by not being concerned with the usefulness of behavior, individuals are free to experiment with its form and place in behavioral sequences (Bateson, 2005; Bruner, 1972; Fagen, 1981). The resulting behavioral and cognitive flexibility characteristic of different forms of play, such as exaggerated, non-sequential, and segmented behavioral routines, is crucial to the development of what Bruner (1972) and West-Eberhard (2003) labeled behavioral "modules"; modules as used here, unlike its use among "evolutionary psychologists," are learned.

This definition of play differs markedly from that proposed by Krasnor and Pepler (1980) to the extent that they advocate a continuous categorization, as more or less playful, depending on the number of criteria met: the more criteria met, the more playful the behavior, implicitly assuming that all attributes are equal. From this position, a behavior meeting four criteria (such as free choice, stress-free, attention to means, and minimal adult intrusion) should be more playful than a behavior meeting only three. Under this rubric, a child taking a nap could qualify as a four-criteria play behavior, whereas a child using a pencil as a rocket ship might qualify as a three-criteria behavior, and thus less playful. However, most observers would consider the second, not the first, example to be play.

From my definition, object play typically involves pretending with an object. Using objects in pretend initially entails that children are simulating someone else's use of those objects. That is, children use objects in ways similar to the ways in which others use them, but not in their functional contexts; for example, pretending to drink tea from an empty cup. With experience, children learn to have other, more abstract, objects represent other objects, for example using a broom stick to represent a horse on which to ride. Correspondingly, children's play with objects is typified by them using objects in novel and varied ways (Pellegrini & Hou, 2011). For example, they can have a pencil representing a hammer. This begins in the context of parent–child interactions and then to interaction with peers (Lillard, 2006; Tomasello, 1999). Indeed, of all the ways in which children use objects, play with objects is most highly related to creative uses of objects (Pellegrini & Hou, 2011).

Play with objects, like other forms of play, follows an inverted-U function (Fagen, 1982; Pellegrini, 2009); it first appears at around 12 months of age (Belsky & Most, 1981), increases through the preschool years, and then declines (Fein, 1981, for a review). Establishing an accurate time budget for play with objects during childhood is difficult because object play has typically been conflated with other forms of object use. In those cases where object play was clearly differentiated from other forms of object use, it begins at around 1 year (Belsky & Most, 1981) and increases among

3- to 5-year-olds in American and UK preschool settings to 18–30 % of children's time budgets (McGrew, 1972; Pellegrini & Gustafson, 2005; Pellegrini & Hou, 2001).

Given the clear differences in antecedents, ontogeny, and function between play and exploration, it is confusing when the terms are used inter-changeably and in combination (i.e., "exploratory play"), even within the same research articles, to describe exploration as defined in this chapter (e.g., Baldwin, Markman, & Melartin, 1993; Schulz & Bonawitz, 2007). A similar problem exists with the inexact use of "play" to describe virtually all forms of social interaction between young children (e.g., Fabes, Martin, Hanish, Anders, & Madden-Derdich, 2003; Parten, 1932): If young children are doing it, it is often labeled as play. Such loose word usage has, and will continue, to confuse the meaning of each construct and further muddy the play and object use literatures. Correspondingly, it is nearly impossible for researchers to document time budgets of different types of behavior, including object play and exploration, during childhood, when terms are not used accurately and consistently. Perhaps most basically, when behavioral categories are not based on empirical fact, as exist between play and exploration, our theories and subsequent hypotheses will remain on the borders of science which, from my view, should involve both induction (to empirically form categories) and deduction (to test hypotheses) (Blurton Jones, 1972; Russell, 1931/1959; Smith, 2011; Tinbergen, 1963).

Sex differences in object play are equivocal and not consistent with the more general literature on pretend play where girls, relative to boys, exhibit more and more sophisticated pretense (see Pellegrini, 2009, and Rubin, Fein, & Vandenberg, 1983, for reviews). In an observational study of 92 preschoolers' object use (i.e., exploration, construction, object play, and tool use) across 1 year using growth curve modeling, object play did no differ by sex (Pellegrini & Hou, 2011). It may be that in this study girls' general facility with pretense was diluted by their interactions across a wider variety of objects (beyond replicate toys), while boys' play with some forms of objects (such as using a rake for a pretend gun) increased significantly, thus attenuating sex differences. For example, boys, more than girls, pretend that objects are weapons (Pellegrini & Gustafson, 2005), while girls more frequently use replica objects (e.g., dolls, dishes, pots) in more domestically themed roles (Pellegrini, 2009).

Object play, like pretend play more generally, becomes increasingly social with age (Rubin et al., 1983). For example, less than 2 % of preschool and kindergarten children's object play is solitary, while 12 % and 28 % of preschoolers' and kindergarteners' object play, respectively, is social (Rubin, Watson, & Jambor, 1978). Thus, not only does object play increase across childhood, but it also becomes increasingly social.

Construction

As noted above, much of what we know about construction is subsumed under the Smilansky-inspired label of "constructive play," which, according to Smilansky, has the child learning the "various uses of play materials" and the "building" of something (1968, p. 6). However, construction, according to Piaget (1962) and others (e.g., Smith et al., 1986), is not play, following many definitions. For Piaget, on whom Smilansky based her work, construction is more accommodative and concerned with the end product of activity—the construction *per se*—while play is more assimilative and concerned with the activity, or means, than with the end and consequently is not play *per se* (Piaget, 1962; Rubin et al., 1983; Smith et al., 1986; though see Burghardt, 2005). In further support of the claim that construction is not a form of play, it does not follow the typical inverted-U age-related trajectory of other forms of play (Smith et al., 1986)

Smilansky's (1968) categories of "play" were expanded into a heuristic for describing the social (solitary, parallel, and interactive) and cognitive (functional, constructive, and dramatic/pretense) dimensions of play by Rubin and colleagues (Rubin, Maioni, & Hornung, 1976; Rubin et al., 1978). In this scheme, Rubin and colleagues considered "constructive play" as the manipulation of objects to create something. This scheme has been used to generate massive amounts of descriptive data on the ways that young children use objects (summarized in Rubin et al., 1983). Rubin and colleagues (Rubin et al., 1983) rightfully questioned the validity of "constructive play" as a form of play because of its incongruity with Piagetian theory: "Constructive play might be viewed as belonging to some other coding schemes" (p. 727). Despite these qualifications, little effort has been made to differentiate construction from play with objects and other forms of object use.

The above definition given by Smilansky (1968), and subsequently revised by Rubin (Rubin et al., 1976; Rubin et al., 1978), includes a diverse constellation of goal-directed and non-goal-directed uses of objects. For example, using blocks to build steps might be considered constructive or pretend play. The same act, however, might also actually be considered "tool use" if a child uses the steps to enhance his or her reach (Amant & Horton, 2008). Thus, the descriptive data generated by the Smilansky model provide very general descriptions of children's object use. However, to the extent that the category "constructive play" is too general, it limits our knowledge of the role of "object play" and construction in children's development.

Taking "constructive play" as defined by Rubin and colleagues, it accounts for between 40 % (Rubin et al., 1976) and 51 % (Rubin et al., 1976; Rubin et al., 1978) of all observed behavior subsumed under the Smilansky-Parten play matrix. When construction is defined in a manner more consistent with Piaget (1962), Pellegrini and colleagues found that construction accounted for between 15 % (Pellegrini & Gustafson, 2005) and 17 % (Pellegrini & Hou, 2011) of behavior. The very different figures derived from the Rubin and Pellegrini studies may reflect the fact that what Rubin and colleagues coded as constructive play probably included other forms of object use, such as tool use and perhaps solitary object play.

In terms of sex differences for "constructive play", defined according to Smilansky (1968), it is reported that girls engage in it more than males (Johnson, Ershler, & Bell, 1980; Johnson & Ershler, 1981; Rubin et al., 1976; Rubin et al., 1978). However, boys' constructions tend to be more complex than girls' (Erickson, 1977; see Rubin et al., 1983, for a summary), and boys, relative to girls, tend to be more facile with objects as indicated by their performance on the block-design portion of the Wechsler Preschool and Primary Scale of Intelligence (Caldera, Huston, & O'Brien, 1989). Data from two naturalistic studies of preschoolers' object use using the differentiated categories proffered here help to clarify this confusion. Beginning with an observational study with a limited sample size, girls, relative to boys, spend more time in construction but boys spend more time than girls in object play (Pellegrini & Gustafson, 2005). In the other, larger observational study using growth curve modeling, there were no moderating effects of sex on construction (Pellegrini & Hou, 2011).

Tool Use and Toolmaking

A common definition of tool use has individuals using objects not attached to the environment or being part of individuals' bodies, in the service of a goal, such as getting food and includes both using and making tools (Hansell & Ruxton, 2007; Shumaker, Walkup, & Beck, 2011). For example, using a finger nail to twist a screw would not be an example of tool use but using a screw driver would; shaping the tip of a stick to do so would be an example of toolmaking. Thus, tool use is a convergent activity, involving children learning to use a tool according to cultural conventions, such as using a fork. Making tools, on the other hand, is a more divergent and creative act where individuals use an object to solve a problem for which it might not have been designed, for example, bending a coat hanger to retrieve an object in a remote location.

Using objects as tools, compared to making tools, appears relatively early in human ontogeny (Mounoud, 1996), with skills increasing from infancy through childhood (e.g., Connolly & Dalgleigh, 1989; Connolly & Elliott, 1972; Cutting, Apperly, & Beck, 2011). Further, most studies of tool use in childhood showing increases in facility with age are drawn almost solely from performance on experimental tasks (e.g., Bates, Carlson-Luden, & Bretherton, 1980; Flynn & Whiten, 2008). Developmental descriptions of children's use of objects in children's everyday worlds, encompassing exploration, play, construction, and tool use, are sorely lacking (Power, 2000), thus time budget information is spotty. There is a special paucity of studies of children making tools and innovation in making tools (Cutting et al., 2011). Three studies, two with university laboratory preschoolers and one with African pastoral children, however, provide a relatively consistent picture. First, regarding the university preschool samples, Pellegrini and colleagues (Pellegrini & Gustafson, 2005; Pellegrini & Hou, 2011) observed preschool children's tool use and toolmaking in their classrooms. Children spent between 19 % (Pellegrini & Hou, 2011) and 23 % (Pellegrini & Gustafson, 2005) of their total observed time in tool use. Only in the later study (Pellegrini & Hou, 2011), however, was the sample large enough to calculate a growth curve model, which showed a significant increase in tool use across time. Similarly, Bock's (1999, 2005) pastoral sample of Zambian preschool age children spent a similar amount of time in object use, 17 %, similar to the figures in the Pellegrini studies.

Unlike using tools, toolmaking is still developing through the early and middle childhood periods, indicative of the relatively complex dexterity and cognition needed (Cutting et al., 2011; Mounoud, 1996; Tomasello & Call, 1997; van Schaik, Deaner, & Merrill, 1999). Making tools is cognitively complex to the extent that individuals must identify a goal, identify affordances in objects associated with the goal, and consider the means of using tools to meet that goal. Further, the ability to make tools requires a level of behavioral flexibility, such that rather conventional objects, such as sticks or pipe cleaners, are redesigned to serve different ends, relative to what they were designed for (Cutting et al., 2011). However, when even very young children (e.g., 30 months of age) observed someone else make a tool, they were able to imitate them (Barr & Wyss, 2008; Hayne, Herbert, & Simcock, 2003). Thus, even very young children have the cognitive capacity and dexterity to make tools demonstrated by a model. However, when left on their own, they do not make tools to solve problems successfully until well into middle childhood (Cutting et al., 2011; Mounoud, 1996).

Adults support children's tool use and toolmaking. Specifically, infants' and young children's interest in objects is stimulated when they are interacting with or observing adults using objects (Lancy, this volume). When adults handle objects, for example, children in turn become interested in those objects; they may pick up the objects, examine them, and learn about them (i.e., stimulus enhancement) (McGuigan & Whiten, 2009; Tomasello, 1999; Tomasello & Call, 1997). Relatedly, in emulation, infants or young children observe adults handling and using objects to solve a problem, such as using a coat hanger to retrieve a toy. They thereby recognize that the hanger can be used to solve the problem and they use it, though not as demonstrated by the model (i.e., imitation), to solve the problem, something that they might not have discovered on their own (Tomasello, 1999; Tomasello & Call, 1997). The ease with which children emulate and imitate adults using tools, relative to their independent performance, is testament to the importance of the social context of learning to use tools. However, when children's tool use is observed in their preschool classrooms, it occurs in both social and solitary contexts and does not attract a significant amount of their peers' attention (Pellegrini & Hou, 2011).

Sex differences in tool use are equivocal, perhaps due to the different ways in which it is defined and contexts in which it is assessed. Specifically, studies of preschool children's tool use are either naturalistic or experimental, and in the experimental cases, often involve toolmaking inspired by the Köhler-type (1925) lure retrieval tasks. In some of this work (i.e., tool use tasks), preschool children are presented with an array of objects, some of which are tools that can solve the problem (retrieve the lure). In tool choice experiments, children as young as 2 years of age choose the optimal objects to retrieve the lure (Brown, 1990; Chen & Siegler, 2000). In these cases boys seem better at this than girls, though with minimal help the sex differences are attenuated (e.g., Chen & Siegler, 2000; Gredlein & Bjorklund, 2005).

In terms of sex differences in tool use in naturalistic studies, neither of the Pellegrini and colleagues' (Pellegrini & Gustafson, 2005; Pellegrini & Hou, 2011) studies nor the Bock (2005) study found significant sex differences in time spent in total tool use. However, sex differences were observed when the specific tools used were disaggregated. Among pastoral children, girls spent more time than boys "play pounding", which involves using mortar-like objects, such as sticks and reeds to pound grain-like substances (Bock, 2005). Girls also moved from play pounding to actual tool use, helping adults to pound grain, at an earlier age than boys moved from playful tool use to actual tool use. Boys spent more time than girls in throwing spear-like sticks at targets, and boys were older when they moved from such playful tool use to real hunting. In the case of foraging children (see Gosso et al., 2005), boys (in the Brazilian Amazon) more than girls are frequently seen using bows and arrows and sling-shots. Girls, in contrast, more frequently than boys make tools associated with gathering. For example, making baskets out of palm leaves is another common form of play among the Parakanã girls from Pará State (see Gosso et al., 2005). Indeed, this activity was observed exclusively among girls. So the sex differences observed in some of the experimental studies of children's tool use may be specific to those tasks, rather than a more general sex-related behavior.

Putative Functions of Object Use

Making inferences about the function of a behavior can be done in a number of ways, including its beneficial consequences and in terms of "ultimate function", or reproductive fitness (Darwin, 1859/2006; Hinde, 1980). Perhaps the most frequently cited efforts to determine function of object play in the developmental psychological literature involve experimental manipulations where children are "trained" to play with objects and then they are given similar or different objects in convergent or divergent problem-solving tasks.

Convergent tasks are often modeled after Köhler's (1925) famous experiments of a chimpanzee using objects to solve problems, such as putting together sticks to reach bananas hung above its head. In the paradigmatic child development experiment in this mold, Kathy Sylva and colleagues (Sylva, Bruner, & Genova, 1976) presented children with disassembled components of a tool (i.e., sticks and clamps) that had to be assembled in order to retrieve a lure, such as a toy. Children in different conditions were given opportunities to either play with the unassembled sticks, observe an adult assemble the sticks, or watch an adult use the clamp non-functionally (a control condition). Results indicated that play condition children, relative to other conditions, were more systematic in their problem solving, moving from simple to complex moves and using information from hints and failures more effectively. These findings, however, *do not* replicate under double-blind conditions (Simon & Smith, 1983; Smith, 1988; Vandenberg, 1980).

Using objects in divergent problem-solving situations, or tasks for which there is no one correct answer, is also very common in the child development literature (Sutton-Smith, 1967). Specifically, Dansky and Silverman's (1973, 1975) frequently cited experimental studies examined the effects of "play" with objects on children's associative fluency or creative uses for objects. In the first study, Dansky and Silverman (1973) provided children with conventional, but unfamiliar, objects.

In one condition, they were asked to play with the objects; in others they observed an adult manipulating the objects or were exposed to a control condition. These sessions lasted less than 10 min. Children were then asked to list all the uses possible for one of the objects to which they were exposed. For example, creative uses for a matchbox might include using it as a pretend boat. They found that children in the play condition generated the greatest number of creative responses, relative to children in the other conditions.

In the second experiment by Dansky and Silverman (1975), children were assigned to similar conditions to those in the first experiment, but then asked to generate creative uses for objects with which they did *not* interact in their respective treatments. Again, they found that children in the play condition, relative to the other conditions, were the most creative. They argued that these effects were due to an induced "play set," a temporary, creative orientation to objects presented.

While being widely cited, these studies of associative fluency, like the Sylva and colleagues study, *do not replicate* when double-blind procedures are used (Smith & Whitney, 1987). The results in both types of studies, then, were probably due to experimenter bias. As noted earlier, these studies also suffered from very limited experimental treatments. Furthermore, and especially in the light of the limited time of the treatment and relative unfamiliarity of the experimental props, children may have been more likely to have been exploring the objects, not playing with them.

With all these said, one could rightfully question the efficacy of an experimental treatment of 10 min or so on children's behavior. That the experimental literature on object play and problem-solving has not consistently shown effects may be more due to these very limited treatments than to the lack of efficacy of play or exploration with objects. An alternative, and perhaps more valid, approach to documenting the functions of object use involves documenting the time children spend in different types of object use across a relatively long period of time in their natural ecologies, and then regressing those values on to children's performance in different object use tasks (Pellegrini & Gustafson, 2005). This larger corpus of observations should provide a more robust, and valid, indicator of children's facility with objects, relative to the relatively short-term studies cited above. That is, and following Martin and Caro (1985), if play, or any other form of object use, is naturally selected, benefits associated with the construct should outweigh the costs. An important first step in establishing function from this perspective is to document costs and then relate those costs to a beneficial consequence, fitness, or both. Time spent in different types of activities with objects during childhood can be framed in terms of behavioral ecology theory advanced by van Schaik et al. (1999). From this position, descriptions of the "costs" associated with an activity serve as an indicator of its importance, or possible function. For example, high cost behaviors should correspond to outcomes with high payoffs (Caro, 1988; Martin & Caro, 1985). Costs are typically documented in terms of the resources (time, energy, and survivorship, or risk of injury and death) expended to acquire or learn a skill. Time in an activity is typically expressed as the portion of the total time budget spent in that activity (Martin, 1982) and energy is typically expressed in terms of caloric expenditure in that activity relative to the entire caloric budget (Pellegrini, Horvat, & Huberty, 1998).

The logic of this level of analysis is as follows. Learning and developing specific skills involve different trade-offs between costs and benefits, and individuals tend to adopt the most "efficient," or optimal, strategies to solve different problems at specific points during ontogeny (Krebs & Davies, 1993). For example, in learning to use tools during childhood, trade-offs are made between different opportunities (e.g., playing with objects vs. learning to use an object through observation or direct instruction) in light of the finite amount of time and calories available. From this view, there should be a correspondence between time budgets and the benefits associated with expenditures in each activity: Time spent in different types of activity use should relate positively to using those objects to solve problems.

To my knowledge, there are very few time- and energy-budget studies of children's play, generally (though see Haight & Miller, 1993, for pretend play, and Pellegrini et al., 1998 for locomotor play), and fewer for object use (though see Bock, 2005; Pellegrini & Gustafson, 2005; Pellegrini & Hou, 2011). The problem with documenting costs of object use and object play is compounded with the use of very loose and inconsistent terminology surrounding object use, as discussed above. Consequently, I will discuss data from the two Pellegrini studies (Pellegrini & Gustafson, 2005; Pellegrini & Hou, 2011) because they used definitions consistent with those presented here and they were put in time-budget terms. In two short-term longitudinal studies of novel and creative object use, Pellegrini and colleagues (Pellegrini & Gustafson, 2005; Pellegrini & Hou, 2011) took relatively large assays of children's object use as well as their creative and novel uses of objects by sampling each set of constructs across an entire school year. In the later study, they also documented the social context (i.e., solitary, parallel, or social interaction and attention structure) of each type of object use.

In the first study, Pellegrini and Gustafson (2005) observed a modest sample ($n=35$ where each child was observed weekly) of university preschool children in their classrooms across one school year. The aim was to use children's object use sampled across the year to predict the use of objects to solve divergent and convergent object-related problems. A sub-sample ($n=20$) of children were also asked to participate in three types of object-use tasks (two convergent and one divergent tool tasks) and were administered spatial problem-solving tasks (the Block design score of the Wechsler Preschool and Primary Scales of Intelligence, Object Design Test).

The divergent problem-solving task—associative fluency—involved asking children to generate novel uses for ordinary household objects. The first of the two convergent retrieval tasks involved *selecting a tool* (i.e., a plastic toy hoe, a plastic rake head without a handle, and a plastic toy rake handle without the rake head) with which to retrieve a toy dinosaur that had been placed out of reach of the child.

In the second convergent task, children were asked to *make a tool* from Tinker Toy parts and then use it to retrieve a toy. Children were also given a series of seven graded hints if they stalled. The hints were provided in a sequential order, but in ways that were appropriate to the phase of the task in which the child was engaged. The hints also provided the child with gradually more specific help in accomplishing the second task. Specifically, the hints consisted of the following: (1) Can you think of a way to use some of these things to get the dinosaur? (2) Can you try using a round piece to help you? (3) Can you try using the round pieces and the sticks together to help you? (4) Can you put one stick into each end of the round piece to make a longer stick? (5) I will hold this stick. (The experimenter picked up a stick for the child.) Can you put the round piece on the end of it? (6) Can you use the other sticks and round pieces to make it longer? (7) The experimenter connected the pieces for the child and had him/her use the experimenter-constructed pieces to retrieve the dinosaur. The following dimensions of each child's performance were scored: the total time needed by the child to use one or more of the objects to successfully retrieve the dinosaur; the number of hints provided to the child by the experimenter while completing the task; and the number of swipes (e.g. attempts to use one or more of the objects to retrieve the dinosaur).

On the whole, there was a paucity of predictive relations between observed object uses and performance on the associative fluency task and on the connected and unconnected lure-retrieval tasks, when spatial IQ was controlled. Specifically, neither observed play nor exploration predicted problem solving on any of the three tasks. That exploration was a very low-occurrence behavior may be partially responsible for these results given the age of the children and the relative familiarity of the objects in the classrooms

Construction and tool use did, however, differentially predict performance on the problem-solving tasks. More specifically, construction was a significant predictor of associative fluency and performance on the connected tool use retrieval, but it did not predict performance on the making tool (unconnected) task: Observed tool use predicted number of hints on the toolmaking task. The unconnected task was more difficult than the connected task, as indicated by the differences in time and hints needed to solve each. The time needed to complete the unconnected task was also greater by a factor of four than the connected task, and more than double the number of hints was needed.

Given the paucity of relations between object uses and performance on any of the problem-solving tasks, we might question the often-trumpeted value of play for both convergent and divergent problem-solving tasks with objects, at least as measured in associative fluency and lure retrieval tasks. This is similar to the argument made by Smith (1988) and colleagues in reference to the questionable role of play in lure-retrieval performance (Simon & Smith, 1983, 1985) and associative fluency (Smith & Whitney, 1987).

While this may be true for lack of effects on the lure retrieval tasks, which involve making tools, it is also possible that the task of making tools to retrieve lures is simply too complex for preschool-age children. Specifically, children do not exhibit unassisted toolmaking facility until well into middle childhood (Mounoud, 1996), even though they are capable of choosing the correct tool at a much younger age. As for the lack of relations for divergent, creativity tasks, it may be again that the choice of the task itself is inadequate. Specifically, we might be better served by redefining creative uses of objects in terms of behavioral "modules" and the social learning implications of others observing novel modules. Modules, as defined by Bruner (1972) and more recently by some evolutionary biologists (e.g., West-Eberhard, 2003), develop as responses to local ecological and material demands.

Importantly, I do not use "module" to refer to "innate" brain structures in the same way as some evolutionary psychologists (e.g., Cosmides & Tooby, 1987). Modules, as I use the term, are relatively novel actions and cognitions constructed by individuals in new environments. They are both new behavioral routines and re-combined routines. With experience, these diverse behavioral routines become more focused and relevant to the environments and objects in which individuals are embedded. Speculatively, it may be that play with objects results in the generation of behavioral modules associated with and independent of objects.

Stamps' (1995) example of module development in locomotor play is illustrative. When placed in a new environment, an individual (starlings *Sturnus vulgaris* in Stamps' case) will first explore that environment and then play in it (I acknowledge Pat Bateson for alerting me to this reference). Through exploration, the individual discovers new routes around the environment and eventually distils the optimal routes for foraging and escape from predators. In play, these routes are practiced and re-combined in various ways into a wide repertoire of possible routes. Similarly, in object play individuals learn and practice at combining and disaggregating behavioral modules with varied objects to solve problems. Take, for example, a child engaged in object play with pipe cleaners where he connects and bends two separate pipe cleaners into a pretend "tunnel" for him to drive his toy car through. This specific module of connecting and bending could then be used on similar materials to solve a problem, such as, connecting and bending pipe cleaners to be used to retrieve a lure in a restricted physical space. Correspondingly, modules developed in play can be applied to very different types of objects; for example, attaching to lengths of rope to make it long enough to pull a wagon.

Further and perhaps more crucially, the social learning implications of novel object use may be the most important function of object play, though it has been virtually ignored, with Pat Bateson (2011) being a notable exception. He has suggested that the behavioral flexibility developed in play may be an evolutionary driver and at the leading edge of evolutionary change. That is, novel behaviors could be generated in play because of its high intrinsic motivation and its lack of concern for instrumentality. Those novel behaviors that out-compete alternatives will spread through the population and become dominant, in what I label the "seeding hypothesis" of play. These novel uses should, in turn, attract the attention of peers (Pellegrini & Hou, 2011) and may spread through the population, depending on their usefulness. This hypothesis is consistent with early work with chimpanzees (Menzel, Davenport, & Rogers, 1972), where they gauged peer responses to individuals' novel and varied uses of objects by documenting "attention structure", or the number of chimpanzees looking at chimpanzees as they used objects in different ways.

The centrality of social learning in object use and attention to others using objects is especially important with human infants and juveniles, as humans, from birth, are especially sensitive to social cues and are capable of imitating others (e.g., Meltzoff & Moore, 1985). More specific to object use, infants from 6 months of age imitate adults' use of objects as tools (e.g., Hayne, MacDonald, & Barr, 2000) and, as noted earlier, adults readily improve very young children's tool use, relative to independent tool use. Further, by 2 years of age, children are capable of imitating a model's use of a tool and these uses were socially transmitted in diffusion chain experiments (Flynn, 2008; Flynn & Whiten, 2008).

From this argument, Pellegrini and Hou (2011) observed a relatively large sample ($n = 92$) of young children's object use (3–5 years of age) across a school year in university nursery school classrooms. Object use was coded as: Exploration, play, construction, and tool use; each use was also independently scored for novelty and variety. Consistent with claims that object play is a mechanism for generating novel behavior, they, like Hutt and Bhavnani (1972), found that only object play, not other forms of object use, significantly predicted novelty. As an indicator of the discriminant validity of the claim that play is a novelty generator, exploration (a convergent activity) was negatively and significantly correlated with novelty. That this study found a relation between object play and novel uses of objects may be due to the fact that it sampled novel behaviors more widely than is done in experimental studies, which have typically used a single, short-term, contrived task. Aggregating across a large number of behavioral indicators probably maximized the validity of the construct "novelty" by minimizing measurement error (Cronbach, 1971; Rushton, Brainerd, & Pressley, 1983). Of course as the data from the Pellegrini and Hou study are correlational, not experimental, causal inferences should be minimized.

Specific to the "seeding hypothesis," Pellegrini and Hou (2011) also found that only novel and creative uses of objects correlated significantly with peer attention structure. Further, novel and creative uses of object play observed during the first quarter of the school year predicted peer attention structure of children using objects creatively in the final quarter of the year, with attention structure for the earlier period statistically controlled; again, supporting the claim that novelty attracts peers' attention, while construction, a convergent activity, was a significant *negative* predictor.

While these are results in need of replication, they do suggest that in trying to determine a function of object play researchers may have been off the mark on two points. First, they targeted facility in specific tasks, such as associative fluency and lure retrieval tasks, rather than in a more general tendency to use objects in novel and varied ways. Second, and relatedly, researchers in this literature have virtually ignored the social dynamics of such behavior. It may be that an important function of object play, and perhaps of play more generally, is to provide models to conspecifics of individuals exhibiting these behaviors, in the same way that human (Pellegrini, 2008) and nonhuman (Chance, 1967) individuals attend to socially dominant members of their group. Paying attention to these individuals may benefit individuals and groups, in turn. Learning to use objects in novel ways via social learning is a more effective strategy than having individuals spending time and energy constructing their own modules (Boyd & Richerson, 1985).

While this is possible, researchers must also address Fagen's (1976) counterclaim that it is not "economical" for innovative players to share their creations, adding a cost to innovation and thus not likely to be selected. Specifically, there are costs (e.g., time and caloric expenditure) incurred by innovators, as well as benefits (e.g., discovery of a novel solution to a problem, social group centrality), while there may be fewer costs and equally high benefits for copiers of innovations.

That is, it takes less time and energy to observe an innovation, relative to playing and experimenting with objects and the innovators are not getting pay-back for their investment if peers can copy, at less cost. This argument is, however, predicated on the assumption that individuals compete with each other for resources and that innovators' benefits will be outweighed by costs when they are copied. This critique also poses a serious threat to the hypothesis that play is a driver in the evolution of innovative object use. Specifically, object play does seem to represent a considerable cost to the extent that it represents between 18 %-30 % of children's time budgets in university preschool classrooms (McGrew, 1972; Pellegrini & Gustafson, 2005; Pellegrini & Hou, 2011). With this said, the figure is limited to university preschools where the ethos is to stimulate children's play in object rich environments (Smith, 1988). To get a fuller picture of the actual time budgets of children's object play, they need to be studied in the niches in which they spend most of their time—home and community (see Lancy, this volume).

Even if we assume that object play is costly and that others observe and copy innovative object play, there are indeed costs for "copiers," as with all social learners, to the extent that they would have to spend a relatively large amount of time to observe few innovative behaviors (i.e., be vigilant), because innovations with objects are typically rare (Fagen, 1976; Huffman & Quiatt, 1986). Further, the innovators may still accrue net benefits from their behaviors being copied if the copiers reciprocate and cooperate with the initiator. As noted above, relative costs of innovation will outweigh benefits if "free loaders," or individuals who copy behaviors at no costs to themselves, can use the innovations for their own ends. However, and following the principles of mutualism (Clutton-Brock, 2009), and possibly reciprocal altruism (Trivers, 1971), individuals' costly behaviors (e.g., the innovative player) can be attenuated if individuals benefiting from those behaviors (the copiers) reciprocate with beneficial behaviors. This becomes very plausible when we consider that young children are most likely to interact repeatedly with others who share interests in similar activities and these shared interests are the basis for "friendship" in childhood (Hartup, 1996). Correspondingly and in the course of these activities, friends are also more likely to be reciprocal and share information with each other (Gottman, 1983). Indeed, children's early altruistic acts are first observed in the context of friends interacting with each other (Kanfer, Stifter, & Morris, 1981). While these claims are supposition, they are based on sound theory and supporting data, and testable empirically or through theoretical modeling.

Another, and speculative, benefit of object play might relate to the innovators' social status, rather than their facility in object use. That is, individuals' use of objects in creative and novel ways predicts their peer group centrality as measured by peer attention structure (Pellegrini & Hou, 2001), also a measure of social dominance (Chance, 1967; Pellegrini et al., 2007). It may be the case that in resource-rich niches (e.g., abundant objects with which to interact) such as the university nursery schools within which many of these children were observed, individuals do not rely on costly agonistic strategies to attain status. Instead, they use their facility to use objects in creative ways to attract peers' attention. Further, the dynamics of these sort of social entities are such that both adults and the children themselves do not endorse agonistic, relative to more affiliative, strategies (Pellegrini et al., 2007).

Conclusion

In this chapter, I have discussed children's uses of objects and presented descriptive data on their uses of objects in exploration, play with objects, construction, and tool use. The distinction among these categories is an important one as, to my knowledge, they have not been frequently differentiated in the literature on children's play. First, these categories are distinct, and they should be treated as such, as they have different developmental histories and different implications for using objects to solve problems. Correspondingly, scholars should take care to use labels consistently. With all of these said, much more work is needed, particularly observational work documenting the time spent in different sorts of object use. This advice is in the tradition where science should involve *both* inductive and deductive processes.

This review suggests that children in the industrialized world spend from moderate to substantial portions of their days in different types of object use. With this level of investment, there should be some payoff for children. There is reasonable agreement among students of play from a wide variety of scholarly disciplines that the payoff should relate to children's behavioral flexibility. The search for functions of object uses has been elusive, however, in both the experimental and naturalistic literatures. I posit that the behavioral flexibility associated with object play is indeed important, but not for solving contrived problems. Instead, object play and its associated behavioral flexibility probably serves as a model for other children, who, in turn, emulate and imitate these behaviors. By these means, new behavioral strategies can spread through the population.

It should also be apparent from the discussion in this chapter that much more attention needs to be paid to the social context with which children use objects. Future research should attempt to replicate the relation between object play and behavioral flexibility and attention structure. Further, studies using variations on diffusion chains should test this hypothesis experimentally.

Perhaps one of the more educationally important, and ignored, distinctions in the children's object use literature relates to the play/exploration distinction. As noted above, the two are very distinct from each other. The distinction is especially important when we as educators and psychologists try to use "play' as a form of assessment or diagnosis, as pointed out in a very cogent, and under-cited paper, by Vonnie McLoyd (1982). Specifically, in her critique of the developmental literature on social economic class and pretend play, McLoyd makes the point that when play is used to diagnose young children's social cognitive facility, they are typically presented with objects, they are asked to "play" with them, and the behavior is analyzed, for example, in terms of abstractness. Interestingly, the objects that children are given in these situations are typically those found in middle class, not low socio-economic (LSES), homes and schools, such as Legos, large wooden blocks, and trucks, and dolls. Thus, when LSES children are presented with these objects with which to "play," they first explore the objects because they are not familiar with them. So, if researchers or educators code these exploratory behaviors in terms of abstraction of some other level of fantasy, these children will appear to be "less advanced" than their middle class counterparts. However, and again, as pointed out by McLoyd, after LSES children explore these novel objects, their behavior does indeed become pretend, similar to middle class children. So, these distinctions in types of object use have very important policy implication—it's more than an academic debate about semantics.

Relatedly, specificity and consistency of labels used to describe children's behavior and curricular practices are also important. That is, the use of the term "play" to describe a variety of educational practices is so varied that the term bears little resemblance to the way play is defined by Piaget and in this chapter. Using a current example, the term "guided play" (Fisher, Hirsh-Pasek, Golinkoff, Singer, & Berk, 2011) is an educational practice whereby adults guide children in academic tasks, with a specific end result in mind. Placed along a definitional continuum of play, guided play clearly falls more towards ends-oriented, teacher-directed activity, relative to the way in which I define play (see also Toub et al., this volume). While guided play does seem to pay educational dividends, one should be very careful when using it as part of a larger argument to promote the benefits of play, as I define it (see also Sweller, this volume). This is especially problematic in light of the "definitional drift" that often occurs with play, and as discussed above: Guided play may become play, especially when reported in the popular press (Pellegrini, 2010). This could lead to diverse educational practices that belie replication, unless strict attention is paid to definitions.

Acknowledgment I dedicate this chapter add after to the memory of myfriend and colleague, Kevin Connolly.

References

Amant, R. S., & Horton, T. E. (2008). Revising the definition of animal tool use. *Animal Behaviour, 75*, 1199–1208.

Baldwin, D. A., Markman, E. H., & Melartin, R. L. (1993). Infants' ability to draw inferences about nonobvious object properties: Evidence from exploratory play. *Child Development, 64*, 711–728.

Barr, R., & Wyss, N. (2008). Re-enactment of televised content by 2-year-olds: Toddlers use language learned from television to solve a difficult imitation problem. *Infant Behavior and Development, 31*, 696–703.

Bates, E., Carlson-Luden, V., & Bretherton, I. (1980). Perceptual aspects of tool use in infancy. *Infant Behavior and Development, 3*, 127–140.

Bateson, P. P. G. (2005). Play and its role in the development of great apes and humans. In A. D. Pellegrini & P. K. Smith (Eds.), *The nature of play: Great apes and humans* (pp. 13–26). New York, NY: Guilford.

Bateson, P. P. G. (2011). Theories of play. In A. D. Pellegrini (Ed.), *Oxford handbook of the development of play* (pp. 41–47). New York, NY: Oxford University Press.

Beck, B. B. (1980). *Animal tool behavior*. New York, NY: Garland.

Belsky, J., Goode, M. K., & Most, R. K. (1980). Maternal stimulation and infant exploratory competence: Cross-sectional, correlational, and experimental analyses. *Child Development, 51*, 1163–1178.

Belsky, J., & Most, R. (1981). From exploration to play: A cross-sectional study of infant free-play behavior. *Developmental Psychology, 17*, 630–639.

Bjorklund, D. F., & Gardiner, A. K. (2011). Object play and tool use: Developmental and evolutionary perspectives. In A. D. Pellegrini (Ed.), *Oxford handbook of the development of play* (pp. 153–171). New York, NY: Oxford University Press.
Blurton Jones, N. (1972). Characteristics of ethological studies of human behaviour. In N. Blurton Jones (Ed.), *Ethological studies of child behaviour* (pp. 3–33). London, England: Cambridge University Press.
Bock, J. (1999). The socioecology of children's activities: A new model for work and play. Paper presented at the biennial meetings of the Society for Research in Child Development, Albuquerque
Bock, J. (2005). Farming, foraging, and children's play in the Okavango Delta, Botswana. In A. D. Pellegrini & P. K. Smith (Eds.), *The nature of play: Great apes and humans* (pp. 254–284). New York, NY: Guilford.
Bornstein, M. H., Haynes, O. M., O'Reilly, A. W., & Painter, K. M. (1996). Solitary and collaborative pretense play in early childhood: Sources of individual variation in the development of representational competence. *Child Development, 67*, 2910–2929.
Boyd, R., & Richerson, P. J. (1985). *Culture and the evolutionary process*. Chicago, IL: The University of Chicago Press.
Brown, A. L. (1990). Domain-specific principles affecting learning and transfer in children. *Cognitive Science, 14*, 107–133.
Bruner, J. (1972). The nature and uses of immaturity. *American Psychologist, 27*, 687–708.
Burghardt, G. M. (2005). *The genesis of animal play: Testing the limits*. Cambridge, MA: MIT.
Caldera, Y., Huston, A., & O'Brien, M. (1989). Social interaction and play patterns of parents and toddlers with feminine, masculine, and neutral toys. *Child Development, 60*, 70–76.
Caro, T. (1988). Adaptive significance of play: Are we getting closer? *Trends in Ecology & Evolution, 3*, 50–54.
Chance, M. R. A. (1967). Attention structure as a basis for primate rank order. *Man, 2*, 503–518.
Chen, Z., & Siegler, R. S. (2000). Across the great divide: Bridging the gap between understanding of toddlers' and older children's thinking. *Monographs of the Society for Research in Child Development, 65*, 1–96. Serial No. 261.
Clutton-Brock, T. (2009). Cooperation between non-kin in animal societies. *Nature, 462*(5), 51–56.
Connolly, K., & Dalgleigh, M. (1989). The emergence of a tool-using skill in infancy. *Developmental Psychology, 23*, 894–912.
Connolly, K., & Elliott, J. (1972). The evolution and ontogeny of hand functions. In N. Blurton Jones (Ed.), *Ethological child behavior* (pp. 329–384). London, England: Cambridge University Press.
Cosmides, L., & Tooby, J. (1987). From evolution to behavior: Evolutionary psychology as the missing link. In J. Dupre (Ed.), *The latest on the best essays on evolution and optimality* (pp. 277–306). Cambridge, MA: MIT Press.
Cronbach, L. (1971). Validity. In R. L. Thorndike (Ed.), *Educational measurement* (pp. 443–507). Washington, DC: American Council on Education.
Cutting, N., Apperly, I. A., & Beck, S. R. (2011). Why do children lack the flexibility to innovate tools? *Journal of Experimental Child Psychology, 109*, 497–511.
Dansky, J., & Silverman, I. W. (1973). Effects of play on associative fluency in preschool-age children. *Developmental Psychology, 9*, 38–43.
Dansky, J., & Silverman, I. W. (1975). Play: A general facilitator of associative fluency. *Developmental Psychology, 11*, 104.
Darwin, C. (2006). *The origin of species: By means of natural selection of the preservation of favoured races in the struggle for life*. Mineola, NY: Dover (Original work published 1859).
Erickson, E. H. (1977). *Toys and reason*. New York, NY: Norton.
Fagen, R. (1982). Evolutionary issues in development of behavioral flexibility. In P. Bateson & P. Klopfer (Eds.), *Growing points in ethology* (Vol. 5, pp. 365–383). London, England: Plenum.

Fabes, R. A., Martin, C. L., Hanish, L. D., Anders, M. C., & Madden-Derdich, D. A. (2003). Early school competence: The roles of sex-segregated play and effort control. *Developmental Psychology, 39*, 848–858.

Fagen, R. (1981). *Animal play behavior*. New York, NY: Oxford University Press.

Fein, G. G. (1981). Pretend play in childhood: An integrative review. *Child Development, 52*, 1095–1118.

Fisher, K., Hirsh-Pasek, K., Golinkoff, R. M., Singer, D. G., & Berk, L. (2011). Playing around in school: Implications for learning and educational practice. In A. D. Pellegrini (Ed.), *The Oxford handbook of the development of play* (pp. 341–363). New York, NY: Oxford University Press.

Flynn, E. (2008). Investigating children as cultural magnets: Do young children transmit redundant information along diffusion chains? *Philosophical Transactions of the Royal Society, B: Biological Sciences, 363*, 3541–3551.

Flynn, E., & Whiten, A. (2008). Cultural transmission of tool use in young children: A diffusion chain. *Social Development, 17*, 699–718.

Gosso, Y., Otta, E., de Lima, M., Morais, S. E., Ribeiro, F. J. L., & Bussabb, V. S. R. (2005). Play in hunter-gatherer society. In A. D. Pellegrini & P. K. Smith (Eds.), *The nature of play: Play in great apes and humans* (pp. 213–253). New York, NY: Guilford.

Gottman, J. M. (1983). How children become friends. *Monographs of the Society for Research in Child Development, 48*(3), 1–85. Serial No. 201.

Gredlein, J. M., & Bjorklund, D. F. (2005). Sex differences in young children's use of tools in a problem-solving task. *Human Nature, 16*, 211–232.

Haight, W. L., & Miller, P. J. (1993). *Pretending at home*. Albany, NY: State University of New York Press.

Hansell, M., & Ruxton, G. D. (2007). Setting tool use within the context of animal construction behavior. *Trends in Ecology and Evolution, 23*, 73–78.

Hartup, W. W. (1996). The company they keep: Friendships and their developmental significance. *Child Development, 67*, 1–13.

Hayne, H., Herbert, H., & Simcock, G. (2003). Memory retrieval by 18- to 30-mont-olds: Age-related changes in representational flexibility. *Developmental Science, 6*, 254–261.

Hayne, H., MacDonald, S., & Barr, R. (2000). Developmental changes in the specificity of memory over the second year of life. *Infant Behavior and Development, 20*, 237–249.

Henderson, B. B. (1984). The effect of context on individual differences in exploratory behavior. *Child Development, 55*, 1237–1245.

Henderson, B. B., & Moore, S. G. (1979). Measuring exploratory behavior in young children: A factor analytical study. *Developmental Psychology, 15*, 113–119.

Hinde, R. A. (1980). *Ethology*. London: Fontana.

Huffman, M. A., & Quiatt, D. (1986). Stone handling by Japanese Macaques (*Macacca fuscata*): Implications for tool use of stone. *Primates, 27*, 413–423.

Hughes, M. (1978). Sequential analysis of exploration and play. *International Journal of Behavioral Development, 1*, 83–97.

Hutt, C. (1966). Exploration and play in children. *Symposia of the Zoological Society of London, 18*, 61–81.

Hutt, C., & Bhavnani, R. (1972). Predictions from play. *Nature, 237*, 216–219.

Johnson, J. E., & Ershler, J. (1981). Developmental trends in preschool play as a function of classroom program and child gender. *Child Development, 52*, 995–1004.

Johnson, J. E., Ershler, J., & Bell, C. (1980). Play behavior in a discovery-based and a formal education preschool program. *Child Development, 51*, 271–274.

Kanfer, F. H., Stifter, E., & Morris, S. J. (1981). Self-control and altruism: Delay of gratification for another. *Child Development, 52*, 674–682.

Köhler, W. (1925). *The mentality of apes*. New York, NY: Harcourt Brace.

Krasnor, L., & Pepler, D. (1980). The study of children's play. In K. Rubin (Ed.), *Children's play* (pp. 85–95). San Francisco, CA: Jossey-Bass.

Krebs, J. R., & Davies, N. B. (1993). *An introduction to behavioural ecology*. Oxford, England: Blackwell.

Lillard, A. S. (2006). Guided participation: How mothers structure and children understand pretend play. In A. Göncü & S. Gaskins (Eds.), *Play and development: Evolutionary, sociocultural and functional perspectives* (pp. 131–154). Mahwah, NJ: Erlbaum.
Martin, P. (1982). The energy cost of play: Definition and estimation. *Animal Behaviour, 30*, 294–295.
Martin, P., & Caro, T. (1985). On the function of play and its role in behavioral development. In J. Rosenblatt, C. Beer, M.-C. Bushnel, & P. Slater (Eds.), *Advances in the study of behavior* (Vol. 15, pp. 59–103). New York, NY: Academic Press.
McCall, R. B. (1974). Exploratory manipulation and play in the human infant. *Monographs of the Society for Research in Child Development, 39*(2), 1–88. Serial No. 155.
McGrew, W. C. (1972). *An ethological study of children's behaviour*. London, England: Metheun.
McGuigan, N., & Whiten, A. (2009). Emulation and "overemulation" in the social learning of causally opaque versus transparent tool use by 23- and 30- month olds. *Journal of Experimental Child Psychology, 104*, 367–381.
McLoyd, V. (1982). Social class differences in sociodiamatic play. A critical review. *Developmental Review, 2*, 1–30.
Meltzoff, A. N., & Moore, M. K. (1985). Cognitive foundations and social functions of imitation and intermodal representation in infancy. In J. Mehler & R. Fox (Eds.), *Neonate cognition: beyond the booming buzzing confusion*. Hillsdale, NJ: Erlbaum.
Menzel, E. W., Davenport, R. K., & Rogers, C. M. (1972). Protocultural aspects of chimpanzees' responsiveness to novel objects. *Folia Primatologica, 17*, 161–170.
Mounoud, P. (1996). A recursive transformation of central cognitive mechanisms: The shift from partial to whole representation. In A. J. Sameroff & M. M. Haith (Eds.), *The five to seven year shift: The age of reason and responsibility* (pp. 85–110). Chicago, IL: University of Chicago Press.
Parten, M. (1932). Social participation among preschool children. *Journal of Abnormal and Social Psychology, 27*, 243–269.
Pellegrini, A. D. (2009). *The role of play in human development*. New York, NY: Oxford University Press.
Pellegrini, A. D. (2010). Play and games mean different things in an educational context. *Nature, 467*, 27.
Pellegrini, A. D., & Gustafson, K. (2005). Boys' and girls' uses of objects for exploration, play, and tools in early childhood. In A. D. Pellegrini & P. K. Smith (Eds.), *The nature of play: Great apes and humans* (pp. 113–138). New York, NY: Guilford.
Pellegrini, A. D., Horvat, M., & Huberty, P. D. (1998). The relative cost of children's physical activity play. *Animal Behaviour, 55*, 1053–1061.
Pellegrini, A. D., & Hou, Y. (2011). The development of preschool children's (*Homo sapiens*) uses of objects and their role in peer group centrality. *Journal of Comparative Psychology, 125*, 239–245.
Pellegrini, A. D., Roseth, C., Mliner, S., Bohn, C. M., Van Ryzin, M., Vance, N., … Tarullo, A. (2007). Social dominance in preschool classrooms. Journal of Comparative Psychology, 121, 54–64
Piaget, J. (1952). *The origins of intelligence in children*. New York, NY: Norton.
Piaget, J. (1962). Play, dreams, and imitation in childhood (C. Gattengno & F.M. Hodgson, Trans.) New York, NY: Norton (Original work published 1951)
Piaget, J. (1967). *The psychology of intelligence*. London, England: Routledge & Kegan Paul.
Piaget, J. (1970). Piaget's theory. In P. Mussen (Ed.), *Carmichael's manual of child psychology* (Vol. I, pp. 703–732). New York, NY: Wiley.
Power, T. G. (2000). *Play and exploration in children and animals*. Mahwah, NJ: Erlbaum.
Rheingold, H. L., & Eckerman, G. O. (1970). The infant separates himself from his mother. *Science, 168*, 78–83.
Ross, H. S., Rheingold, H. L., & Eckerman, C. O. (1972). Approach and exploration of a novel alternative by 12-month-old infants. *Journal of Experimental Child Psychology, 13*, 85–93.

Rubin, K. H., Fein, G., & Vandenberg, B. (1983). Play. In E. M. Hetherington (Ed.), *Handbook of child psychology* (Socialization, personality and social development, Vol. IV, pp. 693–774). New York, NY: Wiley.

Rubin, K., Maioni, T., & Hornung, M. (1976). Free play in middle and lower class preschoolers: Parten and Piaget revisited. *Child Development, 47*, 414–419.

Rubin, K., Watson, R., & Jambor, T. (1978). Free-play behaviors in preschool and kindergarten children. *Child Development, 49*, 534–546.

Rushton, J., Brainerd, C., & Pressley, M. (1983). Behavioral development and construct validity: The principle of aggregation. *Psychological Bulletin, 94*, 18–38.

Russell, B. (1959). *The scientific outlook*. New York, NY: Norton (Original work published 1931).

Schulz, L. E., & Bonawitz, E. B. (2007). Serious fun: Preschoolers engage in more exploratory play when evidence is confounded. *Developmental Psychology, 43*, 1045–1050.

Shumaker, R. W., Walkup, K. R., & Beck, B. B. (2011). *Animal tool behavior: The use and manufacture of tools by animals*. Baltimore, MD: Johns Hopkins University Press.

Simon, T., & Smith, P. K. (1983). The study of play and problem solving in preschool children. *British Journal of Developmental Psychology, 1*, 289–297.

Simon, T., & Smith, P. K. (1985). Play and problem solving: A paradigm questioned. *Merrill-Palmer Quarterly, 31*, 265–277.

Smilansky, S. (1968). *The effects of sociodramatic play on disadvantaged preschool children*. New York, NY: Wiley.

Smith, P. K. (1988). Children's play and its role in early development: A re-evaluation of the "play ethos". In A. D. Pellegrini (Ed.), *Psychological bases for early education* (pp. 207–226). Chichester, England: Wiley.

Smith, P. K. (2011). Observational methods in studying play. In A. D. Pellegrini (Ed.), *The Oxford handbook of the development of play* (pp. 138–152). New York, NY: Oxford University Press.

Smith, P. K., & Dutton, S. (1979). Play training in direct and innovative problem solving. *Child Development, 50*, 830–836.

Smith, P. K., Takhvar, M., Gore, N., & Volstedt, R. (1986). Play in young children: Problems of definition, categorization, and measurement. In P. K. Smith (Ed.), *Children's play* (pp. 39–55). London, England: Gordon & Breach.

Smith, P. K., & Whitney, S. (1987). Play and associative fluency: Experimenter effects may be responsible for previous positive findings. *Developmental Psychology, 23*, 49–53.

Stamps, J. (1995). Motor learning and the value of familiar space. *American Naturalist, 146*, 41–58.

Sutton-Smith, B. (1967). The role of play in cognitive development. *Young Children, 22*, 364–369.

Sylva, K., Bruner, J., & Genova, P. (1976). The role of play in the problem-solving of children 3-5 years old. In J. Bruner, A. Jolly, & K. Sylva (Eds.), *Play: Its role in development and evolution* (pp. 244–261). New York, NY: Basic Books.

Tinbergen, N. (1963). On aims and methods of ethology. *Zeitschirift für Tierpsychologie, 20*, 410–413.

Tomasello, M. (1999). *The cultural origins of human cognition*. Cambridge, MA: Harvard University Press.

Tomasello, M., & Call, J. (1997). *Primate cognition*. New York, NY: Oxford University Press.

Trivers, R. (1971). The evolution of reciprocal altruism. *Quarterly Review of Biology, 46*, 35–57.

van Schaik, C. P., Deaner, R. O., & Merrill, M. Y. (1999). The conditions of tool use in primates: Implications for the evolution of material culture. *Journal of Human Evolution, 36*, 719–741.

Vandenberg, B. (1980). Play, problem solving, and creativity. In K. Rubin (Ed.), *Children's play* (pp. 49–68). San Francisco, CA: Jossey-Bass.

Weisler, A., & McCall, R. (1976). Exploration and play: Resume and redirection. *American Psychologist, 31*, 492–508.

West, M. J. (1977). Exploration and play with objects in domestic kittens. *Developmental Psychobiology, 10*, 53–57.

West-Eberhard, M. J. (2003). *Developmental plasticity and evolution*. New York, NY: Oxford University Press.

Chapter 5
Guided Play: A Solution to the Play Versus Learning Dichotomy

Tamara Spiewak Toub, Vinaya Rajan, Roberta Michnick Golinkoff, and Kathy Hirsh-Pasek

A fundamental question we face is how to educate twenty-first century children to best prepare them for a world marked by increased globalization and advancing technology. In addition to developing specific academic skills or content, children must learn to collaborate, communicate, engage in critical thinking, and think creatively. They must also have the confidence to persevere if they do not at first succeed. Golinkoff and Hirsh-Pasek (2016) refer to these as the 6C's—crucial competencies if our children are to be effective leaders who can produce significant change in the world (Fisher, Hirsh-Pasek, Golinkoff, Singer, & Berk, 2010; Hirsh-Pasek, Golinkoff, Berk, & Singer, 2009). Are we maximizing children's learning in our current educational systems? If not, how can we design educational opportunities so that every child thrives? Currently, and for centuries, our educational system has been dominated by an approach that emphasizes adult-directed instruction

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delivered to relatively passive children. Yet many theorists support an alternative to direct instruction that privileges a child's sense of discovery through play, such as in discovering learning approaches. Oftentimes, people view these options as mutually exclusive, and for decades there has been sparring between advocates on each side (Hirsh-Pasek & Golinkoff, 2011). In this chapter, we consider two core evolutionary perspectives and offer a rapprochement through what we call *guided play* (Fisher et al., 2010; Hirsh-Pasek & Golinkoff, 2011; Weisberg, Hirsh-Pasek, & Golinkoff, 2013). With this "best of both worlds" approach, we maximally promote key cognitive and social skills necessary for success in this global era.

The Education Problem in the US

The United States' education system has consistently fallen behind in international rankings when compared to other industrialized nations. Lags in mathematics performance, for example, appeared as early as the first international assessments in 1964 (Husen, 1967). The 2012 Program for International Assessment (PISA) offers a case in point. Of 34 industrialized nations in the Organisation for Economic Co-operation and Development (OECD), the US was ranked 27th in mathematics, 20th in science, and 17th in reading (OECD, 2012). In mathematics, the US performance is below the OECD average, comparable to the performances of countries such as the Slovak Republic and Lithuania. The United States also slipped to 13th among 25 OECD countries with comparable data when comparing the number of students attaining a college degree (OECD, 2012).

Concerns about American global competitiveness and about the wide gaps between low- and middle-income children within the country spurred the passage of No Child Left Behind (NCLB, 2001). The law offered a sweeping attempt at educational reform that would focus new energy around a narrowly construed curriculum largely focused on reading and mathematics to the detriment of other subjects. Its implementation left something to be desired, as well. It was interpreted as requiring repeated testing of material taught in a highly directed way (Miller & Almon, 2009; Singer, Golinkoff, & Hirsh-Pasek, 2006; Sunderman, Tracey, Kim, & Orfield, 2004). The relatively new Common Core was designed to expand that focus to *how* children learn as well as *what* they are expected to learn. Yet, even with this advance, in practice, this new initiative is largely NCLB 2.0 with a narrowly construed educational focus. Teacher practices remain dominated by worksheets, rote-memorization, and dry review of procedural skills without the development of associated conceptual understanding (Hirsh-Pasek et al., 2009).

Data from over 200 kindergarten classroom teachers in New York and Los Angeles revealed that approximately 80 min per class day were spent on literacy instruction and 47 min on mathematics instruction, with children spending fewer than 30 min per day in free play (Miller & Almon, 2009). The teachers also reported devoting an average of over 20 min a day to standardized testing and preparation for tests. According to Elkind (2008), a leading scholar in the value of play, this reduction in playtime and increase in academic study time has resulted in a loss of up to

8 h of free, unstructured play time per week. The new age of early education mounts a false dichotomy between play and learning that forces teachers to choose between letting children play and teaching academic content (Kochuk & Ratnayaka, 2007; Viadero, 2007). Play has become a “4-letter” word (Hirsh-Pasek & Golinkoff, 2003).

The Existing Dichotomy: Play Versus Direct Instruction

This divide between play and academic learning represents a deeper, fundamental debate about *how* children learn, and it is here that evolutionary perspectives can be most informative. On the one hand, scholars like Peter Gray (2011, 2013, this volume) emphasize that young children have a propensity to learn from self-directed play and exploration (see also Bjorklund & Beers, this volume). On the other hand, David Geary’s work (Geary, 1995, 2007a; Geary & Berch, this volume; Sweller, this volume) reminds us that playful, discovery learning will only take us so far. Such approaches to learning may prove optimal for “biologically primary” skills, which are those that serve an evolutionary function and are found across all cultures. One example of a biologically primary skill is numerosity, or children’s sensitivity to the relative magnitudes of collections of items (Feigenson, Dehaene, & Spelke, 2004). In contrast, discovery learning approaches will surely fail to help children learn “biologically secondary” skills, which are only found in some cultures and vary based on schooling and instruction. The complex arithmetic of simultaneous equations is an example of secondary skills, which Geary (1995, 2007a) argues cannot be learned through free play alone.

The arguments made by both Gray and Geary are backed by a rich body of data that contribute to our current understanding of educational curricula and—importantly—pedagogy. Gray’s research starts with the premise of understanding how children learn in ‘the wild,’ positing that, in hunter-gatherer societies, humans evolved to learn largely through free play (Lancy, this volume). Driven by inborn instincts and drives, children are naturally curious and playful, which enables them to learn and adapt to their environment. In the hunter-gatherer model of education, adults did not direct children’s education, but rather children were left to play and explore in their own ways. Gray notes that free play, in particular, with activities that are chosen by children and self-directed rather than adult-directed best promotes rich social, intellectual, and emotional development. The self-directed element of the learning that occurs in the context of free play is crucial in this view. Gray argues that progressive educational theories, such as constructivism, still place the adult in charge of children’s learning, as teachers attempt to drive play and exploration within the context of an established curriculum. In his view, children are capable of successfully directing their own education, and schools should embrace this hunter-gatherer model:

> Today when most people think of *education* they think of schooling … they think of education as something done *to* children *by* adults. But education long predates schooling, and even today most education occurs outside of school … Today, in the minds of most people, the onus for education lies with adults, who have the responsibility to make children acquire

> certain aspects of the culture, whether or not the children want to acquire them. But throughout human history the real onus for education has always laid with children themselves, and it still does today (Gray, 2013, p. 113).

Geary's (1995, 2007a) evolutionary perspective similarly recognizes that free play is important and emphasizes children's natural biases to engage in play that will support development. He argues that free play is most effective for building on preexisting, evolutionarily based cognitive skeletal structures to enhance skills that are biologically primary. Geary (2007b) states that:

> For young children without an extensive base of secondary knowledge, capitalizing on primary forms of learning might be particularly useful in the beginning stages of learning a secondary domain (p. 184).

However, in contrast to Gray (2011, 2013), Geary describes important limitations to older children's learning through free play. Specifically, Geary questions whether play is effective in teaching biologically secondary abilities (Geary, 1995, 2007a). Acquisition of biologically secondary cognitive abilities is slow and effortful, requiring deliberate instruction and practice (Sweller, this volume). Geary's view is that formal direct instruction is the most effective approach to promoting these secondary, culturally based, cognitive skillsets.

By way of example, Klahr and Nigam (2004) studied third- and fourth-graders' developing ability to properly isolate variables when designing a scientific experiment. Klahr and Nigam found that children who received adult instruction and modeling about experimental design showed greater improvements than children who explored similar materials and practiced experimental design by themselves. Discovery learning through free play simply offers too many unconstrained possibilities and can lead young minds down a garden path of irrelevant foci. Geary recognizes that adult guidance is needed, and he concludes that direct instruction is the effective choice.

Proponents from both Gray's (2011, 2013) and Geary's (1995, 2007a) evolutionary perspectives support Bjorklund's (2007) statement that, "Children did not evolve to sit quietly at desks in age-segregated classrooms…" (p. 120). The question before us then is how we can deliver rich curricular choices while maintaining a playful learning environment that moves towards a learning goal. The evolutionary perspectives of Gray and Geary together suggest that free play is an effective and natural activity through which children gain important knowledge and skills; however, there are limitations to what children can learn through the type of free play that Gray advocates.

We argue that the relative effectiveness of free play is diminished when we, as the adults in children's lives, have a learning goal in mind. In those cases, we cannot depend on children to naturally—and in a timely fashion—encounter the requisite educational experiences that development of the targeted skills requires. Yet, the formal direct instruction that Geary recommends for biologically secondary skill acquisition might not be the best approach, either. Perhaps there is some way to capture the best of the playful, discovery approach to learning while still having a key role for adults who subtly guide children through a learning space.

In this chapter, we argue that it is time to embrace a position that incorporates Gray's (2011, 2013) and Geary's (1995, 2007a) insights into an approach that respects both the benefits of free play and the value of direct instruction. In this piece, we shed the false dichotomy that has developed between play and learning. Such a position respects the need for a well-defined learning goal that is quintessential to Geary's discussions of the formal instruction of secondary abilities, while leveraging the agency, openness, and exploration that are core to Gray's position and inherent to childhood (Gopnik, Griffiths, & Lucas, 2015; Hirsh-Pasek & Golinkoff, 2011). The debate between self-directed play and direct instruction can be replaced by an approach that incorporates elements of both pedagogical styles, which we describe as *guided play* (Fisher et al., 2010; Hirsh-Pasek & Golinkoff, 2011; Weisberg, Hirsh-Pasek, & Golinkoff, 2013). Guided play can serve as a useful blueprint for how we can help children acquire the skills that are important in the modern world while simultaneously respecting the need for active, child-centered exploration.

What Is Guided Play?

Together with free play, guided play falls under the umbrella term of *playful learning*—a whole-child pedagogical approach to the promotion of academic, socio-emotional, and cognitive development (see Fig. 5.1) (Fisher et al., 2010; Hirsh-Pasek & Golinkoff, 2011; Resnick, 2004; Weisberg, Hirsh-Pasek, & Golinkoff, 2013; Weisberg, Kittredge, Hirsh-Pasek, Golinkoff, & Klahr, 2015). To best understand guided play, it is useful to contextualize it by considering, first, how "play" is typically defined and, second, how guided play differs from other approaches to children's learning.

Theorists traditionally view play as a fun, flexible, and voluntary activity without extrinsic goals that involves active child engagement and often incorporates make-believe (Fisher et al., 2010; Johnson, Christie, & Yawkey, 1999; Pellegrini, 2009; Weisberg, Hirsh-Pasek, & Golinkoff, 2013). Guided play maintains most traditional elements of play, especially the enjoyable and engaging nature and the child's own agency, but adds a focus on the extrinsic goal of developing children's skills and knowledge.

There are two key dimensions to consider when defining guided play and how it differs from other pedagogical approaches (see Fig. 5.1). When an adult enters a situation with a particular learning goal in mind, there are varying degrees to which the adult might constrain the child's environment to promote the educational goal (as illustrated by the horizontal arrow in Fig. 5.1). Second, there is the degree to which the adult controls the moment-by-moment flow of the child's activities within that environment (as illustrated by the vertical arrow). The free play subtype of playful learning most clearly exemplifies both the lack of constraints from an adult's designated learning goal and the child's complete agency within that unconstrained atmosphere. This is the type of learning opportunity that Gray (2011, 2013) strongly promotes. Free play is part of playful learning because children can and do learn from such activities. During a child's free play, especially with other children, exploration of objects or pretend play provides opportunities to practice various skills (Fisher et al., 2010; Pellegrini, 2009; Singer et al., 2006; Pellegrini, this volume), such as mathematics and spatial skills (Ginsburg, Pappas, & Seo, 2001; Wolfgang, Stannard, & Jones, 2003), language and literacy skills (Pellegrini & Galda, 1990;

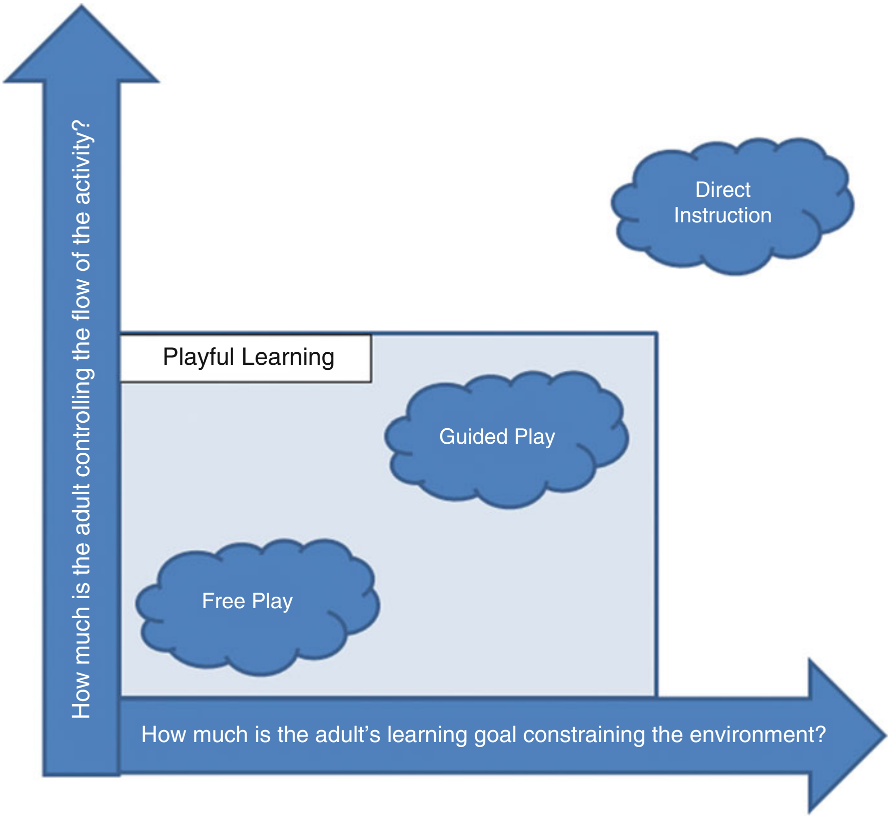

Fig. 5.1 Conceptualization of guided play and other approaches to children's learning

Weisberg, Zosh, et al., 2013), and socio-emotional skills (Lillard, 2001). However, it is difficult to predict which skills and knowledge will develop from free play, with the content depending on children's whims and their chosen play environment.

When an adult has a particular learning goal in mind, it is risky to assume that children will naturally stumble upon just those experiences that support that learning goal within the context of free play. Instead, the adult can provide goal-oriented scaffolding through guided play, the other playful learning approach. In guided play, the adult increases the likelihood of the child achieving the designated learning goal by constraining the environment just enough to help ensure that the child engages with relevant materials and encounters relevant experiences. Children still have choices and agency, but these choices are framed by the adult in service of the learning goal. A study by Morrow and Rand (1991) showed that teachers' support was especially effective for increasing children's literacy play when the teachers gave children initial guidance and modeled the use of literacy-related materials instead of simply providing the same items without suggestions. The Montessori educational approach, which often leads to better academic and social outcomes than do other educational styles, embraces adult guidance for how to play with objects to promote a learning goal (Lillard, 2013). Such guidance can be highly effective and can maintain many of the essential ingredients of play.

Besides providing relevant materials and initial suggestions about their use, adults can also join the child's play and act as a coach during guided play, asking provocative questions or making comments during play that help ensure children's exposure to ideas and information relevant to the learning goal (Fisher et al., 2010; Weisberg, Zosh, et al., 2013). A common illustration is with puzzle assembly. When a child struggles to fit an upside-down puzzle piece into position and an adult suggests that the child try rotating the piece, the adult is scaffolding the child's attempt. By simply observing what a child is doing and saying phrases such as, "I wonder what would happen if… " or "There could be other ways to [do that], too!" (Kittredge, Klahr, & Fisher, 2014; Weisberg et al., 2015), an adult suggests a possible next step to the child without taking control of the activity. The guided play challenge is to provide gentle support so that even though the choices are limited, it is still up to the child which direction to pursue.

That maintenance of child directedness, even when an adult is helping to shape the experience based on a learning goal, is a key difference between guided play and other approaches, such as the direct instruction Geary (1995, 2007a) advocates for secondary skill acquisition. In direct instruction, the adult's learning goal very much constrains the learning environment, which is what Geary argues is often necessary to ensure the child focuses on the desired content. However, in some circumstances, such directive adult involvement can reduce children's playing, exploring, *and learning*. Bonawitz et al. (2011) found that children who were explicitly taught about one specific causal property of a novel toy learned about that property, but did not discover other relevant properties that had not been demonstrated for them. In contrast, children who had not seen any demonstration explored the novel toy more thoroughly and discovered more of the causal properties in the process. Therefore, it can be counterproductive for an adult to lend too much directive support.

Thus, there is a delicate balance between maintaining child-directedness and providing sufficient guidance to promote achievement of a given learning goal. In Alfieri, Brooks, Aldrich, and Tenenbaum's (2010) meta-analysis of 56 studies, more learning occurred through approaches involving guided play (or what the authors called "enhanced discovery learning") compared to direct instruction or free play. Adults should function more like coaches than like directors; directors intrude more on children's autonomy. In the puzzle example, if the adult proceeds to dictate to the child where to put each of the pieces or in what order they should be placed, the child no longer has any control over the direction of the activity. This tips the scale away from child-directedness and towards the child passively following instruction (or quitting entirely!), even though the child is physically active. With a good coach, however, who asks questions (*Do you think that green piece belongs in the middle of the red ones?*) or obliquely suggests a strategy (*Hmmm… would it be easier to find the flower in the picture first?*), guided play offers a promising pedagogical approach that challenges children to think and not just carry out orders.

Principles for Effective Learning

The defining characteristics of guided play are consistent with empirical evidence from the large body of research on how children learn best. Individual fields such as psychology, education, and cognitive science have merged and evolved into the newer interdisciplinary Science of Learning, which aims to understand the mechanisms that fuel effective learning and how to design learning environments accordingly (Bransford, Brown, & Cocking, 1999; Chi, 2009; Marcon, 1999; Meltzoff, Kuhl, Movellan, & Sejnowski, 2009). We are therefore well-positioned to make evidence-based decisions about how to educate and equip our children with the skills needed for success in the twenty-first century. We presented a more comprehensive introduction to the Science of Learning field elsewhere (Hirsh-Pasek, Zosh, et al., 2015), and many authors have promoted this type of approach to formal education (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Mayer, 2011). Chi (2009) reviewed research supporting a hierarchical framework in which some types of activities are more effective than others for promoting learning: active trumps passive, constructive trumps active, and interactive trumps constructive. Here, with the specific consideration of relations to guided play in mind, we add to Chi's work to briefly synthesize the research that demonstrates that humans learn best when one or more of these four "pillars" are present (Hirsh-Pasek, Zosh, et al., 2015): (1) individuals take an **active** role in the learning environment, (2) they are **engaged**, (3) information is **meaningful**, and (4) learners **interact** in a social context.

Guided play naturally incorporates all four principles for effective learning. The child is actively engaged, and the predominantly child-directed nature of guided play ensures that the child's own interests drive the agenda, within the context of the learning goal. New information is therefore meaningfully related to the learner's existing knowledge and experience. Guided play also aligns well with Chi's (2009) suggestion that the best learning contexts are not just active or constructive, but also interactive. Through guided play, adults follow the child's lead while also providing targeted learning experiences. The teacher can provide high-quality social interactions that are contingent and adaptive by commenting on children's experiences, asking open-ended questions, or by co-playing and exploring learning materials with children. Thus, all four pillars can be achieved through guided play, which explains its effectiveness. We briefly elaborate on each of the four pillars and illustrate their importance through examples from our own research.

Active Versus Passive Learning

The notion that "learners are not empty vessels waiting to be filled" (Sawyer, 2006, p. 2) but that children learn through active exploration and participation in their environment dates back at least to the days of Piaget and Vygotsky. Since then, our approach to education has increasingly embraced the view of learning as knowledge construction rather than response or knowledge acquisition (Mayer, 1992). This approach is consistent with seeing children as mini scientists who form, test, and adapt their concepts of the world based on personal experiences (Gopnik, Meltzoff, & Kuhl, 1999). Just as adults learn better through active rather than passive engagement (Leopold & Mayer, 2015; Mazur, 2009), children benefit from being actively involved in their own learning (Chi, 2009). Rather than settling for the less reflective regurgitation of acquired knowledge (*knowledge telling*), educational environments should demand higher-order cognitive processes involved in "knowledge transforming" (Bruer, 1993).

This active involvement is not physical but "minds-on" activity, in which the child is cognitively engaged with the material (Hirsh-Pasek, Zosh, et al., 2015). While active engagement can occur during free play, adult scaffolding in guided play can also effectively support this type of minds-on involvement. Multiple studies show that children learn more from science museum exhibits when they engage in question and answer dialogs or other relevant commentary during their visits than when they are more passive (Borun, Chambers, & Cleghorn, 1996; Haden, 2002). Similarly, children learn more about chemistry when they draw relevant illustrations while learning than when they simply read about concepts or read and study preexisting, associated images (Schwamborn, Mayer, Thillmann, Leopold, & Leutner, 2010; Zhang & Linn, 2011). This phenomenon applies to other academic subjects, as well. For example, children show greater vocabulary gains from book-reading sessions when readings include question-asking and children's own use of the words than when children are passive listeners (Sénéchal, Thomas, & Monker, 1995).

One way of being "minds-on" active is to engage in cognitive exploration, which is an important hallmark of the relatively long childhood in humans compared to other species (Gopnik et al., 2015). Gopnik and colleagues recently argued that, with early neural plasticity and flexibility, children are especially well-positioned to approach learning with open-minded exploration. These authors draw a parallel to computer science's process of simulated annealing (a term borrowed from metallurgy) in which initial "high-temperature" searches consider a broad field of possibilities, and then "low-temperature" searches focus on narrower, more likely subsets of options. The authors write, "Childhood may be evolution's way of performing simulated annealing" (p. 91) in that young children approach a problem by considering a very broad array of possibilities and then, with age, use their increased experience and knowledge to focus on narrower ranges of the most likely possibilities. Pedagogies, such as playful learning, that invite children to be cognitively actively engaged capitalize on this exploratory and fluid thinking that comes naturally to young children.

One illustrative example of the impact of the *active* pillar can be found in research from our laboratories investigating children's learning about the criterial properties of geometric forms (Fisher, Hirsh-Pasek, Newcombe, & Golinkoff, 2013). In this study, children were randomly assigned to one of three conditions. In one condition, the experimenter and child pretended to be detectives trying to discover the defining properties of shapes (e.g., what makes a triangle a triangle?). Using *guided play*, the experimenter asked questions and offered suggestions, and the child was actively involved in the discovery process. In the second condition, the experimenter-turned-detective enacted a discovery process using more *didactic instruction* while the child passively watched. Children in the final condition were given an opportunity to *play freely* with the same materials, without any adult guidance or involvement. At test, children were asked to categorize shapes. Children in the guided play condition correctly identified both canonical (e.g., equilateral triangle) and non-canonical (e.g., scalene triangle) versions of the shapes, demonstrating a greater understanding of the shapes' defining properties than children in the other two groups showed. The superior learning from guided play, especially compared to didactic instruction, provides support for active learning.

Additional support for active learning comes from our Read-Play-Learn intervention project (Dickinson et al., 2016; Toub et al., 2016). This iterative series of studies investigated the use of shared book-reading and associated play activities for facilitating vocabulary development in preschoolers from low-income families. After hearing new vocabulary words via shared book-reading, children engaged in guided play with book-related toys (Toub et al., 2016). An adult incorporated vocabulary review into the children's play by using the words and asking children closed- and open-ended questions about the words. As reported by Ilgaz, Weisberg, Hirsh-Pasek, Golinkoff, and Nicolopoulou (2013), children learned more vocabulary if they answered more of the adult's questions about the words during the play, even though the frequency of the adult's use of the words was unrelated to children's vocabulary gains.

In another study showing that children learn new words better when they are actively involved, Zosh, Brinster, and Halberda (2013) presented 3- to 3.5-year-olds with images of novel objects. In the Instructional condition, the experimenter explicitly told children the label of a depicted novel object (e.g., "This is a dax"), and children simply watched and listened. Children in the Inferential condition, however, were more actively engaged in a minds-on manner: the adult showed them the image of the novel object alongside a known object and provided a novel label (e.g., "Can you point at the dax?"). This required children to use an active process of elimination to make the connection between the label and the novel object. Although children in the Instruction condition spent more time looking at the novel object during the learning period, children in the Inference condition showed better retention of the novel object names. This finding further supports the argument that children learn words better when they are actively involved—cognitively active—in the learning process.

Engaged Versus Distracted Learning

The second principle for supporting effective learning indicates that environments should promote on-task engagement and should not provide distracting elements. Multi-tasking is extremely difficult, even for adults (Watson & Strayer, 2010), and learning is most effective when an individual can focus on relevant information and disregard extraneous information (Mayer, 2014).

The evidence for this pillar plays out in two very distinct literatures: one focused on the role of distractions and learning and the other focused on cognitive processing load or cognitive load theories of memory (Cognitive Load Theory (CLT); see also Sweller, this volume). The distraction literature is very straightforward. Children learn best in environments where there are fewer distractions. In a number of laboratories, researchers found that children learned fewer letters, labels, or facts from books that had manipulative features (e.g., flaps, pull-tabs, pop-ups) than from similar books without those features (Chiong & DeLoache, 2012; Tare, Chiong, Ganea, & DeLoache, 2010). Even decorations on classroom walls can be distracting (Fisher, Godwin, & Seltman, 2014), at least when they are novel (Imuta & Scarf, 2014).

We found parallel results in our work on children's learning through books with varying degrees of extra features (Parish-Morris, Mahajan, Hirsh-Pasek, Golinkoff, & Collins, 2013). In one study, parents read books with their 3- or 5-year-old children. Half of the dyads were randomly assigned to read electronic console (EC) books, the precursor to books on tablets. The console enabled children to activate a pre-recorded story narrative, sound effects, or music or to play associated games. The remaining dyads read traditional books. While books were matched on elements such as story complexity, words per page, total pages, and characters, the book-reading experience significantly differed based on condition: parents reading traditional books said more things that related to the story and made fewer comments about children's behavior than parents reading EC books. Story-related utterances included "distancing prompts," which connect the story to children's own lives or require them to make inferences beyond the story's text. Such prompts are key elements of dialogic reading and are known to promote children's language development (Zevenbergen, Whitehurst, & Zevenbergen, 2003). The behavior-related utterances often redirected children's attention away from the buttons and back to the story. Thus, children and their parents reading a traditional book were more engaged with the story and less distracted.

To see how these differences in engagement and distraction related to children's learning, Parish-Morris and others from our lab (2013) conducted a second study. We tested children's story comprehension after the dyadic reading of a traditional or EC book with the same characters. Although 5-year-olds in both conditions performed at ceiling, 3-year-olds in dyads who read the traditional book showed significantly better story comprehension than those who read the EC book. More specifically, use of traditional books promoted more accurate responses about the content and chronology of the story, which depend on a deeper understanding of the story narrative. Putting these two studies together indicated that 3-year-olds learned better when they were reading traditional books, which facilitated greater engagement and less distraction than the EC books.

In another line of research relevant to the value of engagement versus distraction, we explored how well children can learn new words when their learning experience is disrupted by an unrelated event (Reed, Hirsh-Pasek, & Golinkoff, 2016). In a within-subjects design, mothers taught their 2-year-old children two novel words that labeled specific actions (e.g., *blicking* = a particular style of bouncing an object on one's knee, which was demonstrated for mothers in advance). Each word-learning "lesson" lasted approximately 60 s, and mothers completed two lessons per session. For one of the words, the interrupted condition, the experimenter interrupted the mother with a 30-s cell phone call after 30 s had elapsed. Mothers were then given the final 30 s to continue the lesson. For the second word, parents did not receive a cell phone call until the entire 60 s had passed. The order of the two conditions was counterbalanced across dyads. Subsequent preferential looking data indicated that children learned the novel words when they were presented without interruption, but did not learn the words delivered in the disrupted sessions. This study emphasizes the importance of consistent engagement without distractions if we want to achieve optimal learning. Even after controlling the total amount of time mothers engaged in teaching, the distracting break in the mother–child interaction interfered with the child's learning.

In part, the distraction literature concerns whether children can suppress information that is not relevant to the task. The distraction findings also speak to CLT, an educational theory anchored in an evolutionary framework that argues that the processing of biologically secondary knowledge requires a large information store that can be hindered by the limited capacity of working memory (Sweller, 2004, 2007, this volume). According to CLT, instructional practices should be designed to reduce the load on students' working memory. This is especially important to keep in mind in early childhood, as the development of working memory occurs gradually with continued improvement through adolescence (Gathercole, Pickering, Ambridge, & Wearing, 2004). Teaching practices should not tax children's working memory capacity. Interestingly, the meta-analysis by Alfieri et al. (2010) suggested that guided learning involves greater working memory demands than does direct instruction. Thus, there is a paradox in that guided instruction approaches can lead to deeper learning, but at the same time they can add counterproductive memory processing.

There is also some debate as to whether discovery learning leads to deeper learning. Kirschner, Sweller, and Clark (2006) find that problem-based instruction places heavy demands on the limited capacity working memory system, especially when dealing with novel content information, which in turn leads to *poorer* learning. Their conclusion is that teachers should provide direct, explicit instruction when teaching new content and skills to students (Kirschner et al., 2006). However, before jumping immediately to the use of direct instruction, there might be ways to circumvent the memory load problem. For example, one way to reduce working memory load might be to link new information to previously learned concepts or other relevant experiences and observations. Indeed, this relates to the pillar of learning that emphasizes making meaningful connections, which we address in the next section.

These disparate findings underscore the need for further research that specifies those contexts in which discovery versus direct instruction might be optimal for learning a particular content area or goal. Even at this point, however, we know that consideration of distractions and of working memory load will be key to designing appropriate guided play activities. To that end, we propose that guided play, when structured around the pillars of effective learning, can be implemented in a way that reduces both extraneous detail and the demands on working memory.

Meaningful Versus Unrelated Learning

A third feature of many highly effective learning environments is that they highlight connections between new information being acquired and preexisting knowledge or personal experience. Learning individual tidbits of information is not as valuable or long-lasting when done in the absence of the identification of similarities, differences, and other meaningful relations among such tidbits (Ausubel, 1968; Bransford et al., 1999; Shuell, 1990). Consider a child who knows about different kinds of dinosaurs. Once the child understands that there are various meaningful groupings, e.g., herbivores versus carnivores or bipedal versus quadrupedal, she can more quickly understand the features of a new dinosaur as she learns about it. Chi's (2009) framework of learning recognizes the construction of a mental model as an important part of the learning process. Similarly, Gray (2011) argues that environments that foster individuals' thoughtful consideration of new information rather than mere memorization of facts are most supportive of "educative instincts." These instincts, retained through natural selection, are the characteristics that drive people "to observe, explore, and practice essential elements of the culture that surrounds them" (p. 29). Education is therefore best achieved by leveraging natural inclinations to engage in personally relevant and meaningful activity. New material can be made more relevant and meaningful by highlighting for students how that material connects to real world phenomena and to their existing knowledge. More research is needed to confirm our impression that children learn better when they find the connective tissue between the new material and knowledge from their past learning or other experiences and observations about the world.

Meaningful connections for new information can be facilitated by presentation contexts that are inherently interesting, cohesive, or familiar (Hirsh-Pasek, Zosh, et al., 2015). For example, Hudson and Nelson (1983) found that children recalled more story events when they were part of more familiar narratives such as attending a birthday party versus making cookies. The *meaningful* element can also relate to the *engaged* element previously discussed and can be a motivating reward. Alvarez and Booth (2014) also noted that children were more persistent in completing a boring task when rewarded by causally meaningful information than when they were rewarded by less meaningful information or tangible rewards. When a situation is more meaningful, it is also likely more engaging.

Our work in the Read-Play-Learn series illustrates the superior learning that can occur in more meaningful contexts. In this research, children showed significant gains in receptive and expressive vocabulary knowledge about new words presented to them in the contexts of storybooks and associated play activities (Dickinson et al., 2016; Hassinger-Das, et al., 2015; Toub et al., 2016). In one study

(Toub et al., 2016), after participating in book-reading sessions that involved the introduction of new vocabulary words, preschoolers either played freely with book-related toys or engaged in one of two variations of adult-supported play. In the adult-supported play, adults helped focus the play (e.g., on scenes from the story), used commentary to connect vocabulary words to the story and children's actions, and asked questions about the words. When children played freely, however, meaningful context for vocabulary was only present if the children themselves brought the words into their play. Children in the adult-supported play conditions showed greater gains on receptive and expressive vocabulary tests than children who simply played freely. These findings demonstrate that more meaningful contexts facilitate better word-learning.

In another study in the Read-Play-Learn series (Hassinger-Das, et al., 2015; Toub et al., 2016), adults presented new words to children during book-reading and then reviewed the words in one of two ways. For half the words, adults supported children in promoting meaning-making by incorporating the words into children's guided play and asking open-ended questions about the words. For the other half of the words, children played a picture card game. This activity promoted minimal meaning-making because children merely associated words with pictures that depicted the meaning; the game did not address relations between words and the story or children's lives. When tested, children were significantly better able to express the meanings of words that were reviewed in guided play than the meanings of words that were reviewed in the picture card activity. Not all kinds of activity promote meaning-making or learning equally.

Play with board games offers another example of how meaningful, play-based approaches can support word learning. Researchers such as Ramani, Siegler, and Hitti (2012) have found that number-related board games can facilitate mathematics development, and our similar work explores games as a vehicle for preschoolers' vocabulary development. We used a book-reading activity similar to those used in the Read-Play-Learn project and coupled it with a board game (Hassinger-Das, Ridge, et al., 2016). After presenting vocabulary words in the book-reading context, the adult led children through a board game involving the words. The game was similar to *Snakes and Ladders*, and children moved their pieces across the board, periodically landing on squares that required them to review a vocabulary word from the storybook by answering the experimenter's scripted questions about the word. Questions either prompted children to recall elements of the story or stimulated them to think more deeply and make inferences or predictions. Game play only continued once a child answered correctly, either independently or with experimenter scaffolding. Therefore, the meaning of the words gained personal significance as part of the game's process. In a control condition, other children played the same board game without the integration of vocabulary review. For those children, words were reviewed separately so that children experienced a similar amount of word exposure, but in a context that was meaningful only in relation to the book. Results from pre- and post-intervention vocabulary tests indicated that children who played the integrated version of the board game gained more receptive and expressive knowledge of words than did children in the control condition. Making the words part of a fun game gave children a reason to remember them.

Our final illustration of the importance of meaningful learning contexts is a study on parent–child block play, with children ages 3- to 5-years old (Ferrara, Hirsh-Pasek, Newcombe, & Golinkoff, 2011). All parent–child dyads played with the same block set, but were randomly assigned to one of three conditions. In one condition, the only instruction was to play with blocks as they would at home. In the guided play condition with more adult scaffolding, dyads were instructed to collaboratively use the blocks to build a garage or a helipad based on step-by-step photographs. Dyads in the third condition were instructed to play freely with a preassembled garage or helipad. Based on video footage, we calculated the proportions of parents' and of children's spatial language—references to location, shapes, or dimensions, for example. Parents in the guided play with more adult scaffolding condition used significantly more spatial language than parents in the other two conditions. Similarly, children playing freely with blocks did not use as much spatial language as children building a garage or helipad through guided play or children playing with preassembled versions. Overall, free play with blocks was less effective for getting parents and children to vocalize about spatial relations and properties. Although this study did not test children's gains in spatial skills, other longitudinal work (Pruden, Levine, & Huttenlocher, 2011) and experimental research (Loewenstein & Gentner, 2005) suggests that exposure to and personal use of spatial language facilitates spatial skills. Thus, one way meaningful contexts relate to learning is by facilitating adults' and children's use of relevant language.

Interactive Versus Solitary Learning

Our fourth and final pillar of effective learning emphasizes the importance of socially interactive learning experiences, which is compatible with Chi's (2009) hierarchical framework highlighting "interactive" as the most effective characteristic of learning environments. Evolutionary perspectives differ in their emphasis on social interaction and collaboration within learning experiences. Some perspectives suggest it is likely that learning through social interaction was shaped by evolution (Herrmann, Call, Hernandez-Lloreda, Hare, & Tomasello, 2007). According to Gray (2011, 2013), hunter-gatherer children benefit from age-mixed play, in which older children can explain concepts to younger children. While serving as models for younger children to emulate, older children can also benefit from the creative and imaginative activities of younger children. From Geary's (2007a) perspective, too, social imitation and other learning within social contexts can be beneficial for the development of primary skills; however, once again, he emphasizes that socializing with other children is inadequate for mastering abstract concepts and skills (e.g., solving linear algebra problems). Direct or explicit teacher-delivered instruction is required for such biologically secondary skills, he argues.

In response, Berch (2007, 2013) claims that teacher-directed forms of instruction are not the only way that children can acquire biologically secondary knowledge and that students can attain such skills by socializing with their peers and engaging in cooperative learning and problem-solving activities. Berch (2007) cites evidence that structure and scripting of activities increases the effectiveness of cooperative learning; however, the guided play approach balances the benefits of social interaction with the aim of maintaining child-directedness and in-the-moment freedom within limited constraints. The benefits that older students gain from truly collaborative learning have been pointed out elsewhere (see Johnson, Maruyama, Johnson, Nelson, & Skon, 1981, for a review), and adult scaffolding can help facilitate such interactive learning.

Several examples of the role of social interaction in learning have emerged in the literature—starting with infants and language development, which is basic to all further learning. According to Kuhl's "social gating" hypothesis, the computations that are involved in language learning are "gated" by the social brain (Kuhl, 2007). Indeed, the linguistic input that children experience from the social environment (e.g., by parents, teachers, and peers) is positively associated with language learning. To elaborate, both the quantity (Hart & Risley, 1995) and quality (Golinkoff, Deniz Can, Soderstrom, & Hirsh-Pasek, 2015; Hirsh-Pasek, Adamson, et al., 2015; Rowe, 2012; Goldin-Meadow et al., 2014) of parental communicative input is associated with childhood language growth.

It is not merely the presence of a social partner that is important for learning, but engagement in high-quality social interactions that are contingent and adaptable (Tamis-LeMonda, Kuchirko, & Song, 2014). Infants and toddlers learn less when information is presented via television compared to live face-to-face interaction, a phenomenon known as the video deficit effect (see Anderson & Hanson, 2010 for a review). Troseth, Saylor, and Archer (2006) tested the role of social contingency in the video deficit effect by having toddlers participate in an object retrieval task. Children were more likely to follow directions to find a hidden toy when someone instructed them face-to-face versus when the same person instructed them via video. However, when the person instructed children via a contingent interaction through closed-circuit video, children successfully found the hidden toy (Troseth et al., 2006).

Recent research from our laboratory extended upon these findings. Roseberry, Hirsh-Pasek, and Golinkoff (2014) exposed toddlers to novel words in one of three conditions: socially contingent live interaction, socially contingent video chat, or a yoked video using a non-contingent pre-recorded video of the experimenter video-chatting with another child. Toddlers learned novel words from both the live interaction and the video chat conditions better than the yoked video condition. These results suggest that the video deficit effect is not driven by the digital delivery itself, but by the non-contingent interaction that children typically experience in that context.

These lessons go well beyond infancy to the importance of learning in the social nexus of the classroom. Research by Huttenlocher, Vasilyeva, Cymerman, and Levine (2002) notes that the language that children hear spoken by their teachers is linked to language outcomes. Specifically, teacher language related to growth in 4-year-olds' comprehension of complex syntax over the course of the year. Peer interaction also has tremendous impact on both expressive and receptive language achievement during the pre-kindergarten year (Mashburn, Justice, Downer, & Pianta, 2009).

Guided Play as a Middle Ground: A Recapitulation

In light of the evidence about how children learn, and equipped with evidence in favor of guided play, we suggest that the long-standing but false dichotomy between play and learning through direct instruction should be discarded. Children learn best when they are **active** (not passive), when they are **engaged** (not distracted), when the information is **meaningful** (rather than disembodied or disjointed), and when an activity is socially **interactive** (Hirsh-Pasek, Zosh, et al., 2015). These four characteristics emerge in playful environments, making playful learning an attractive option. Guided play offers a particularly promising approach (Weisberg, Hirsh-Pasek, & Golinkoff, 2013) that embraces these four pillars and should be integrated into early education to promote children's learning and development from a young age.

The short- and long-term benefits of early childhood education programs are incontrovertible (Barnett, 1995; Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2001). Children's emergent mathematical and literacy skills serve as important early predictors of later school achievement (Duncan et al., 2007; Whitehurst & Lonigan, 1998). The question before us is how we can best achieve these ends and how evolutionary perspectives can assist us in deriving the best education for all.

Gray (2011, 2013) advocates capitalizing on children's educative instincts and associated exploration as he promotes a hunter-gatherer model of education that emphasizes the importance of free play. He argues that children are capable of directing their own education and should be allowed to do so. Geary (1995, 2007a) also describes the natural biases that lead children to learn many essential and basic abilities through organic play. However, Geary (1995, 2007a) argues that there are limitations to the power of play for learning; children cannot learn biologically secondary skills through such activities alone.

We have reviewed evidence that suggests that free play is not the best approach for promoting specific educational outcomes, such as knowing how to identify a particular geometric form (e.g., a triangle) or learning a particular set of vocabulary words (Fisher et al., 2013; Toub et al., 2015). There are simply too many degrees of freedom in free play for children to notice what they are supposed to learn. The research findings are clear that, although free play has many benefits and helps support children's social and self-regulatory skills (Fisher et al., 2010; Singer & Singer, 2005), guided play trumps free play when there is a specific learning goal in mind. On the other hand, the role of the adult need not be as directive as Geary's (1995, 2007a) preferred style of formal instruction would suggest. The research findings reviewed in this chapter support the assertion that when there is a clear learning goal, we must constrain the learning possibilities and help young children focus on the most relevant content. However, one can choose to constrain the learning environment and assist in the learning of secondary skills through guided play rather than direct instruction. As noted by Weisberg, Hirsh-Pasek, and Golinkoff (2013), with guided play, the adult constructs the environment in a way that facilitates discovery of the learning dimensions. “[T]eachers might enhance children’s exploration and learning by commenting on their discoveries, co-playing along with the children, asking open-ended questions about what children are finding, or exploring the materials in ways that children might not have thought to do” (Weisberg, Hirsh-Pasek, & Golinkoff, 2013, p. 105). Use of such scaffolding techniques like dialogic inquiry and heightening engagement helps direct children’s attention and exploration and facilitates their “sense-making” processes, all of which are key elements that underlie the effectiveness of guided play (Fisher et al., 2013). Guided play thus preserves the best of both Gray’s and Geary’s positions and asks how they might work in tandem to optimize the learning of primary and secondary skills. Merging insights from Gray and Geary’s evolutionary perspectives, guided play combines the emphasis on child exploration with the guidance of a goal-oriented adult.

The weight of the evidence forces us to conclude that guided play can offer a preferred middle ground between free play and direct instruction (Fig. 5.1). Guided play presents an evidence-based, pedagogical sweet spot with a careful balance between constraining the learning environment and scaffolding an activity versus respecting children’s agency as they direct their play. As a child-directed activity that maintains the enjoyable nature of play within the context of an adult’s developmentally appropriate, contingent, scaffolded, and goal-directed support, guided play naturally uses mechanisms that foster strong learning (Weisberg, Hirsh-Pasek, & Golinkoff, 2013). As we have argued elsewhere (Weisberg, Hirsh-Pasek, Golinkoff, & McCandliss, 2014), guided play can also promote in children a positive approach to learning (through *mise en place*), rather than promoting a view of learning as an unpleasant and unenjoyable experience (Resnick, 2004). All these characteristics make guided play a promising approach to learning.

Conclusion

The US education system has been mired by reforms that have unintentionally pitted rich curricula against age-appropriate pedagogy—learning versus play. It is time to re-examine issues of educational reform in terms of the rich literature available in the learning sciences and evolutionary psychology. When we do so, we quickly realize that children learn best when they are active, engaged, learning meaningful material, and in a social context. These ingredients emerge in play. But, as Geary so rightly notes, play alone will not be sufficient to help children learn biologically secondary information like simultaneous equations or even literary inference. Adults must provide scaffolding to constrain the potential interpretations and possibilities. Here we offered evidence from early childhood studies that children can both be masters of their learning and navigate through a constrained learning space that elevates their performance toward a learning goal. Guided play thus offers a new pedagogical approach that is antithetical to many current educational practices. It is, however, consistent with both findings in the science of learning and a blended evolutionary theory on how children learn best.

Future Directions

We propose five main questions about guided play to address as we move forward (see Table 5.1). First, how is guided play best operationalized? Second, what are the long-term impacts of guided play on academic and social outcomes? Third, in what

Table 5.1 Key questions and directions for future research on guided play

Key question	Future direction
How is guided play best operationalized?	We need to determine the optimal balance of adult-led guidance and scaffolding without intruding on children's autonomy in the learning experience
What are the long-term impacts of guided play on academic and social outcomes?	There is some evidence that children who experience playful, child-initiated preschool programs, compared with direct instruction or a combination approach, show better social and academic outcomes in sixth grade (Marcon, 1999, 2002). More work needs to explore the potential long-term benefits and knowledge transfer gained through playful learning, and guided play in particular
In what cases is guided play more (or less) effective?	One consideration is age. Since most existing work focuses on young children, we need to examine whether guided play relates to cognitive and social outcomes in older children and adults. Also, distinctions between procedural versus conceptual learning or novel versus familiar material might have implications for pedagogy, given concerns about the working memory load of guided play
How can we best train teachers (and parents) to adopt guided play pedagogical approaches?	It takes mastery to weave tidbits of content related to learning goals into play in meaningful ways without usurping children's agency. Teachers in the Read-Play-Learn project had difficulty juggling both the specific vocabulary review strategies and the guided play style that we sought to achieve (Toub et al., 2015). What type of support do teachers or parents need to comfortably and effectively implement guided play approaches? In addition, Geary's (1995) emphasis on direct instruction is based on universal education and a practical concern about the feasibility of individualized instruction. How can guided play be implemented in large classroom settings?
How do we best disseminate this information?	Unfortunately, many policymakers operate under the false belief that adopting rigid curricula and standardized assessments is the best way to gauge student learning (Miller & Almon, 2009). We must inspire parents, educators, and policymakers to embrace guided play as a favorable alternative and better communicate with these stakeholders about the merits of guided play

cases is guided play more (or less) effective? Fourth, how can we best train teachers (and parents) to adopt guided play approaches in their interactions with children? Lastly, how do we best disseminate this information? Our collective pursuit of answers to such questions will help us clarify and maximize the benefits of guided play as a pedagogical approach to add to our active repertoires.

References

Alfieri, L., Brooks, P., Aldrich, N. J., & Tenenbaum, H. R. (2010). Does discovery-based instruction enhance learning? *Journal of Educational Psychology, 103*(1), 1–18. doi:10.1037/a0021017.

Alvarez, A. L., & Booth, A. E. (2014). Motivated by meaning: Testing the effect of knowledge-infused rewards on preschoolers' persistence. *Child Development, 85*(2), 783–791. doi:10.1111/cdev.12151.

Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How learning works: Seven research-based principles for smart teaching*. San Francisco, CA: Jossey-Bass.

Anderson, D. R., & Hanson, K. G. (2010). From blooming, buzzing confusion to media literacy: The early development of television viewing. *Developmental Review, 30*(2), 239–255. doi:10.1016/j.dr.2010.03.004.

Ausubel, D. (1968). *Educational psychology: A cognitive view*. New York, NY: Holt, Rinehart, & Winston.

Barnett, W. S. (1995). Long-term effects of early childhood programs on cognitive and school outcomes. *The Future of Children, 5*(3), 25–50. doi:10.2307/1602366.

Berch, D. B. (2007). Instructing evolved minds: Pedagogically primary strategies for promoting biologically secondary learning. In J. S. Carlson & J. R. Levin (Eds.), *Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology* (pp. 109–118). Greenwich, CT: Information Age.

Berch, D. B. (2013). *Evolutionary theory can inform the intelligent design of educational policy and practice*. Retrieved from https://evolution-institute.org/project/education/evolutionary-theory-can-inform-the-intelligent-design-of-educational-policy-and-practice/.

Bjorklund, D. F. (2007). The most educable of animals. In J. S. Carlson & J. R. Levin (Eds.), *Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology* (pp. 119–129). Greenwich, CT: Information Age.

Bonawitz, E., Shafto, P., Gweon, H., Goodman, N. D., Spelke, E., & Schulz, L. (2011). The double-edged sword of pedagogy: Instruction limits spontaneous exploration and discovery. *Cognition, 120*(3), 322–330. doi:10.1016/j.cognition.2010.10.001.

Borun, M., Chambers, M., & Cleghorn, A. (1996). Families are learning in science museums. *Curator: The Museum Journal, 39*, 123–138. doi:10.1111/j.2151-6952.1996.tb01084.x.

Bransford, J., Brown, A., & Cocking, R. (Eds.). (1999). *How people learn: Brain, mind, experience and school*. Washington, DC: National Academy of Sciences.

Bruer, J. T. (1993). *Schools for thought: A science of learning in the classroom*. Cambridge, Mass: MIT Press. eBook Collection (EBSCOhost), EBSCOhost (accessed August 4, 2015).

Campbell, F. A., Pungello, E. P., Miller-Johnson, S., Burchinal, M., & Ramey, C. T. (2001). The development of cognitive and academic abilities: Growth curves from an early childhood education experiment. *Developmental Psychology, 37*(2), 231–242. doi:10.1037/0012-1649.37.2.231.

Chi, M. T. H. (2009). Active-constructive-interactive: A conceptual framework for differentiating learning activities. *Topics in Cognitive Science, 1*, 73–105. doi:10.1111/j.1756-8765.2008.01005.

Chiong, C., & DeLoache, J. S. (2012). Learning the ABCs: What kinds of picture books facilitate young children's learning? *Journal of Early Childhood Literacy, 13*(2), 225–241. doi:10.1177/1468798411430091.

Dickinson, D. K., Nesbitt, K. T., Collins, M. F., Hadley, E. B., Newman, K., Rivera, B., … Hirsh-Pasek, K. (2016). *Using book reading to teach for breadth and depth of vocabulary*. Manuscript in preparation.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., & Japel, C. (2007). School readiness and later achievement. *Developmental Psychology, 43*(6), 1428–1446. doi:10.1037/0012-1649.43.6.1428.

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest, 14*, 4–58. doi:10.1177/1529100612453266.

Elkind, D. (2008). Can we play? *Greater Good, 4*, 14–17. Retrieved from http://greatergood.berkeley.edu/article/item/can_we_play/.

Feigenson, L., Dehaene, S., & Spelke, E. (2004). Core systems of number. *Trends in Cognitive Sciences, 8*(7), 307–314. doi:10.1016/j.tics.2004.05.002.

Ferrara, K., Hirsh-Pasek, K., Newcombe, N., & Golinkoff, R. (2011). Block talk: Spatial language during block play. *Mind, Brain & Education, 5*(3), 143–151. doi:10.1111/j.1751-228X.2011.01122.x.

Fisher, A. V., Godwin, K. E., & Seltman, H. (2014). Visual environment, attention allocation, and learning in young children: When too much of a good thing may be bad. *Psychological Science, 25*(7), 1362–1370. doi:10.1177/0956797614533801.

Fisher, K., Hirsh-Pasek, K., Golinkoff, R. M., Singer, D. G., & Berk, L. (2010). Playing around in school: Implications for learning and educational policy. In A. Pellegrini (Ed.), *The Oxford handbook of the development of play* (pp. 341–363). New York, NY: Oxford University Press.

Fisher, K. R., Hirsh-Pasek, K., Newcombe, N., & Golinkoff, R. M. (2013). Taking shape: Supporting preschoolers' acquisition of geometric knowledge through guided play. *Child Development, 84*(6), 1872–1878. doi:10.1111/cdev.12091.

Gathercole, S. E., Pickering, S. J., Ambridge, B., & Wearing, H. (2004). The structure of working memory from 4 to 15 years of age. *Developmental Psychology, 40*(2), 177–190. doi:10.1037/0012-1649.40.2.177.

Geary, D. C. (1995). Reflections of evolution and change in children's cognition: Implications for mathematical development and instruction. *American Psychology, 50*(1), 24–37.

Geary, D. C. (2007a). Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology. In J. S. Carlson & J. R. Levin (Eds.), *Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology* (pp. 1–99). Greenwich, CT: Information Age.

Geary, D. C. (2007b). Reflections and refinements. In J. S. Carlson & J. R. Levin (Eds.), *Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology* (pp. 177–203). Greenwich, CT: Information Age.

Ginsburg, H. P., Pappas, S., & Seo, K. (2001). Everyday mathematical knowledge: Asking young children what is developmentally appropriate. In S. L. Golbeck (Ed.), *Psychological perspectives on early childhood education: Reframing dilemmas in research and practice* (pp. 181–219). Mahwah, NJ: Lawrence Erlbaum.

Goldin-Meadow, S., Levine, S. C., Hedges, L. V., Huttenlocher, J., Raudenbush, S. W., & Small, S. L. (2014). New evidence about language and cognitive development based on a longitudinal study: Hypotheses for intervention. *American Psychologist, 69*(6), 588–599. doi:10.1037/a0036886.

Golinkoff, R. M., Deniz Can, D., Soderstrom, M., & Hirsh-Pasek, K. (2015). (Baby)talk to me: The social context of infant-directed speech and its effects on early language acquisition. *Current Directions in Psychological Science, 24*, 339–344.

Golinkoff, R. M., & Hirsh-Pasek, K. (2016). *Becoming brilliant: What science tells us about raising successful children*. Washington, DC: American Psychological Association.

Gopnik, A., Griffiths, T. L., & Lucas, C. G. (2015). When younger learners can be better (or at least more open-minded) than older ones. *Current Directions in Psychological Science, 24*(2), 87–92. doi:10.1177/0963721414556653.

Gopnik, A., Meltzoff, A. N., & Kuhl, P. K. (1999). *The scientist in the crib: Minds, brains, and how children learn*. New York, NY: Morrow Press.

Gray, P. (2011). The evolutionary biology of education: How our hunter-gatherer educative instincts could form the basis for education today. *Evolution: Education and Outreach, 4*(1), 28–40. doi:10.1007/s12052-010-0306-1.

Gray, P. (2013). *Free to Learn: Why unleashing the instinct to play will make our children happier, more self-reliant, and better students for life*. New York, NY: Basic Books.

Haden, C. A. (2002). Talking about science in museums. *Child Development, 4*, 62–67. doi:10.1111/j.1750-8606.2009.00119.x.

Hart, B., & Risley, T. R. (1995). *Meaningful differences in the everyday experiences of young American children*. Baltimore, MD: Brookes.

Hassinger-Das, B., Ridge, K., Parker, A., Golinkoff, R., Hirsh-Pasek, K., & Dickinson, D. K. (2016). *Building vocabulary knowledge in preschoolers through shared book-reading and game play*. Manuscript submitted for publication.

Hassinger-Das., B., Toub, T. S., Ilgaz, H., Weisberg, D., Nesbitt, K. T., Collins, M. F., & Nicolopoulou, A. (2015). Playing to learn: How book-reading + guided play can improve vocabulary for low-income preschoolers. In T. S. Toub (Chair), *Beyond book-reading: Promoting vocabulary development through innovative activities.* Philadelphia, PA: Society for Research in Child Development.

Herrmann, E., Call, J., Hernandez-Lloreda, M. V., Hare, B., & Tomasello, M. (2007). Humans have evolved specialized skills of social cognition: The cultural intelligence hypothesis. *Science, 317*(5843), 1360–1366. doi:10.1126/science.1146282.

Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., … Suma, K. (2015). The contribution of early communication quality to low-income children's language success. *Psychological Science, 26*, 1071–1083. doi:10.1177/0956797615581493.

Hirsh-Pasek, K., & Golinkoff, R. M. (2003). *Einstein never used flashcards: How our children really learn and why they need to play more and memorize less*. Emmaus, PA: Rosedale.

Hirsh-Pasek, K., & Golinkoff, R. M. (2011). The great balancing act: Optimizing core curricula through playful learning. In E. Zigler, W. S. Gilliam, & W. S. Barnett (Eds.), *The pre-K debates: Current controversies and issues* (pp. 110–115). Baltimore, MD: Brookes.

Hirsh-Pasek, K., Golinkoff, R. M., Berk, L. E., & Singer, D. G. (2009). *A mandate for playful learning in school: Presenting the evidence*. New York, NY: Oxford University Press.

Hirsh-Pasek, K., Zosh, J., Golinkoff, R. M., Gray, J., Robb, M., & Kaufman, J. (2015). Putting education in "educational" apps: Lessons from the science of learning. *Psychological Science in the Public Interest, 16*(1), 3–34. doi:10.1177/1529100615569721.

Hudson, J., & Nelson, K. (1983). Effects of script structure on children's story recall. *Developmental Psychology, 19*(4), 625–635. doi:10.1037//0012-1649.19.4.625.

Husen, T. (Ed.). (1967). *International study of achievement in mathematics: A comparison of twelve countries (Vols. 1 & 2)*. New York, NY: Wiley.

Huttenlocher, J., Vasilyeva, M., Cymerman, E., & Levine, S. (2002). Language input and child syntax. *Cognitive Psychology, 45*(3), 337–374. doi:10.1016/S0010-0285(02)00500-5.

Ilgaz, H., Weisberg, D., Hirsh-Pasek, K., Golinkoff, R. M., & Nicolopoulou, A. (2013). Not all play is created equal: When playful learning sparks vocabulary acquisition in low-income children. In D. Dickinson (Chair), *Effects of varied types of adult-supported play on preschool children's receptive vocabulary learning*. Seattle, WA: Society for Research on Child Development.

Imuta, K., & Scarf, D. (2014). When too much of a novel thing may be what's 'bad': Commentary on Fisher, Godwin, and Seltman (2014). *Frontiers in Psychology, 5*, 1–2. doi:10.3389/fpsyg.2014.01444.

Johnson, J. E., Christie, J. F., & Yawkey, T. D. (1999). *Play and early childhood development*. New York, NY: Addison Wesley Longman.

Johnson, D. W., Maruyama, G., Johnson, R., Nelson, D., & Skon, L. (1981). Effects of cooperative, competitive, and individualistic goal structures on achievement: A meta-analysis. *Psychological Science, 89*(1), 47–62. doi:10.1037/0033-2909.89.1.47.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86. doi:10.1207/s15326985ep4102_1.

Kittredge, A. K., Klahr, D., & Fisher, A. V. (2014). *Direct instruction of discovery*. Poster presented at the annual meeting of the American Educational Research Association, Philadelphia, PA.

Klahr, D., & Nigam, M. (2004). The equivalence of learning paths in early science instruction: Effects of direct instruction and discovery learning. *Psychological Science, 15*(10), 661–667. doi:10.1111/j.0956-7976.2004.00737.x.

Kochuk, N., & Ratnayaka, M. (2007). *NCLB/ESEA: It's time for a change! Voices from America's classrooms*. Washington, DC: National Education Association.

Kuhl, P. K. (2007). Is speech learning 'gated' by the social brain? *Developmental Science, 10*(1), 110–120. doi:10.1111/j.1467-7687.2007.00572.x.

Leopold, C., & Mayer, R. E. (2015). An imagination effect in learning from scientific text. *Journal of Educational Psychology, 107*(1), 47–63. doi:10.1037/a0037142.

Lillard, A. (2001). Pretend play as twin earth: A social-cognitive analysis. *Developmental Review, 21*(4), 495–531. doi:10.1006/drev.2001.0532.

Lillard, A. S. (2013). Playful learning and Montessori education. *American Journal of Play, 5*(2), 157–186.

Loewenstein, J., & Gentner, D. (2005). Relational language and the development of relational mapping. *Cognitive Psychology, 50*(4), 315–353. doi:10.1016/j.cogpsych.2004.09.004.

Marcon, R. A. (1999). Differential impact of preschool models on development and early learning of inner-city children: A three-cohort study. *Developmental Psychology, 35*(2), 358–375. doi:10.1037/0012-1649.35.2.358.

Marcon, R. (2002). Moving up the grades: Relationships between preschool model and later school success. *Early Childhood Research and Practice, 4*(1), 517–530.

Mashburn, A. J., Justice, L. M., Downer, J. T., & Pianta, R. C. (2009). Peer effects on children's language achievement during pre-kindergarten. *Child Development, 80*(3), 686–702. doi:10.1111/j.1467-8624.2009.01291.x.

Mayer, R. E. (1992). Cognition and instruction: Their historic meeting within educational psychology. *Journal of Educational Psychology, 84*(4), 405–412. doi:10.1037//0022-0663.84.4.405.

Mayer, R. E. (2011). *Applying the science of learning*. Upper Saddle River, NJ: Pearson.

Mayer, R. E. (2014). Research-based principles for designing multimedia instruction. In V. A. Benassi, C. E. Overson, & C. M. Hakala (Eds.), *Applying science of learning in education: Infusing psychological science into the curriculum*. Retrieved from the Society for the Teaching of Psychology website, http://teachpsych.org/ebooks/asle2014/index.php.

Mazur, E. (2009). Farewell, lecture? *Science, 323*(5910), 50–51. doi:10.1126/science.1168927.

Meltzoff, A. N., Kuhl, P. K., Movellan, J., & Sejnowski, T. J. (2009). Foundations for a new science of learning. *Science, 325*(5938), 284–288. doi:10.1126/science.1175626.

Miller, E., & Almon, J. (2009). *Crisis in kindergarten: Why children need to play in school*. College Park, MD: Alliance for Childhood.

Morrow, L. M., & Rand, M. K. (1991). Promoting literacy during play by designing early childhood classroom environments. *Reading Teacher, 44*(6), 396–402. Retrieved from http://www.jstor.org/stable/20200675.

No Child Left Behind Act (NCLB, 2001). *Public Law* 107–110, USA.

Organisation for Economic Co-operation and Development (2012). *PISA 2012 Results: What Student Know and Can Do—Student Performance in Reading, Mathematics and Science (Volume 1)*. Retrieved from http://www.oecd.org/pisa/keyfindings/pisa-2012-results-volume-I.pdf.

Parish-Morris, J., Mahajan, N., Hirsh-Pasek, K., Golinkoff, R. M., & Collins, M. F. (2013). Once upon a time: Parent-child dialogue and storybook reading in the electronic era. *Mind, Brain, and Education, 7*(3), 200–211. doi:10.1111/mbe.12028.

Pellegrini, A. D. (2009). *The role of play in human development*. New York, NY: Oxford University Press.

Pellegrini, A. D., & Galda, L. (1990). Children's play, language, and early literacy. *Topics in Language Disorders, 10*(3), 76–88.

Pruden, S. M., Levine, S. C., & Huttenlocher, J. (2011). Children's spatial thinking: Does talk about the spatial world matter? *Developmental Science, 14*(6), 1417–1430. doi:10.1111/j.1467-7687.2011.01088.x.

Ramani, G. B., Siegler, R. S., & Hitti, A. (2012). Taking it to the classroom: Number board games as a small group learning activity. *Journal of Educational Psychology, 104*, 661–672. doi:10.1037/a0028995.

Reed, J., Hirsh-Pasek, K., & Golinkoff, R. M. (2016). *Learning on hold: Cell phones sidetrack parent-child interactions*. Manuscript under review.

Resnick, M. (2004). Edutainment? No thanks. I prefer playful learning. *Associazione Civita Report on Edutainment, 14*, 1–4.

Roseberry, S., Hirsh-Pasek, K., & Golinkoff, R. M. (2014). Skype me! Socially contingent interactions help toddlers learn language. *Child Development, 85*(3), 956–970. doi:10.1111/cdev.12166.

Rowe, M. L. (2012). A longitudinal investigation of the role of quantity and quality of child-directed speech in vocabulary development. *Child Development, 83*(5), 1762–1774. doi:10.1111/j.1467-8624.2012.01805.x.

Sawyer, R. K. (Ed.). (2006). *The Cambridge handbook of the learning sciences*. New York, NY: Cambridge University Press.

Schwamborn, A., Mayer, R. E., Thillmann, H., Leopold, C., & Leutner, D. (2010). Drawing as a generative activity and drawing as a prognostic activity. *Journal of Educational Psychology, 102*(4), 872–879. doi:10.1037/a0019640.

Sénéchal, M., Thomas, E., & Monker, J. (1995). Individual differences in 4-year-old children's acquisition of vocabulary during storybook reading. *Journal of Educational Psychology, 87*(2), 218–229. doi:10.1037/0022-0663.87.2.218.

Shuell, T. J. (1990). Phases of meaningful learning. *Review of Educational Research, 60*(4), 531–547. doi:10.3102/00346543060004531.

Singer, D. G., Golinkoff, R. M., & Hirsh-Pasek, K. (2006). *Play: How play motivates and enhances children's cognitive and social-emotional growth*. New York, NY: Oxford University Press.

Singer, D. G., & Singer, J. L. (2005). *Imagination and play in the electronic age*. Cambridge, MA: Harvard University Press.

Sunderman, G. L., Tracey, C. A., Kim, J., & Orfield, G. (2004). *Listening to teachers: Classroom realities and No Child Left Behind*. Cambridge, MA: The Civil Rights Project at Harvard University. Retrieved from http://files.eric.ed.gov/fulltext/ED489176.pdf.

Sweller, J. (2004). Instructional design consequences of an analogy between evolution by natural selection and human cognitive architecture. *Instructional Science, 32*(1–2), 9–31. doi:10.1023/B:TRUC.0000021808.72598.4d.

Sweller, J. (2007). Evolutionary biology and educational psychology. In J. S. Carlson & J. R. Levin (Eds.), *Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology* (pp. 165–175). Greenwich, CT: Information Age.

Tamis-LeMonda, C. S., Kuchirko, Y., & Song, L. (2014). Why is infant language learning facilitated by parental responsiveness? *Current Directions in Psychological Science, 23*(2), 121–126. doi:10.1177/0963721414522813.

Tare, M., Chiong, C., Ganea, P., & DeLoache, J. (2010). Less is more: How manipulative features affect children's learning from picture books. *Journal of Applied Developmental Psychology, 31*, 395–400. doi:10.1016/j.appdev.2010.06.005.

Toub, T. S., Hassinger-Das., B., Nesbitt, K. T., Unlutabak, B., Wilson, S., Nicolopoulou, A., … Dickinson, D. (2015, March). Playing for words: Best practices for guided play in support of vocabulary development. In B. Hassinger-Das (Chair), *Learning to play: Identifying and assessing key elements of playful learning*. Symposium conducted at the biennial meeting of the Society for Research in Child Development, Philadelphia, PA.

Toub, T. S., Hassinger-Das, B., Nesbitt, K. T., Ilgaz, H., Weisberg, D. S., Collins, M. F., … Dickinson, D. (2016). *The language of play: Developing preschool vocabulary through play following shared book-reading*. Manuscript under review.

Troseth, G. L., Saylor, M. M., & Archer, A. H. (2006). Young children's use of video as a source of socially relevant information. *Child Development, 77*(3), 786–799. doi:10.1111/j.1467-8624.2006.00903.x.

Viadero, D. (2007). Teachers say NCLB has changed classroom practice. *Education Week, 26*, 6–22. Retrieved from http://www.edweek.org/ew/articles/2007/06/20/42rand.h26.html.

Watson, J. M., & Strayer, D. L. (2010). Supertaskers: Profiles in extraordinary multitasking ability. *Psychonomic Bulletin & Review, 17*(4), 479–485. doi:10.3758/PBR.17.4.479.

Weisberg, D. S., Hirsh-Pasek, K., Golinkoff, R. M., & McCandliss, B. D. (2014). Mise en place: Setting the stage for thought and action. *Trends in Cognitive Sciences, 18*(6), 276–278. doi:10.1016/j.tics.2014.02.012.

Weisberg, D. S., Hirsh-Pasek, K., & Golinkoff, R. M. (2013). Guided play: Where curricular goals meet a playful pedagogy. *Mind, Brain, and Education, 7*(2), 104–112. doi:10.1111/mbe.12015.

Weisberg, D. S., Kittredge, A. K., Hirsh-Pasek, K., Golinkoff, R. M., & Klahr, D. (2015). Guided play: Making play work for education. *Phi Delta Kappan, 96*, 8–13.

Weisberg, D. S., Zosh, J. M., Hirsh-Pasek, K., & Golinkoff, R. M. (2013). Talking it up: Play, language, and the role of adult support. *American Journal of Play, 6*(1), 39–54. Retrieved from http://www.journalofplay.org/.

Whitehurst, G. J., & Lonigan, C. J. (1998). Child development and emergent literacy. *Child Development, 69*(3), 848–872. doi:10.2307/1132208.

Wolfgang, C. H., Stannard, L. L., & Jones, I. (2003). Advanced construction play with LEGOs among preschoolers as a predictor of later school achievement in mathematics. *Early Child Development and Care, 173*(5), 467–475. doi:10.1080/0300443032000088212.

Zevenbergen, A. A., Whitehurst, G. J., & Zevenbergen, J. A. (2003). Effects of a shared-reading intervention on the inclusion of evaluative devices in narratives of children from low-income families. *Journal of Applied Developmental Psychology, 24*, 1–15. doi:10.1016/S0193-3973(03)00021-2.

Zhang, Z. H., & Linn, M. C. (2011). Can generating representations enhance learning with dynamic visualizations? *Journal of Research in Science Teaching, 48*(10), 1177–1198. doi:10.1002/tea.20443.

Zosh, J. M., Brinster, M., & Halberda, J. (2013). Optimal contrast: Competition between two referents improves word learning. *Applied Developmental Science, 17*(1), 20–28. doi:10.1080/10888691.2013.748420.

Part II
Social and Moral Development

Chapter 6
Eight Myths of Child Social Development: An Evolutionary Approach to Power, Aggression, and Social Competence

Patricia H. Hawley

> Myths are stories that express meaning, morality or motivation.
> —Michael Shermer
> Science must begin with myths, and with the criticism of myths.
> —Karl Popper

Evolutionary approaches to human behavior and child development often challenge widespread views of these phenomena. My own work for almost two decades, for example, has focused on power relationships in childhood and adolescence. My first published piece was an outline of my theoretical framework (Hawley, 1999) that has since come to be known as resource control theory (RCT; see also Geary, 2005; Pellegrini & Long, 2003). This framework was built on the shoulders of giants who wrote elegantly about the development of aggression in children (Coie, Dodge, Terry, & Wright, 1991; Dodge, Coie, Pettit, & Price, 1990), the evolution of competition via cooperation (Alexander, 1979; Charlesworth, 1996; Trivers, 1971), and social dominance relationships (Bernstein, 1981; Maslow, 1936a, 1936b; Strayer & Strayer, 1976). RCT offered the view that social dominance from an animal behavior perspective was alive and well in humans (young and old), and that these evolved power patterns were cloaked by human values and language. Namely, I proposed, that we simply call social dominance a variety of self-interested "leadership".

There are a number of hurdles to an evolutionarily informed child development. The first being the widespread misunderstanding that evolution implies that humans are motivationally selfish. This assumption is simply false. Second, developmentalists often use the terms "prosocial" (behavior that benefits another; Eisenberg, Fabes, & Spinrad, 2006, p. 646) and "altruistic" (e.g., motivated by other concern: Eisenberg & Fabes, 1998) interchangeably. This conflation not only causes confusion in developmental circles, but also hinders the integration of evolution and child

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development. But misconceptions are not only limited to the incorrect application of evolution. Sometimes our deeply held beliefs and preferences (e.g., "cheaters never prosper") can stand in the way of seeing human behavior in its full complexity. No definitive statement of the nature of human nature has been advanced.

This chapter is organized around eight related "myths" relevant to evolution and child development. Though it should be borne in mind that every narrative has some element of truth to it hinging on, for example, semantics (what is meant by social competence? Myth 4). This is one reason why science is not about uncovering "truths" per se.

In addition to addressing prosociality and altruism from evolutionary and developmental (psychology) perspectives, I will also address how "nice guys" do not in fact "finish last," how cheaters sometimes *do* prosper, why social competence doesn't necessarily mean being nice all the time, and how "mean" kids are liked and how bullies benefit from their behavior. I will close by describing how hierarchies do not first emerge in adolescence, why social dominance and power is not solely the purview of males, and finally, why these issues really matter.

Myth 1: Evolution Implies That We Are Selfish (or, Genetically Selfish Behavior Is Motivationally Selfish)

One the most frequent misconceptions about evolutionary theory is that it implies people are selfish (Brem, Ranney, & Schindel, 2003). Communication within scientific circles is sometimes no better off. For example, researchers in both child development and evolutionary sciences seek to understand human altruism. Indeed, altruism is an important point of contact for these historically distinct fields. Unfortunately, shared terms such as altruism refer to *unshared constructs*. Consequently, a good deal of confusion has resulted about this important aspect of human behavior. Famously, Richard Dawkins made a case for the "selfish gene" (Dawkins, 1989). This immediately led many to erroneously conclude (including Dawkins himself) that humans were selfishly motivated. Extending this logic further, perhaps this is why child development is the "last frontier" of evolutionary sciences; child researchers, clinicians, and practitioners may be reluctant to see children as inherently selfish. But this conclusion is born from confusion, which I will attempt to clarify (see Hawley, 2014 for a full explication).

Prosocial Behavior and Altruistically Motivated Behavior Are Not the Same

First, even within our own discipline, we tend to use the terms "altruistic" and "prosocial" interchangeably. I will defer to Nancy Eisenberg in defining prosocial behavior: "voluntary behavior intended to benefit another" (Eisenberg et al., 2006; p. 646).

This definition includes helping, sharing, and cooperating. Altruistic motivations (e.g., out of sympathetic or empathic concern for others, Eisenberg & Fabes, 1998; increasing another's welfare without the goal of increasing one's own, Batson, 1998) may underlie said behavior. However, Eisenberg and colleagues are careful to point out that prosocial behavior may have several underlying motivations, such as "egoistic, other-oriented, or practical concerns" (Eisenberg et al., 2006; p. 646). Since prosociality has many underlying motivations, altruistic being only one class, altruistically motivated (prosocial) behavior is a smaller subcategory of the higher order group of prosocial behavior in general. Thus, these terms should not be used interchangeably.

What are altruistic motivations in children? Eisenberg and colleagues argue for other-concerning motives that comprise empathic or sympathetic concern (Eisenberg, 1991; Eisenberg, Shea, Carlo, & Knight, 1991), the cognitive taking of another's perspective (Eisenberg, 1991), or acting out of one's internalized value system or a strong personal moral identity (Eisenberg, 1991; Eisenberg et al., 1991). In contrast, self-serving motivations include behaving out of desire to reduce unpleasant emotional arousal (e.g., Eisenberg et al., 1991), guilt (e.g., Batson, 2011), pride or righteousness (Batson & Shaw, 1991; Eisenberg, 1986), expectation of present or future material gains (Hawley, Shorey, & Alderman, 2009), or reputational gains such as social approval (Carlo & Randall, 2002; Mestre, Carlo, Samper, Tur-Porcar, & Mestre, 2015).

Because altruistic motivations operate in the psychological domain, evolutionists tend to refer to them as *proximate levels of causation* (psychological mechanisms and processes) to differentiate them from *ultimate levels of causation*, a level that involves functions shaped by natural selection (Tinbergen, 1963). For prosocial behavior to be considered altruistic from this proximate view, motives must be established. But motivations are complicated, and not the same as intentions (self-report of one's goals) which are vulnerable to falsification to manage the impressions of others (see Shaw, this volume). Motivations in contrast are internal psychological forces that may be conscious or unconscious (Bargh & Morsella, 2008; Batson & Shaw, 1991), and as such, assessing them goes beyond self-report. Conscious goals and intentions interact in complex ways with unconscious processes, and lie beyond this chapter. For now, it is enough to say that human motivations are complex, invisible, and cannot be merely assumed. Motives may or may not be accessible to respondents and moreover do not often correspond closely to behavior (Webb & Sheeran, 2006). This latter point is especially relevant to evolutionary approaches to behavior.

Evolutionary Definitions of Prosocial and Altruistic Behavior

Evolutionists, like psychologists, are deeply concerned with "behavior that benefits another," such as helping, sharing, and cooperating (e.g., Clutton-Brock, 2002, 2009). Indeed, such behavior has posed some of the greatest theoretical and philosophical puzzles in evolutionary circles for over a century. Evolutionary definitions of other-oriented behavior (such as "altruism"), however, differ fundamentally from psychological definitions. Namely, "altruism" from a biological evolutionary perspective has little to do with "intentions" or "motivation," which lie strictly in the psychological/proximal domains.

A Focus on Fitness Cost. Instead, evolutionary approaches focus on *effects* of *behavior* (motoric, cognitive, emotional), especially currencies related to reproductive success (e.g., somatic development, material and social resource acquisition, hierarchy ascension, mating, parenting). That is, while altruism from a psychologist's view is directed behavior that benefits another and is motivated by true other-oriented concern (and as such is considered psychologically unselfish), biologists define altruism as behaviors that can influence lifetime fitness effects: A behavior is altruistic insofar as it confers a fitness benefit to a recipient at a fitness cost to the actor (Trivers, 1971). Nothing at this level is stated in terms of intention or motivation (Hawley, 2014).

Indeed, and of central importance to our first myth, no conclusions can be drawn about motivation even when knowing whether a behavior is genetically selfish or genetically altruistic. That is, psychological altruism is independent from biological altruism.

Has a Fitness Cost Been Incurred? No. The predominant point of view in biological circles is that genetically altruistic behaviors (i.e., costly behaviors that do not in some way enhance survival or reproduction) cannot evolve. Instead, all documented mechanisms of natural and sexual selection result in genetic benefit conferred on the actor.

With **kin selection** mechanisms, for example, the benefits of which are measured by "inclusive fitness" (shared genes with descendent and non-descendent kin; Hamilton, 1964). Kin selection accounts for cooperation among related individuals that, while perhaps costly in proximate terms (time, energy), is benefit bestowing in terms of evolutionary payoffs (survival and reproduction). At the same time, these behaviors (especially parenting) are most assuredly proximately both prosocial and motivationally altruistic.

Direct reciprocity (formerly known as reciprocal altruism; Trivers, 1971) sought to solve the puzzle of cooperation among *unrelated* individuals (i.e., reciprocal exchange). The mechanism for the evolution of this form of cooperation would lie in the probability that the favor would be later returned to the actor. Thus, in the end, Trivers' theory too claims that such exchanges are fitness enhancing in the long term, and therefore not biologically altruistic because they are driven by genetic self-interest. Thus, "reciprocal altruism" is not altruistic in either biological or psychological senses, and as such, has unfortunately caused a good deal of confusion. As an extension of Trivers' theory of direct reciprocity, **indirect reciprocity** operates on the currency of reputational benefits (Alexander, 1987); people who have been visibly helpful to those in need (i.e., have reputations for being "helpful") are more likely to receive help from the group (Nowak & Sigmund, 2005). By extension, public signals suggesting altruism can be used to enhance status (e.g., competitive altruism; Böhm & Regner, 2013; Frank, 1988; Griskevicius, Tybur, & Van den Bergh, 2010). Even **multilevel selection** (group selection) which is often invoked to account for psychological altruism is, down the line, about genetic selfishness. In populations with multiple "groups," individuals who are in groups that engage in within-group cooperation outreproduce groups with little within-group cooperation (Wilson, Van Vugt, & O'Gorman, 2008). Genetic benefits are enjoyed by the group and by many of the individuals within the group (many of whom will be genetic relatives).

A good deal of confusion and lack of successful interdisciplinary integration stems from the tendency to equate psychological and evolutionary altruism on the one hand, and psychological and evolutionary egoism and selfishness on the other. From early on, biologists used the terms altruism and egoism (or selfishness) metaphorically having borrowed it from a domain used to describe motivations (most famously by Richard Dawkins). Consequently, it is all too easy to say the organism is behaving "altruistically" or "selfishly." Even Dawkins' early representation of human selfishness stated outright that evolutionarily selfish behavior (ultimate) implied psychologically selfish motivation: "Be warned that if you wish, as I do, to build a society in which individuals cooperate generously and unselfishly towards a common good, you can expect little help from biological nature. Let us try to teach generosity and altruism, because we are born selfish." (Dawkins, 1976/1989; p. 3). This implication is misleading.

Casual criticism of evolutionary psychology often portrays the field in ways that make it appear as though we think evolutionary selfishness and psychological selfishness go hand in hand. Certainly some work focuses on this intersection, but probably less than most think. Some unsavory aspects of human behavior might reside where psychological and evolutionary selfishness overlap (i.e., quadrant 1, Fig. 6.1). Sexual coercion might live here, and other crimes of interindividual exploitation. But parenting certainly doesn't. I would put raising one's own children in quadrant 2.

Notice here, however, that genetic "selfishness" can apply to virtually *every living organism*, even if they are no more complex than a single cell. Psychological altruism does not. What does psychological altruism mean to a pathogenic bacteria or a beetle?

The majority of evolutionists would agree, however, that quadrants 3 and 4 invoke the most debate among biologists. Can anything that reproduces sexually or asexually evolve to be genetically self-sacrificing relative to reproductive competitors? Unquestionably we can think of single exemplars, like Mother Teresa who forewent reproduction to serve humanity. Biologists don't claim single examples can't exist; they claim that they *can't evolve*. Psychologists can do the dirty work of disentangling her complex motivational tapestry. Was she psychologically altruistic in her service to the poor? Undoubtedly. Did she have her personal salvation firmly in mind? Possibly. And so on.

The key point is, one cannot draw conclusions about psychological motivation based on the evolutionary mechanism underlying the behavior. One might have a *preference* for a selfish view of human nature, but this preference is not logically derivable from evolutionary theory. Moreover, at the opening of the chapter I differentiated prosocial behavior from altruistically motivated behavior, two behavioral

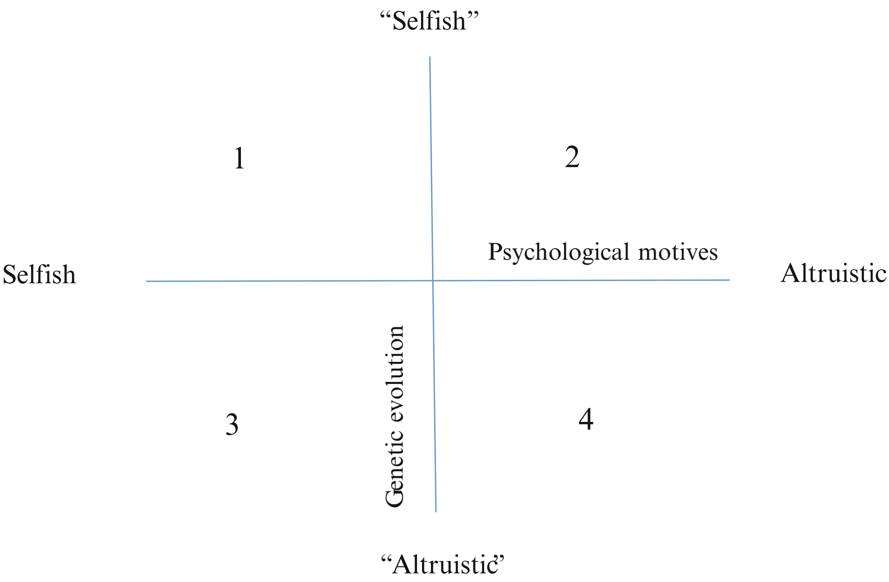

Fig. 6.1 The intersection of psychological motives (selfishness and altruism) and biological constructs with shared labels (used metaphorically in biology), but unshared meanings. Whether a behavior is psychologically selfish or altruistic does not speak to underlying genetic mechanism

classes that are overlapping (presumably most altruistically motivated behavior is prosocial), but prosociality has multiple motivations propelling it (only some prosocial behavior is altruistically motivated). This latter point leads to our second myth.

Myth 2: "Nice" Behavior is Altruistic

Much of the work in developmental psychology on prosocial behavior focuses on altruistic motivation. Sometimes, because of the close connection in the literature, we accidentally equate the two (see Hawley, 2014 for extended discussion). From an evolutionary perspective, it is important to explore the social and material rewards that are associated with prosociality—regardless of psychological motivation or intention—as they presumably are historically related to reproductive success. With no such connection, prosociality would be, evolutionarily speaking, inert.

Though not a pleasant topic for polite conversation, when pushed, most adults will admit that being nice to others really is an effective means to get what you want from them. The idiom, "you can catch more flies with honey than with vinegar," suggests exactly this, while the idiom "do well by doing good" suggests social and material success can result from behaving benevolently. These idioms and our acknowledgment of them betray the fact that we realize on an everyday level that prosocial behavior need not be altruistically motivated.

Indeed, college students, preadolescents, and adolescents will readily reply to self-report measures querying them about their "nice" behavior that is employed to attain goals. In the framework of RCT (recall, resource control theory: Hawley, 1999), we have called these prosocial strategies of resource control. Because these strategies when put baldly into writing appear to some to be distastefully manipulative, their prosocial nature has been called into question. Yet, college students in focus groups defend these strategies. Moreover, they assert that they are the powerful currency of reciprocal relationships and accordingly are part of good friendships. Additionally, they are positively correlated with self-reported goal attainment (i.e., resource control) in both adolescents and emerging adults (Hawley, 2003a; Hawley et al., 2009).

Perhaps more compelling than self-report (where it must be specified that the behavior is performed *for the purposes of goal attainment*) is observational work. Here we can record the association between behaviors that are "nice" (e.g., helping, giving objects, making suggestions) and actual resource control (e.g., occupying the active role in an experimental game; Hawley, 2002) objectively and without impression management filters of respondents.

Why would seemingly nice behavior be effective at goal attainment? Evolutionary models based on direct and indirect reciprocity (see above) find their currency in the benefits of forging long-term (resource yielding) bonds with others. That is, prosocial strategies win resources by competently capitalizing on positive social relationships as a means to access material, social, and informational resources by, for example, forging reciprocal relationships (e.g., friendships, cooperative alliances) that yield long-term benefit for both parties (Charlesworth, 1996; Kropotkin, 1902; Trivers, 1971).

From a psychological perspective, it is reasonable to hypothesize that prosocial strategies require some degree of social skill to be effective. These strategies require not only self-serving goal directedness, but also the ability to win the esteem of others. Elsewhere I have spoken of the dual needs of humans, to get along while simultaneously get ahead (Hawley, 2002; Hawley, Little, & Card, 2007; Hawley, Little, & Rodkin, 2007).

Can prosocial behavior be used to "get ahead"? Prosocial behavior when executed judiciously in the service of goal attainment can lead not only to social status (e.g., being liked or popular in a social group), but also to dominance status (a position of control and influence). This point leads us to Myth 3.

Myth 3: Nice Kids Finish Last

Resource control theory (Hawley, 1999) elaborated on the idea that friendly cooperative behavior need not be self-sacrificing (even if it costs time and effort), but rather resource yielding. Furthermore, RCT explicitly proposed that success at accessing resources in the social group underlies social dominance in humans and other species.

Shifting from Form to Function

Historically, the construct social dominance (derived from zoology and ethology) was indicated by agonism with impunity (e.g., bullying). That is, the underlying mechanism for hierarchy formation had long been thought to be aggression. Indeed, social dominance in behavioral ecology was and still is most typically assessed by the number and direction of physical attacks or threats, such that dominance is inferred when one individual is able to chastise another with relative immunity ("sexually selected manifestation of conflict"; Alcock, 2009, p. 332: see also Hofer & East, 2003; Krebs & Davies, 1997; Pelletier & Festa-Bianchet, 2006). Priority access to resources was seen as the *raison d'etre* of such attacks and threats, even if in the moment those attacks appeared to be pointless.

This agonism-based definition of social dominance, however, inappropriately focuses on the *form* of behavior over the *function*. I argued early on that focusing on form is incomplete because evolutionary approaches are predicated on *functions* of behaviors and morphological characteristics (Hawley, 1999). Some behaviors are so strikingly distinct that they can be mischaracterized if one focuses on their forms. They may in fact serve similar functions. This aspect of evolution was recognized by John Bowlby of attachment theory fame; both cries (negative emotions) and smiles (positive emotions) similarly function to reduce the distance between infant and caregivers (Hawley, Little & Card, 2007; Hawley, Little & Rodkin, 2007). That is, these affective states, it could be argued, are distinct forms, but yet serve similar functions. In developmental circles, this point isn't even controversial any more.

Similar to Bowlby's logic, RCT claims that both prosociality and aggression can serve personal goal attainment. Prosociality goes through the group in ways that are consistent with norms and morals, and thus wins esteem and peer regard. Aggression, in contrast, goes around the norms and morals of the group and accordingly runs the risk of earning censure (but see Myths 5a and 5b below).

Despite its form focus, the early work in animal behavior nonetheless demonstrated that aggressively wielded dominance related to more than just access to material resources, but also to sexual behavior, physical health, grooming patterns (in primates), and social preference (e.g., Maslow, 1936a, 1936b; Scott, 1956; see Hawley, 1999; Hawley, Little & Card, 2007; Hawley, Little & Rodkin, 2007 for review). As such, hierarchies are a central organizing feature of multiple dimensions of social life: Dominant animals are highly socially central, and targets of others attention, gazes, desire, social aspirations, and imitation (e.g., Chance, 1967; Hawley & Little, 1999; Strayer & Strayer, 1976).

Following the argument to its logical end, if prosociality is a strategy of resource control, and resource control defines social dominance, then would people who use prosocial strategies—like aggressive dominants—enjoy social centrality and power as well? The instrumentality of aggression virtually goes unquestioned. However, we needed to demonstrate the instrumentality of prosocial behavior in a disciplinary climate that focused on altruistic motivation (see also Hardy & Van Vugt, 2006; Griskevicius et al., 2010; Van Vugt & Iredale, 2013).

It turns out, when you ask the right questions, demonstrating that cooperation and niceness *pays* is not difficult to do. Under the influences of William Charlesworth (e.g., Charlesworth & La Freniere, 1983) and Fred Strayer (Strayer & Strayer, 1976), my colleagues and I set up and filmed quasi-experimental play situations to explore in detail what young children do when drawn to a highly attractive novel toy (i.e., a limited resource) in the presence of a peer. In a research preschool designed for observational study, and in contrast to the traditional methodology used by ethologists (e.g., recording children in free play situations), we could concentrate behavior between two known individuals in a brief but highly informative five-minute interaction. David Kenny's social relations model (Kenny & LaVoie, 1984) required us to film each child and code their behavior across multiple dyadic interactions. In so doing, we documented that prosocial behaviors (e.g., making helpful suggestions, issuing polite requests, offering "help," initiating trades) were more frequently employed than coercive strategies (twice as often as taking, aggression, insults, which were also associated with resource use), but were also highly positively correlated with resource use ($r = 0.53$) and to the same magnitude as were coercive behaviors.

Additionally, and perhaps unexpected from non-evolutionary perspectives, coercive and prosocial strategies were highly related to each other ($r = 0.67$), as one would expect of behaviors of similar *function*, albeit different *forms*. Overall, children employing these behaviors controlled the novel toy (and thus interaction) over 70 % of the time. Thus the instrumentality of prosocial behavior within our program of work has been documented across multiple age groups and by multiple methods (Hawley, 2002, 2003a, 2003b; see also Green, Cillessen, Rechis, Patterson, & Hughes, 2008; Pellegrini, 2008; Roseth et al., 2011; Teisl, Rogosch, Oshri, & Cicchetti, 2012).

Aggression as Adaptation (vs. Maladaptation)

Typically, prosociality and antisociality are treated in very different literatures. Regarding physical and social aggression, most of the child development work has clinical roots, and these models have been strongly influenced by medical/epidemiological approaches (e.g., Jessor, 1991). Terms are invoked such as "contagion" of maladaptive behaviors, externalizing and internalizing "symptoms," and "treatment" of "disordered" children (see Hawley, 2011 for an extended argument).

Assumptions implicit in these frameworks are quite different from assumptions of evolutionary models. For example, evolutionists interpret aggression as an adaptation, and therefore as adaptive in certain environments under certain conditions (e.g., provocation, resource defense, mate guarding). Aggressive displays are a "normal" and an expected part of countless species' repertoires. Developmental work instead has focused on the environmental inputs that put a child "at risk" for antisociality, and the additional "maladaptive" outcomes downstream. In contrast, prosocial behavior in developmental circles is considered "adaptive" (as it also is in evolutionary circles). One can even see the oppositeness implied in the words "prosocial" and "antisocial," as I have argued elsewhere (Hawley, 2011). Accordingly, most psychological work would expect prosocial and antisocial behaviors to be negatively correlated. Instead, RCT hypothesizes that they would either be uncorrelated or positively correlated. This represents a fundamental shift in reasoning, theory, and measurement.

Types of Resource Controllers

Because we do not anticipate these classes of behavior to be negatively correlated, we have formed types based on the relative degree to which each class of strategy is employed by individuals composing a social group. The relative degree to which individuals employ prosocial and coercive strategies of resource control can be measured via observation (Hawley, 2002; La Freniere & Charlesworth, 1987), self-report (Hawley, 2003a; Hawley, Little, & Pasupathi, 2002), or other report (such as teachers or peers; Hawley, 2003b; Hawley, Little & Card, 2007; Hawley, Little & Rodkin, 2007), depending on the age of the participant. Prosocial controllers by definition employ prosocial strategies to a high frequency *relative to other group members*, while coercive strategists employ predominantly coercive strategies. Children who are low on both strategies are non-controllers, while bistrategic controllers employ both strategies to a relatively high degree. Most children are typical controllers as they score around the average of each strategy.

Nice Kids Don't "Finish Last"

My colleagues and I have been building a logic upon which we can weigh in on the myth, "nice guys finish last." All of our work has pointed to the fact that prosocial controllers are the nice kids. They are the ones who stand out as especially socially skilled, have abundant moral aptitude, are agreeable and conscientious, enjoy positive and intimate friendship relations, and accordingly their peers are drawn to them across various age groups (i.e., they are well liked; Hawley, 2002; Hawley, Little & Card, 2007; Hawley, Little & Rodkin, 2007). But important for our purposes, *they are also high status*. That is, they are named as popular by their peers (an indicator of status that is granted by the peer group), and rate themselves and are rated by others as being successful resource controllers (Hawley, Little & Card, 2007; Hawley, Little & Rodkin, 2007). In the currency that is recognized by natural selection, they are winners because they have power and they are successful at material and informational goal attainment. In these important senses, nice kids finish at the top (or very near, but see below). We think of them as peer leaders, and, from evolutionary and developmental views, they are the shining example of human social competence. These findings and theoretical narrative fit well within a growing empirical literature that demonstrates prosociality is an effective competitive strategy and signal of social prestige (e.g., Van Vugt & Iredale, 2013, after Zahavi, 1995). Moreover, women find men who are both prosocial and dominant attractive (Jensen-Campbell, Graziano, & West, 1995).

As wonderful as it sounds that nice children are at the top of the hierarchy, they are not in fact at the very top. Those positions apparently are reserved for those who pull from the darker side of human nature.

Myths 4a and 4b: "Cheaters Never Prosper" and its Corollary, "Socially Competent Kids are Nice all the Time"

On the other side of the coin are the coercive strategies and, by extension, the types of kids who use them and are winning resources. The animal behavior literature has long impressed us with the fact that aggressively achieved social dominance leads to social and material rewards. These consequences make sense through evolutionary lenses through which aggression is adaptive; that is, it increases access to resources that enhance survival and reproduction. These consequences are also more palatable when one is thinking about nonhumans.

But the lenses donned by most psychologists do not typically view aggression in this light, as explained above. How can a behavior be adaptive in the ultimate sense of the term (evolutionary), but maladaptive in the proximate sense (psychological)? The answer may be: Perhaps aggression is not as proximally maladaptive in humans as we would like to think. And this is what my research has shown for over a decade.

Aggressive Youth are Heterogeneous

The last 15 years or so have ushered in new ways of thinking about childhood aggression that have challenged prevailing models of aggression as maladapted. The early works of Cairns (Cairns, Cairns, Neckerman, Gest, & Gariepy, 1988), Strayer and Santos (Strayer & Santos, 1996), Vaughn (Vaughn & Waters, 1981), and Sutton and Smith (Sutton, Smith, & Swettenham, 1999), among others, laid the groundwork for rethinking the social reception of aggressive individuals. My work certainly benefited greatly from this groundwork. Not coincidentally, all of these writers were or are well versed in evolutionary theory.

Whereas coercive controllers' profiles fit developmental/epidemiological models of maladaptive childhood aggression (e.g., associated with poor social skills, ill reception from peers, impulsivity), bistrategic controllers by and large do not fit these clinically based models. Bistrategic controllers—like coercive controllers—describe themselves as aggressive, endorse cheating, and value material resources over friendships (Hawley et al., 2002, 2009). But, like prosocial controllers, they have some key positive social skills such as a social intelligence and are morally savvy.

Indeed, I have characterized this combination of traits and behavioral proclivities as *a type* of social competence in humans (Hawley, 2002, 2003a; Hawley, Little & Card, 2007; Hawley, Little & Rodkin, 2007). Though perhaps shocking at first, this proposition stands to reason in the sense that bistrategic controllers have all types of resource control behaviors at their disposal. With all strategies at their fingertips, they have the potential to enjoy extremely high material control and social status.

Indeed, the empirical work on these youths from preschool to adolescence demonstrates this success unequivocally. First, across all types and all ages, they are the highest on resource control (whether via observation, self-report, teacher report, or peer report). Second, their profile of social skills is similar to the profile of prosocial controllers: they are socially perceptive, morally astute, and extroverted (e.g., Hawley et al., 2002). In preschool, they demonstrate that, cognitively speaking, they understand the rules. In college, they truly value social relationships (Hawley, 2003b; Hawley & Geldhof, 2012). And in adolescence, their friends find them fun and their relationships high on intimacy (Hawley, Little & Card, 2007; Hawley, Little & Rodkin, 2007). Accordingly, they are high on others' friendship aspirations ("Who do you wish was your friend who isn't?"). Finally, they score well on health indicators (Massey, Byrd-Craven, & Swearingen, 2014).

At the same time, however, they have qualities in common with the unskilled coercive controllers. For example, the same "fun and intimate" relationships in adolescence are rated high in conflict (Hawley, Little & Card, 2007; Hawley, Little & Rodkin, 2007). Preschoolers are attuned to moral norms; however, their teachers report them to be low on emotions associated with moral internalization, namely guilt and shame (Hawley & Geldhof, 2012). In college, their value of social relationships is superseded by the value they place on material resources (Hawley et al., 2009). Moreover, they see relationships as an instrumental avenue to resources, quite explicitly (Hawley et al., 2009).

Given this mix of characteristics, you would think that peers would steer clear of them. Their social reception, however, is quite different from this conventional expectation.

Myth #5a and 5b: "Mean" Kids are Disliked and its Corollary, It Doesn't Pay to be a Bully

As straightforward as coercive strategies seem, they have correlates that have been controversial in circles where medically inspired clinical models are prevalent. That is, we have long assumed that the peer group is biased against such brazenly self-serving behaviors that are hostile towards others. How could children not be? They should move away from others who aggress against themselves or others. At the same time, however, this wisdom that admittedly has tremendous face validity has been chipped away as the heterogeneity of aggressive youths has been documented with ever-increasing frequency since the mid-eighties.

Sociological works, for example, provided an illuminating description of teen peer culture (Eder, 1985) and descriptions of how "meanness" and popularity can go hand in hand (Merten, 1997). We might be tempted to explain away the status of these youths (e.g., they may be popular, but they aren't *liked*). Though resource control theory hasn't focused on "popular kids" per se, it has focused on the resource control types and documented the associated popularity and likability patterns associated with each type (versus looking at popularity status and associations with aggression as is required from a sociometric perspective). We have found that aggressive bistrategic controllers are not only popular (by way of popularity nominations), but they are also liked (receive "like most" nominations) and viewed by many peers as a "best friend" (Hawley et al., 2007). Unlike the sociometric tradition, RCT predicts that those occupying top social dominance positions in the group (i.e., those who have demonstrated competitive success) will win positive regard because of their evident effectiveness in the material world. This is a hypothesis based on evolutionary theory. In other words, we (humans) are expected to find power in our groups attractive, even if this power is wielded aggressively. I have referred to this elsewhere as the social centrality hypothesis of RCT (Hawley, 1999; see also Massey et al., 2014).

Notice here that our argument that bistrategic controllers embody a type of social competence is strengthened by the documented patterns: Not only do they "win" materially, but they also "win" socially. Thus, they have solved the problem of getting along and getting ahead. Additionally, this line of reasoning fits well with evolutionary and biological approaches that propose that there is *continuity between species* rather than human exceptionalism. From this perspective, it makes sense then to talk of a general theory of social dominance that applies across species rather than creating new "theories" depending on how a species uniquely works its power patterns (Hawley, 1999).

Does it Pay to Be a Bully?

Bullying is one unfortunately common context of dominance striving that manifests disruptively in childhood and adolescence (as well as adulthood; see also Volk, this volume). By bullying, I refer to the accepted definition used in developmental circles, namely, repeated acts of aggression (social or physical) toward a victim who is weaker in size or social status (e.g., social skills, SES, and ethnic or gender minority; Olweus, 1993). This behavior is pervasive enough across species and cultures to warrant it being considered an adaptation in and of itself (Volk, Camilleri, Dane, & Marini, 2012). To the extent that bullying is goal oriented and is associated with status or resource acquisition (e.g., Sijtsema, Veenstra, & Salmivalli, 2009), it can be considered a type of coercive resource control strategy.

Early work by ethologists (who also have evolutionary lenses) focused on some of the social rewards that especially adolescent males win by being visibly aggressive with others. In contrast to the conventional narrative that "bullies bully because they have low self-esteem," these authors have long focused on the benefits associated with bullying others. Being attractive to the opposite sex appears to be one of these benefits (Pellegrini, 2001; Pellegrini & Long, 2003; Sutton et al., 1999). Being perceived as high status by peers and being preferred in friendships are others (Reijntjes et al., 2013; even as they are disliked by others in the group; e.g., Rodkin & Berger, 2008). Finally, bullies influence the attitudes and behaviors of their peer group (Vaillancourt, McDougall, Hymel, & Sunderani, 2010). Such influence is the very definition of power from social psychological perspectives (e.g., Keltner, Gruenfeld, & Anderson, 2003). This is not to say that bullying bears no cost to the aggressor; bullying has been associated, for example, with poor academic outcomes (Ma, Phelps, Lerner, & Lerner, 2009; Pepler & Craig, 2005). Nonetheless, this emerging complex profile confronts the conventional wisdom that bullies are oafish outcasts, and emphasizes the need to take a functional analysis of behavior quite seriously.

Myth #6: Status Hierarchies Emerge in Adolescence

Eder's (1985) account of peer cultures emphasized adolescents' quest for status and accordingly opened the door for much needed research on the central function that status plays in adolescent peer groups. Indeed, that popularity and status become explicitly valued and sought by adolescents is a well-accepted fact (e.g., Adler & Adler, 1998; Cillessen & Rose, 2005; Eder, 1985).

Adolescents certainly can articulate well the political dynamics of their groups. But that should not leave us with the impression that status becomes important only when we can articulate it. In fact, we have shown that even very young preschoolers behave as if they understand the political structures of the group, *sans* articulation (Hawley, 2002; Hawley & Little, 1999). That is, their behavior is consistent with predictions made by theories of social dominance.

The behavior of infants is also consistent with such predictions. Mascaro and Csibra (2012, 2014) for example demonstrated (via patterns of gaze) that infants expect dominance structures to be linearly organized and asymmetrical relationships to be stable. Even infants as young as 10 months use size as a cue to predict outcome of conflicts of interest (Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011). Cognitive work with adults demonstrates that hierarchical relationships are a "fluent" form of relationship (Zitek & Tiedens, 2012). That is, they are easier to process than nonhierarchical relationships, and thus are even more "preferred" than equal relationships (which are harder to process; see also Van Berkel, Crandall, Eidelman, & Blanchar, 2015). It appears that we have evolved a cognitive architecture suitable to solve problems associated with power differentials, and are accordingly prepared for hierarchical living as early as infancy.

Myth #7: Power and Social Dominance are the Purview of Males

As we laid out early on (Hawley, Little, & Card, 2008), if one equates dominance with aggression, as is traditionally done, then dominance and its accompanying political structure become masculine as well. In biological circles, it is well documented that masculine characteristics such as morphological weaponry (e.g., tusks, antlers) and behaviors (e.g., contests, displays) function in agonistic contests. In contrast, females are portrayed as being less interested in social politics, more communal, and less aggressive.

Biological approaches to a masculine view of dominance typically rest on sexual selection theory. Female primates—in contrast to males—evolved to protect and provision offspring (Darwin, 1871; Trivers, 1972). Consequently, they are on average more averse to risk of physical harm than males (Campbell, 1999; Taylor et al., 2000). Additionally, the lower parental investment of males leaves them free to pursue multiple mates, and compete with other males to access them. These intrasexual processes led to the evolution of sexual dimorphism in terms of size and strength, with concomitantly aggressive behaviors, motivations, and social roles (Clutton-Brock, 1983).

While these selection pressures cannot be denied, it is also safe to say that political processes in female primates have historically gotten far less attention than that of males. For example, Sarah Blaffer Hrdy (1981/1999) argued that females' behavior is in actuality no less self-interested, competitive, or dominance striving than males. Yet, their competitive strategies are much more difficult to see and to measure than are males' overt displays and contests (especially to biologists out in the field). For example, females inhibit each other's reproductive cycles, sexually manipulate males, and kill infants of rival families (while appearing to "allomother" them; see also Clutton-Brock, 2007). Moreover, the outcomes of these competitions influence the troop's social organization in ways *that last several generations*.

Shortly after Hrdy's first edition, and in a very different literature, developmentalists were busy outlining just how political and aggressive human females are (Björkqvist, Österman, & Kaukiainen, 1992; Crick & Grotpeter, 1995; Eder, 1985). In the meantime, exploring the relationship between girls' aggression and their social status became a flourishing avenue for research in developmental circles (Cillessen & Mayeux, 2004; Rose, Swenson, & Waller, 2004; Zimmer-Gembeck, Geiger, & Crick, 2005).

In our study of German youths (Hawley et al., 2008), at a time in their lives when the quest for status is the most salient (adolescence), we uncovered the usual suspects of average differences across genders, favoring boys; influence was more important to boys, they reported being more successful, they used coercive strategies to a higher degree, and they were more overtly and relationally aggressive than girls. Peers' judgments were in line with gender stereotypes as well; they saw boys as more resource controlling than girls, and more overtly aggressive. More interesting to us, however, was the general lack of gender differences when looking at the youths of highest rank (i.e., bistrategic controllers). First, bistrategic controllers were equally male and female in number (see also Hawley, 2003a, 2003b), were rated by peers as equally effective at resource control, and saw themselves equally as influential. Furthermore, both genders were very aggressive in what are considered to be gender nonnormative ways. That is, bistrategic boys were high on relational aggression (typically thought of as normative for females), and bistrategic girls were high on overt aggression (normative for males). The high status bistrategic girls especially were the targets of their peers' social aspirations. Strategies and correlates of female competition are an exciting and fruitful direction for further research (for additional views, see Benenson, 2013; Geary, 2010; Geary, Winegard, & Winegard, 2014; Vaillancourt & Sharma, 2011).

Myth #8: At the End of the Day, Power Doesn't Matter

In this chapter, I have made the point that winning yields benefits even if the power that results is wielded aggressively. It appears that aggression balanced with prosociality is not only a superior configuration of traits when the currency is resource control, but also that this configuration does not appear to bear onerous costs such as social ostracism. Indeed, high status aggressive individuals appear to enjoy a degree of social admiration. Alternatively, this perspective does not advance benefits to losing, as if subordinance was also some sort of adaptation (see extended logic, Hawley & Little, 1999).

Indeed, the evolutionary thinking outlined here emphasizes the profound negative impact that chronic subordinance (i.e., repeated competitive loss) can have on one's development and later reproductive success (Hawley, 2015). For example, when the power players use bullying tactics, there is an abundance of evidence that their victims experience acute and protracted harm such as increased loneliness, emotional distress, depression, physical symptoms, social anxiety, and poor school adjustment and performance (Haynie et al., 2001; Juvonen, Graham, & Schuster, 2003; Marini, Dane, Bosacki, & Cura, 2006; Schwartz, Gorman, Nakamoto, & Toblin, 2005). Chronic economic loss (e.g., income inequality) also has a profound impact on physical health and disease (e.g., Boyce, 2014; Dowd, Zajacova, & Aiello, 2009; Ziol-Guest, Duncan, Kalil, & Boyce, 2012). Moreover, inequality exacerbates social anxiety and fosters distrust (Wilkinson & Pickett, 2009).

Conclusion

Competition is inherent to group living, and the degree to which one can compete cooperatively, so much the better. At the same time, power disparities result, and conferred status falls in line with these power differentials (Adler & Adler, 1998).

Power has often been assumed to be toxic in relationships. But as I have shown in this chapter, it may also be a positive force in children's lives. In either case, power (dominance) is most certainly a central organizing feature, one begins early and persists through adulthood, includes both males and females, and can potentially have lasting health effects. Evolutionary and developmental perspectives both stand to uniquely contribute to our understanding of group dynamics in developing humans, as long as we are clear about semantics and disciplinary distinctions.

References

Adler, P. A., & Adler, P. (1998). *Peer power: Preadolescent culture and identity*. New Brunswick, NJ: Rutgers University Press.

Alcock, J. (2009). *Animal behavior: An evolutionary approach* (9th ed.). New York, NJ: Sinauer.

Alexander, R. D. (1979). *Darwin and human affairs*. Washington, DC: University of Washington Press.

Alexander, R. D. (1987). *Biology of moral systems* (5th ed.). Hawthorne, NY: Aldine de Gruyter.

Bargh, J. A., & Morsella, E. (2008). The unconscious mind. *Perspectives on Psychological Science, 3*(1), 73–79.

Batson, C. D. (1998). Altruism and prosocial behavior. In D. T. Gilbert, S. T. Fiske, & G. Lindzey (Eds.), *Handbook of social psychology* (4th ed., pp. 282–316). New York, NJ: McGraw-Hill.

Batson, C. D. (2011). *Altruism in humans*. New York, NJ: Oxford University Press.

Batson, C. D., & Shaw, L. L. (1991). Evidence for altruism: Toward a pluralism of prosocial motives. *Psychological Inquiry, 2*(2), 107–122.

Benenson, J. F. (2013). The development of human female competition: Allies and adversaries. *Philosophical Transactions of the Royal Society, B: Biological Sciences, 368*(1631), 20130079.

Bernstein, I. S. (1981). Dominance: The baby and the bathwater. *Behavioral and Brain Sciences, 4*, 419–457.

Björkqvist, K., Österman, K., & Kaukiainen, A. (1992). The development of direct and indirect aggressive strategies in males and females. In K. Björkqvist & P. Niemelä (Eds.), *Of mice and women: Aspects of female aggression* (pp. 51–64). San Diego, CA: Academic Press.

Böhm, R., & Regner, T. (2013). Charitable giving among females and males: An empirical test of the competitive altruism hypothesis. *Journal of Bioeconomics, 15*(3), 251–267.

Boyce, W. T. (2014). The lifelong effects of early childhood adversity and toxic stress. *Pediatric Dentistry, 36*(2), 102–108.

Brem, S. K., Ranney, M., & Schindel, J. (2003). Perceived consequences of evolution: College students perceive negative personal and social impact in evolutionary theory. *Science Education, 87*(2), 181–206.

Cairns, R. B., Cairns, B. D., Neckerman, H. J., Gest, S. D., & Gariepy, J. L. (1988). Social networks and aggressive behavior. Peer support or peer rejection? *Developmental Psychology, 24*, 815–823.

Campbell, A. (1999). Staying alive: Evolution, culture, and women's intrasexual aggression. *Behavioral and Brain Sciences, 22*, 203–252.

Carlo, G., & Randall, B. A. (2002). The development of a measure of prosocial behaviors for late adolescents. *Journal of Youth and Adolescence, 31*(1), 31–44.

Chance, M. R. A. (1967). Attention structure as the basis of primate rank orders. *Man, 2*, 503–518.

Charlesworth, W. R. (1996). Co-operation and competition: Contributions to an evolutionary and developmental model. *International Journal of Behavioral Development, 19*(1), 25–38.

Charlesworth, W. R., & La Freniere, P. (1983). Dominance, friendship, and resource utilization in preschool children's groups. *Ethology and Sociobiology, 4*(3), 175–186.
Cillessen, A. H. N., & Mayeux, L. (2004). From censure to reinforcement: Developmental changes in the association between aggression and social status. *Child Development, 75*, 147–163.
Cillessen, A. H. N., & Rose, A. J. (2005). Understanding popularity in the peer system. *Current Directions in Psychological Science, 14*(2), 102–105.
Clutton-Brock, T. M. (1983). Selection in relation to sex. In D. S. Bendall (Ed.), *Evolution: From molecules to men* (pp. 457–481). London, England: Cambridge University Press.
Clutton-Brock, T. (2002). Breeding together: Kin selection and mutualism in cooperative vertebrates. *Science, 296*(5565), 69–72.
Clutton-Brock, T. (2007). Sexual selection in males and females. *Science, 318*, 1882–1885.
Clutton-Brock, T. (2009). Cooperation between non-kin in animal societies. *Nature, 462*(7269), 51–57.
Coie, J. D., Dodge, K. A., Terry, R., & Wright, V. (1991). The role of aggression in peer relations: An analysis of aggression episodes in boys' play groups. *Child Development, 62*, 812–826.
Crick, N. R., & Grotpeter, J. K. (1995). Relational aggression, gender, and social-psychological adjustment. *Child Development, 66*, 710–722.
Darwin, C. (1871). *The descent of man, and selection in relation to sex*. London, England: John Murray.
Dawkins, R. (1989). *The selfish gene*. Oxford, England: Oxford University Press.
Dodge, K. A., Coie, J. D., Pettit, G. S., & Price, J. M. (1990). Peer status and aggression in boys' groups: Developmental and contextual analysis. *Child Development, 61*, 1289–1309.
Dowd, J. B., Zajacova, A., & Aiello, A. (2009). Early origins of health disparities: Burden of infection, health, and socioeconomic status in US children. *Social Science & Medicine, 68*(4), 699–707.
Eder, D. (1985). The cycle of popularity: Interpersonal relations among female adolescents. *Sociology of Education, 58*, 154–165.
Eisenberg, N. (1986). *Altruistic emotion, cognition, and behavior*. Hillsdale, NJ: Erlbaum.
Eisenberg, N. (1991). Values, sympathy, and individual differences: Toward a pluralism of factors influencing altruism and empathy. *Psychological Inquiry, 2*, 128–131.
Eisenberg, N., & Fabes, R. (1998). Prosocial development. In W. Damon & N. Eisenberg (Eds.), *Handbook of child psychology* (Social, emotional, and personality development, Vol. 3, pp. 701–778). New York, NY: Wiley.
Eisenberg, N., Fabes, R. A., & Spinrad, T. (2006). Prosocial development. In N. Eisenberg (Ed.), *Handbook of child psychology: Social, emotional, and personality development* (pp. 646–718). Hoboken, NJ: Wiley.
Eisenberg, N., Shea, C. L., Carlo, G., & Knight, G. P. (1991). Empathy related responding and cognition: A "chicken and the egg" dilemma. In W. Kurtines & J. Gewirtz (Eds.), *Handbook of moral behavior and development* (Research, Vol. 2, pp. 63–88). Hillsdale, NJ: Erlbaum.
Frank, R. H. (1988). *Passions within reason: The strategic role of the emotions*. New York, NJ: W.W. Norton.
Geary, D. C. (2005). *The origin of mind: Evolution of brain, cognition, and general intelligence*. Washington, DC: American Psychological Association.
Geary, D. C. (2010). *Male, female: The evolution of human sex differences* (2nd ed.). Washington, DC: American Psychological Association.
Geary, D. C., Winegard, B., & Winegard, B. (2014). Reflections on the evolution of human sex differences: Social selection and the evolution of competition among women. In V. A. Weekes-Shackelford & T. K. Shackelford (Eds.), *Evolutionary perspectives on human sexual psychology and behavior* (pp. 393–412). New York, NY: Springer.
Green, V. A., Cillessen, A. H. N., Rechis, R., Patterson, M. M., & Hughes, J. M. (2008). Social problem solving and strategy use in young children. *Journal of Genetic Psychology, 169*, 92–112.
Griskevicius, V., Tybur, J. M., & Van den Bergh, B. (2010). Going green to be seen: Status, reputation, and conspicuous conservation. *Journal of Personality and Social Psychology, 98*(3), 392.

Hamilton, W. D. (1964). The genetical evolution of social behaviour. II. *Journal of Theoretical Biology, 7*(1), 17–52.
Hardy, C. L., & Van Vugt, M. (2006). Nice guys finish first: The competitive altruism hypothesis. *Personality and Social Psychology Bulletin, 32*(10), 1402–1413.
Hawley, P. H. (1999). The ontogenesis of social dominance: A strategy-based evolutionary perspective. *Developmental Review, 19*(1), 97–132.
Hawley, P. H. (2002). Social dominance and prosocial and coercive strategies of resource control in preschoolers. *International Journal of Behavioral Development, 26*, 167–176.
Hawley, P. H. (2003a). Prosocial and coercive configurations of resource control in early adolescence: A case for the well-adapted Machiavellian. *Merrill-Palmer Quarterly, 49*, 279–309.
Hawley, P. H. (2003b). Strategies of control, aggression, and morality in preschoolers: An evolutionary perspective. *Journal of Experimental Child Psychology, 85*, 213–235.
Hawley, P. H. (2011). The evolution of adolescence and the adolescence of evolution: The coming of age of humans and the theory about the forces that made them. *Journal of Research on Adolescence, 21*(1), 307–316.
Hawley, P. H. (2014). Evolution, prosocial behavior, and altruism: A roadmap for understanding where the proximate meets the ultimate. In L. Padilla-Walker & G. Carlo (Eds.), *Prosocial development: A multidimensional approach* (pp. 43–69). New York, NY: Oxford University Press.
Hawley, P. H. (2015). Social dominance in childhood and its evolutionary underpinnings: Why it matters and what we can do. *Pediatrics, 135*, S31.
Hawley, P. H., & Geldhof, J. G. (2012). Preschoolers' social dominance, moral cognition, and moral behavior: An evolutionary perspective. *Journal of Experimental Child Psychology, 112*, 18–35.
Hawley, P. H., & Little, T. D. (1999). On winning some and losing some: A social relations approach to social dominance in toddlers. *Merrill-Palmer Quarterly, 43*, 185–214.
Hawley, P. H., Little, T. D., & Card, N. A. (2007). The allure of a mean friend: Relationship quality and processes of aggressive adolescents with prosocial skills. *International Journal of Behavioral Development, 31*(2), 170–180.
Hawley, P. H., Little, T. D., & Card, N. A. (2008). The myth of the alpha male: A new look at dominance-related beliefs and behaviors among adolescent males and females. *International Journal of Behavioral Development, 32*(1), 76–88.
Hawley, P. H., Little, T. D., & Pasupathi, M. (2002). Winning friends and influencing peers: Strategies of peer influence in late childhood. *International Journal of Behavioral Development, 26*(5), 466–474.
Hawley, P. H., Little, T. D., & Rodkin, P. C. (2007). *Aggression and adaptation: The bright side to bad behavior*. New York, NJ: Routledge.
Hawley, P. H., Shorey, H. S., & Alderman, P. M. (2009). Attachment correlates of resource-control strategies: Possible origins of social dominance and interpersonal power differentials. *Journal of Social and Personal Relationships, 26*(8), 1097–1118.
Haynie, D. L., Nansel, T., Eitel, P., Crump, A. D., Saylor, K., Yu, K., & Simons-Morton, B. (2001). Bullies, victims, and bully/victims: Distinct groups of at-risk youth. *The Journal of Early Adolescence*, *21*(1), 29–49.
Hofer, H., & East, M. L. (2003). Behavioral processes and costs of co-existence in female spotted hyenas: A life history perspective. *Evolutionary Ecology, 17*, 315–331.
Hrdy, S.B. (1999). *The woman that never evolved*. Cambridge, MA: Harvard University Press (Original work published 1981).
Jensen-Campbell, L. A., Graziano, W. G., & West, S. G. (1995). Dominance, prosocial orientation, and female preferences: Do nice guys really finish last? *Journal of Personality and Social Psychology, 68*(3), 427–440.
Jessor, R. (1991). Risk behavior in adolescence: A psychosocial framework for understanding and action. *Journal of Adolescent Health, 12*(8), 597–605.
Juvonen, J., Graham, S., & Schuster, M. A. (2003). Bullying among young adolescents: The strong, the weak, and the troubled. *Pediatrics, 112*(6), 1231–1237.

Keltner, D., Gruenfeld, D. H., & Anderson, C. (2003). Power, approach, and inhibition. *Psychological Review, 110*(2), 265.

Kenny, D. A., & LaVoie, L. (1984). The social relations model. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (pp. 141–182). New York, NY: Academic.

Krebs, J. R., & Davies, N. B. (1997). *Behavioral ecology: An evolutionary approach*. Oxford, England: Blackwell Science.

Kropotkin, P. (1902). *Mutual aid: A factor of evolution*. London, England: Doubleday.

La Freniere, P. J., & Charlesworth, W. R. (1987). Effects of friendship and dominance status on preschooler's resource utilization in a cooperative/competitive situation. *International Journal of Behavioral Development, 10*(3), 345–358.

Ma, L., Phelps, E., Lerner, J. V., & Lerner, R. M. (2009). Academic competence for adolescents who bully and who are bullied: Findings from the 4-H study of positive youth development. *The Journal of Early Adolescence, 29*(6), 862–897.

Marini, Z. A., Dane, A. V., Bosacki, S. L., & Cura, Y. L. C. (2006). Direct and indirect bully-victims: Differential psychosocial risk factors associated with adolescents involved in bullying and victimization. *Aggressive Behavior, 32*(6), 551–569.

Mascaro, O., & Csibra, G. (2012). Representation of stable social dominance relations by human infants. *Proceedings of the National Academy of Sciences, 109*(18), 6862–6867.

Mascaro, O., & Csibra, G. (2014). Human infants' learning of social structures: The case of dominance hierarchy. *Psychological Science, 25*(1), 250–255.

Maslow, A. H. (1936a). The role of dominance in the social and sexual behavior of infra-human primates: I. Observations at Vilas Park Zoo. *The Pedagogical Seminary and Journal of Genetic Psychology, 48*(2), 261–277.

Maslow, A. H. (1936b). A theory of sexual behavior in infra-human primates. *Journal of Genetic Psychology, 48*, 310–336.

Massey, A. R., Byrd-Craven, J., & Swearingen, C. L. (2014). Preschool power play: Resource control strategies associated with health. *Child Development Research, 2014*, 1–7.

Merten, D. E. (1997). The meaning of meanness: Popularity, competition, and conflict among junior high school girls. *Sociology of Education, 70*, 175–191.

Mestre, M. V., Carlo, G., Samper, P., Tur-Porcar, A. M., & Mestre, A. L. (2015). Psychometric evidence of a multidimensional measure of prosocial behaviors for Spanish adolescents. *The Journal of Genetic Psychology, 176*, 206–271.

Nowak, M. A., & Sigmund, K. (2005). Evolution of indirect reciprocity. *Nature, 437*, 1291–1298.

Olweus, D. (1993). *Bullying in schools. What we know and what we can do*. Oxford, England: Blackwell.

Pellegrini, A. D. (2001). The roles of dominance and bullying in the development of early heterosexual relationships. *Journal of Emotional Abuse, 2*(2–3), 63–73.

Pellegrini, A. D. (2008). The roles of aggressive and affiliative behaviors in resource control: A behavioral ecological perspective. *Developmental Review, 28*, 461–487.

Pellegrini, A. D., & Long, J. D. (2003). A sexual selection theory longitudinal analysis of sexual segregation and integration in early adolescence. *Journal of Experimental Child Psychology, 85*(3), 257–278.

Pelletier, F., & Festa-Bianchet, M. (2006). Sexual selection and social rank in bighorn rams. *Animal Behaviour, 71*, 649–655.

Pepler, D., & Craig, W. (2005). Aggressive girls on troubled trajectories: A developmental perspective. In D. Pepler, K. Madsen, K. Levene, & C. Webster (Eds.), *The development and treatment of girlhood aggression*. Hillsdale, NJ: Ellbaum.

Reijntjes, A., Vermande, M., Goossens, F. A., Olthof, T., van de Schoot, R., Aleva, L., & van der Meulen, M. (2013). Developmental trajectories of bullying and social dominance in youth. *Child abuse & neglect*, *37*(4), 224–234.

Rodkin, P. C., & Berger, C. (2008). Who bullies whom? Social status asymmetries by victim gender. *International Journal of Behavioral Development, 32*(6), 473–485.

Rose, A. J., Swenson, L. P., & Waller, E. M. (2004). Overt and relational aggression and perceived popularity: Developmental differences in concurrent and prospective relations. *Developmental Psychology, 40*, 378–387.

Roseth, C. J., Pellegrini, A. D., Dupuis, D. N., Bohn, C. M., Hickey, M. C., Hilk, C. L., & Peshkam, A. (2011). Preschoolers' bistrategic resource control, reconciliation, and peer regard. *Social Development, 20*, 185–211.

Schwartz, D., Gorman, A. H., Nakamoto, J., & Toblin, R. L. (2005). Victimization in the peer group and children's academic functioning. *Journal of Educational Psychology, 97*(3), 425.

Scott, J. P. (1956). The analysis of social organization in animals. *Ecology, 37*, 213–221.

Sijtsema, J. J., Veenstra, R. L. S., & Salmivalli, C. (2009). Empirical test of bullies' status goals: Assessing direct goals, aggression, and prestige. *Aggressive Behavior, 35*, 57–67.

Strayer, F. F., & Santos, A. J. (1996). Affiliative structures in preschool peer groups. *Social Development, 5*(2), 117–130.

Strayer, F. F., & Strayer, J. (1976). An ethological analysis of social agonism and dominance relations among preschool children. *Child Development, 47*, 980–989.

Sutton, J., Smith, P. K., & Swettenham, J. (1999). Social cognition and bullying: Social inadequacy or skilled manipulation? *British Journal of Developmental Psychology, 17*(3), 435–450.

Taylor, S. E., Klein, L. C., Lewis, B. P., Gruenewald, T. L., Gurung, R. A. R., & Updegraff, J. A. (2000). Biobehavioral responses to stress in females: Tend and befriend, not fight-or-flight. *Psychological Review, 107*, 411–429.

Teisl, M., Rogosch, F. A., Oshri, A., & Cicchetti, D. (2012). Differential expression of social dominance as a function of age and maltreatment experience. *Developmental Psychology, 48*, 575–588.

Thomsen, L., Frankenhuis, W. E., Ingold-Smith, M., & Carey, S. (2011). Big and mighty: Preverbal infants mentally represent social dominance. *Science, 331*(6016), 477–480.

Tinbergen, N. (1963). On aims and methods of ethology. *Zeitschrift für Tierpsychologie, 20*(4), 410–433.

Trivers, R. L. (1971). The evolution of reciprocal altruism. *Quarterly Review of Biology, 46*, 35–57.

Trivers, R. L. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), *Sexual selection and the descent of man* (pp. 136–179). Chicago, IL: Aldinc.

Vaillancourt, T., McDougall, P., Hymel, S., & Sunderani, S. (2010). The relationship between power and bullying behavior. In S. M. Swearer & D. L. Espelage (Eds.), *Handbook of bullying in schools: An international perspective* (pp. 211–222). New York, NY: Routledge.

Vaillancourt, T., & Sharma, A. (2011). Intolerance of sexy peers: Intrasexual competition among women. *Aggressive Behavior, 37*(6), 569–577.

Van Berkel, L., Crandall, C. S., Eidelman, S., & Blanchar, J. C. (2015). Hierarchy, dominance, and deliberation egalitarian values require mental effort. *Personality and Social Psychology Bulletin, 41*, 1207–1222. 0146167215591961.

Van Vugt, M., & Iredale, W. (2013). Men behaving nicely: Public goods as peacock tails. *British Journal of Psychology, 104*(1), 3–13.

Vaughn, B. E., & Waters, E. (1981). Attention structure, sociometric status, and dominance: Interrelations, behavioral correlates, and relationships to social competence. *Developmental Psychology, 17*(3), 275–288.

Volk, A. A., Camilleri, J. A., Dane, A. V., & Marini, Z. A. (2012). Is adolescent bullying an evolutionary adaptation? *Aggressive Behavior, 38*(3), 222–238.

Webb, T. L., & Sheeran, P. (2006). Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. *Psychological Bulletin, 132*, 249–268.

Wilkinson, R., & Pickett, K. (2009). *The spirit level: Why greater equality makes societies stronger*. New York, NY: Bloomsbury.

Wilson, D. S., Van Vugt, M., & O'Gorman, R. (2008). Multilevel selection theory and major evolutionary transitions implications for psychological science. *Current Directions in Psychological Science, 17*(1), 6–9.

Zahavi, A. (1995). Altruism as a handicap: The limitations of kin selection and reciprocity. *Journal of Avian Biology, 26*, 1–3.

Zimmer-Gembeck, M. J., Geiger, T. C., & Crick, N. R. (2005). Relational and physical aggression, prosocial behavior, and peer relations: Gender moderation and bidirectional associations. *The Journal of Early Adolescence, 25*, 421–452.

Ziol-Guest, K. M., Duncan, G. J., Kalil, A., & Boyce, W. T. (2012). Early childhood poverty, immune-mediated disease processes, and adult productivity. *Proceedings of the National Academy of Sciences, 109*(2), 17289–17293.

Zitek, E. M., & Tiedens, L. Z. (2012). The fluency of social hierarchy: The ease with which hierarchical relationships are seen, remembered, learned, and liked. *Journal of Personality and Social Psychology, 102*(1), 98.

Chapter 7
Adolescent Bullying in Schools: An Evolutionary Perspective

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Adolescent Bullying in Schools: An Evolutionary Perspective

Bullying is an important problem for adolescents, affecting an estimated 30 % of adolescents worldwide each year (Volk, Craig, Boyce, & King, 2006). Bullying has been traditionally defined as "it is aggressive behavior or intentional 'harm doing,' which is carried out repeatedly and over time in an interpersonal relationship characterized by an imbalance of power" (Olweus, 1993, pp. 8–9). This definition however has come under criticism (e.g., Liu & Graves, 2011), leading to a newer definition of bullying founded on evolutionary theory: "bullying is when an individual uses goal-directed behavior that causes significant harm to another individual within the context of a power imbalance" (Volk, Dane, & Marini, 2014). Central to this new definition are the concepts of power, harm, and goal directedness.

Components of Bullying

Power

Power is perhaps the most important feature for distinguishing bullying from other forms of aggression. Bullying is a relational problem whereby one individual has difficulty defending him or herself from the aggression of another individual

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(Olweus, 1993; Volk et al. 2014). This power imbalance changes the costs and benefits of the aggressive behavior so that it becomes relatively cheap to bully another individual while simultaneously increasing the cost of being a victim of bullying (Veenstra, Verlinden, Huitsing, Verhulst, & Tiemeier, 2013; Volk et al., 2014). Research shows that a power imbalance leads to quantitatively more severe outcomes for victims of bullying (Hunter, Boyle, & Warden, 2007; Ybarra, Espelage, & Mitchell, 2014). While bullying outcomes are generally qualitatively similar to those found in other forms of aggression, the quantitatively greater severity associated with the power imbalance is important to consider. As noted by one of history's worst bullies, Joseph Stalin, "quantity has a quality all of its own." We discuss the potential harm from bullying below.

A power imbalance is also likely to trigger evolved human mental adaptations that are geared towards promoting fairness and equality within a group (Gavrilets, 2012). This may help explain the tendency for some bystanders to intervene in bullying even when there is no immediate benefit for them doing so (Cappadocia, Pepler, Cummings, & Craig, 2012; Polanin, Espelage, & Pigott, 2012). Individuals have a vested interest in preventing one individual from obtaining too much power and thus becoming able to bully whomever they wish. However, power not only influences the desire, but also the ability of others to prevent bullying, with more popular/powerful bullies being less susceptible to bullying interventions in school settings (Garandeau, Lee, & Salmivalli, 2014). The nature of the power imbalance can vary between and within individuals, as reflected by individuals who are both bullies and victims (Haynie et al., 2001). The one constant is that bullies appear to be adept at targeting the weakness of their victim (e.g., attacking someone who does not have any sway over one's social group), regardless of other strengths that the victim may possess (Veenstra et al., 2013). Thus an emphasis on power draws attention to unique features of bullying that are important for both research and interventions.

Harm

One of the key reasons that bullying has received so much recent attention is the degree of harm that it can cause. For those who bully, there is mixed evidence regarding potential mental and physical health risks (see Gini & Pozzoli, 2009 and Volk, Camilleri, Dane, & Marini, 2012a, 2012b for contrasting reviews). There is much greater consensus regarding their risk for concurrent and future participation in other antisocial activities (Copeland, Wolke, Angold, & Costello, 2013; Ttofi & Farrington 2011). For those who are victims of bullying, the research is unequivocal; being victimized is associated with mental and physical health problems (see Gini & Pozzoli, 2009 and Volk et al., 2012b for reviews). These appear to both precede and follow from being a victim (Berger, 2007). Further, these health effects are both immediate and persistent, in some cases lasting into adulthood (Copeland et al., 2013, 2014). Most tragically, bullying can result in the death of the victim, either as the direct result of bullying (QMI Agency, 2013) or indirectly as a result of suicide motivated by the bullying (Winsper, Lereya, Zanarini, & Wolke, 2012). The latter is frequently influenced by the feelings of powerlessness and helplessness that characterize bullying as a form of aggression and make it a particularly harmful experience for victims (Hunter et al., 2007; Ybarra et al., 2014).

This harm has been traditionally captured by the quantity of the bullying episode (i.e., its repetition). However, the insistence on bullying being repetitive was initially applied to avoid trivial incidents that were not harmful (Olweus, 1993). Later definitions have abandoned repetition as a required component of bullying, particularly given the positive skew of bullying frequency data (e.g., Pellegrini & Long, 2002). Modern definitions of harm rely instead on conceptualizing harm as a product of both the severity and the frequency of the bullying in combination with the attributes and resilience of the victim (Volk et al., 2014; Winsper et al., 2012). Thus a single highly traumatic event may be sufficient for being called bullying (Slonje & Smith, 2008), while a low-intensity event (a single, brief prank phone call) may cause significant harm if repeated frequently enough (e.g., every hour for a month). Indeed, it may well be adaptive to avoid repetitive behaviors that carry costs of retaliation and/or detection and instead rely on a single traumatic aggressive episode to attain the goals of the bully (Volk et al., 2014).

Goal Directedness

Goal directedness is the final required component for a behavior to be considered bullying (Volk et al. 2014). It replaces the difficult to measure concept of intentionality (Kahneman, 2011) and instead offers concrete outcomes that themselves reveal intentionality, whether it be implicit or explicit. The three primary goals of bullying are resources, reproduction, and reputation—the three "Rs."

Resources represent any nonsocial or reproductive outcomes that benefit the bully. They can include food, money, job opportunities, or a particular geographic area. This goal of bullying is more prevalent when competition for resources is high and zero-sum (Volk et al. 2014). For example, for individuals in starving communities (Turnbull, 1972) or prison camps (Harden, 2012) bullying for food can be a matter of life or death. Bullying is more common when income inequality is high (Elgar et al., 2013) or when there is competition for limited opportunities (Flanagan, 2008).

Reproduction represents opportunities to increase one's biological fitness. Adolescents who engage in bullying have an increased desire to date, an earlier start of dating, and a greater number of sexual partners (Connolly, Pepler, Craig, & Taradash, 2000). Reproductively motivated bullying can target individuals of the same sex as a means of discouraging competitors (Volk et al., 2012a). In this intrasexual guise, boys tend to question the masculinity of the victim while girls tend to question the promiscuity of other girls (Vaillancourt, 2013; Volk et al., 2012a). Intersexual reproductive bullying typically involves harassing members of the opposite sex for dating or sexual access (Volk et al., 2012b).

Finally, bullying may be used to gain a reputation for violence that can enhance one's status and social power (Volk et al. 2014). This helps to explain why bullying persists within dominance hierarchies whose function is to reduce, not promote, bullying (Alcock, 1988). Under these conditions, a bully attacks another individual much lower in the hierarchy not because of the threat that individual poses, but rather as a cost-effective signal of their willingness to use violence. This signal can then deter competition or conflict with more similarly ranked individuals who view the bully as more costly to compete with (Volk et al. 2014). This appears to be an effective strategy as bullies do attain greater social dominance and popularity (see below).

Thus bullying is a goal-driven behavior that uses aggression to significantly harm individuals in the context of a power imbalance. But is it the result of evolutionary selection?

Is Bullying Adaptive?

For bullying to be an evolutionary adaptation, it must meet two necessary, but not sufficient, criteria (Williams, 1966). First, bullying must have a genetic component in which the effects of multiple genes reliably work together in the expression of the adaptive behavior (Symons, 1990). That is, a species' gene pool should contain a set of genes that are related to bullying for the evolutionary process to act upon (Symons, 1990). Without a genetic link, evolution would be unable to operate on traits associated with bullying (Volk et al., 2012a). Using a cohort of over 1100 families with 10-year-old twins, Ball et al. (2008) found that genetic factors were partially responsible (i.e., a heritability coefficient of 0.61) for bullying behavior in children. Indirect evidence for a potential genetic basis of bullying is its ubiquity. Bullying is found throughout historical cultures (e.g., Hsiung, 2005; Rawson, 2003), modernized cultures (Elgar et al., 2013; Pepler, Jiang, Craig, & Connolly, 2008), and hunter-gatherer cultures, including those that explicitly eschew displays of anger (Briggs 1970). From a developmental point of view, this either represents a startling persistence of unrelated cultural factors that encourage bullying across all of these cultures, or else it represents a genetic predisposition towards bullying that is (to some degree) independent of culture. When combined with the behavioral genetics data and comparative data (below), the ubiquity of bullying suggests the likelihood that there was enough "genetic traction" for natural and/or sexual selection to have acted on in past environments (Dawkins, 1989). As a result, the first necessary criterion for bullying as an adaptive behavior appears to be satisfied.

The second criterion that bullying must meet in order to be considered an evolutionary adaption is that the behavior should be instrumental in achieving a specific goal related to enhancing biological fitness in ancestral environments (Irons, 1998; Symons, 1990). For this, we first turn to bullying among nonhuman animals, which is widespread and typically involves a stronger animal repeatedly attacking a weaker animal (Archer, 1988; Lorenz, 1966). There is evidence for the adaptive function of bullying behavior found in numerous social animals (i.e., *Lycaon pictus,* African wild dogs: Creel & Creel, 2002; *Pan troglodytes*, chimpanzees: Goodall, 1986; *Gallus gallus,* chickens: Masure & Allee, 1934; *Canis lupus*, wolves: Mech, 1970) as a way of securing resources related to dominance, food, and mating (Book, Volk, & Hosker, 2012 Bullying as a functional adaptation in social animals may help us to better understand the adaptive function of bullying in humans. Next we examine evidence that suggests bullying serves adaptive purposes for adolescents in industrial societies, contemporary hunter-gatherer groups, and historical civilizations.

Similar to the adaptive function of bullying in nonhuman animals, there is evidence to suggest that adolescents in modernized societies also bully for dominance, physical resources, and mates (Volk, Della Cioppa, Earle, & Farrell 2015). Adolescent bullies tend to be perceived by their peers as more popular (de Bruyn, Cillessen, & Wissink, 2010), powerful (Vaillancourt, Hymel, & McDougall, 2003), and socially prominent (Zimmer-Gembeck, Geiger, & Crick, 2005), all of which may be indices of dominance (Volk et al., 2012a). In addition, Reijntjes et al. (2013) found that bullying is linked to the achievement of social dominance. Achieving social dominance within a peer group may be a way of facilitating future access to other significant adaptive benefits such as tangible resources and sexual partners (Flinn & Ward, 2005; Kolbert & Crothers, 2003). If bullies hold the powerful, dominant position in their peer groups, then we expect them to also have improved access to physical resources and mates. Adolescents who engage in bullying are able to obtain numerous material resources (i.e., food, money, electronics, and preferred playing and eating areas; Volk et al., 2012b). Furthermore, adolescent bullies also are more likely to have dated, more likely to have had sex, have more sexual partners, have a heightened interest in sexual activity, and engage in sexual intercourse at an earlier age (Connolly et al., 2000; Volk, Dane, Marini, & Vaillancourt, in press). Thus, bullying appears to be a social strategy aimed at gaining significant adaptive benefits related to survival and reproduction.

Furthermore, adolescent bullies do not appear to suffer from many unfavorable outcomes (Berger, 2007). For instance, previous research has suggested that bullies may demonstrate good social skills, Theory of Mind abilities, cognitive empathy, leadership, social competence, and self-efficacy (Caravita, DiBlasio, & Salmivalli, 2009; Vaillancourt et al., 2003). They are often portrayed as the strongest and healthiest individuals in their groups (Juvonen, Graham, & Schuster, 2003). These results suggest that perpetrators of bullying may experience competitive somatic advantages for both boys and girls (Rigby, 2003). Taken together, bullying appears to be contextually adaptive for adolescents in modernized societies.

In addition to technologically advanced societies, bullying may also play a similar adaptive role for adolescents in hunter-gatherer communities. Bullying has been described in a number of nonindustrialized societies such as contemporary hunter-gatherer groups (e.g., Turnbull, 1972). For example, one survival obstacle includes mortality rate in which nearly 50 % of children in hunter-gatherers failed to survive to adolescence and is significantly higher than the 1 % mortality rate among children in developed nations (Volk & Atkinson, 2008, 2013).

Thus, imminent death during periods of resource scarcity may have made bullying extremely valuable as a way of obtaining immediate food resources to ensure survival (Volk et al., 2012b). Among the Ik people, adolescents engaged in bullying peers and members of their community over food in order to avoid impending starvation (Turnbull, 1972). Similarly, the Labrador Inuit were involved in indirect bullying during periods of food scarcity (Briggs 1970). Bullying for resources (i.e., food) may have been adaptive among adolescents in nonindustrialized societies because it presumably led to greater chances of surviving. This may be reflected in the increase in bullying in modern industrialized countries when income inequality is greater (Elgar et al., 2013).

Besides industrialized societies and modern hunter-gatherers, bullying may have been a plausible adaptation in a number of past civilizations and cultures. Historical records have documented that bullying has taken place in numerous contexts dating back to ancient Greece (Golden, 1990) and Rome (Rawson, 2003). Bullying in these historical civilizations included goal-driven physical, verbal, and social attacks in the context of a power imbalance, which lead to victims being excluded and isolated (Volk et al., 2012a). Additionally, bullies competed with others for access to limited jobs or apprenticeships (Cunningham, 2005; Golden, 1990; Hsiung, 2005; Orme, 2001; Rawson, 2003). By obtaining a job position or apprenticeship, individuals would gain future access to resources to help improve survival and reproduction (Volk et al., 2012a).

Adolescent bullying has occurred across diverse, industrialized nation-states, contemporary hunter-gatherer groups, and historical cultures for the purpose of solving (at least implicitly) survival and reproduction-related problems both today and in the evolutionary past. This means that the second necessary criterion for bullying as an adaptive behavior appears to be met as bullying behavior leads to the achievement of particular goals that could have enhanced biological fitness in ancestral environments. The evidence presented on bullying indicates that the behavior meets both of the necessary criteria to be adaptive. Thus, it is reasonable to suggest that bullying is, at least in part, the result of an evolutionary adaptation. Throughout the chapter, bullying as an evolved adaption will be examined in the context of school as it relates to parents, teachers, peers, and school atmosphere.

School Bullying

There are several changes both structural and developmental that facilitate the peak and adaptation of bullying in the school context. Regarding school structure, middle adolescence is often marked by the transition from middle school to high school (Juvonen & Graham, 2014). High school is usually different from middle school in that there are traditionally multiple teachers instructing different subjects, which often coincides with more independence and less adult supervision in areas of school outside of the classroom (Kasen, Berenson, Cohen, & Johnson, 2004). Reduced supervision allows for ample opportunities for bullying in out-of-classroom areas where there are fewer risks or costs (i.e., getting caught) associated with bullying in these areas. Increased independence also facilitates some developmental social changes. More specifically, there is exposure to new peers, and as a result, as will be discussed later under the context of peers, this requires the formation of new social networks (Totura et al., 2009). Thus, the restructuring of peer networks is a crucial time of both transition and uncertainty. This may maximize opportunities for adolescents to compete with one another for social power and status (Juvonen & Graham, 2014; Pellegrini & Long, 2002). Using bullying as a social strategy under these circumstances may lead to more benefits, particularly with respect to emerging reproductive resources associated with the onset of puberty (Volk et al. 2014). The benefits of using bullying may be reflected in the high prevalence rates, particularly during middle adolescence.

Prevalence Rates

The majority of studies using both peer nominations and self-report measures have found that approximately 30 to 40 % of adolescents are involved in school bullying with varying roles (e.g., Espelage & Holt, 2007; Hymel & Swearer, 2015; Kim, Koh, & Leventhal, 2004; Vaillancourt et al., 2010). For instance, Espelage and Holt (2007) found that approximately 15 % of adolescent students were involved as perpetrators, 14 % as victims, and 4.4 % as bully–victims (individuals who are both bullies and victims). Additionally, the majority of studies on bullying have found perpetration was often highest amongst boys during middle adolescence (e.g., Barboza et al., 2009; Kim et al., 2004; Solberg, 2003; Sourander, Helstelä, Helenius, & Piha, 2000; Volk et al., 2006). It is also important to acknowledge that the rates may vary based on particular subtypes of bullying behaviors.

Prevalence of Subtypes

Specific subtypes of bullying may be more adaptive at various times of adolescence. Researchers have found that while direct physical bullying (e.g., hitting, pushing) is preferred by boys during early adolescence, direct verbal bullying (e.g., threatening, teasing) is relatively high and stable throughout adolescence (Hong & Espelage, 2012; Hymel & Swearer, 2015; Scheithauer, Hayer, Petermann, & Jugert, 2006; Smokowski & Kopasz, 2005; Wang, Iannotti, & Nansel, 2009). Evolutionarily, boys may be more likely to use physical bullying to demonstrate physical strength in comparison to girls, who may have a tendency to avoid physical risks (Archer, 2009; Benenson, 2009), thereby preferring indirect social bullying (e.g., gossiping, excluding; Smokowski & Kopasz, 2005; Wang et al., 2009). In turn, boys may have more to gain from using physical confrontation in comparison to girls (Daly & Wilson, 1988). This may lead to reputational and reproductive benefits, as discussed earlier. In addition to sex differences, age differences are evident. Complex covert bullying behaviors, such as rumor spreading, are increasingly used during later adolescence and may reflect improved skills at manipulating social dynamics (Vaillancourt et al., 2010). These behaviors may be more adaptive for adolescents as while they require greater cognitive skill (that may be lacking younger children), they are more difficult for authority figures to detect (Scheithauer et al., 2006; Wolke, Woods, Bloomfield, & Karstadt, 2000). The adaptive use of each subtype of bullying may be important when addressing school bullying interventions.

It may be especially important to acknowledge the prevalence and relevance of each subtype of bullying when developing and implementing anti-bullying policies at schools. Many anti-bullying initiatives may treat bullying as a homogeneous phenomenon (Volk et al., 2012b). However, it is evident that certain subtypes are more prevalent and adaptive than others, especially for different ages and sexes. Therefore, considering the costs and benefits associated with each subtype, interventions should focus on how adolescents may gain benefits similar to those associated with each bullying behavior, but in a more prosocial manner. For instance, if boys use physical bullying behaviors to display their physical strength or dominance to attract potential dates, schools may provide alternative opportunities to demonstrate similar dominance, such as through the availability of participating in visibly competitive sports (Ellis et al., 2012). Furthermore, interventions may be even more effective if additional factors that affect school bullying are addressed. These factors include parenting, teachers, peers, and the school atmosphere, which will be discussed in the following sections.

Parents and School Bullying

Examining children and adolescents' bullying behavior through an evolutionary lens suggests that parents may be transferring bullying behaviors to their children. Parental investment theory (Trivers, 1972), which is a ubiquitous evolutionary theory on parenting, provides an explanation for how this might transpire. It states that caring for an offspring comes with high costs such as taking time away from mating opportunities and limiting resources that could aid in one's own growth and development. However, parental care and nurturance is vital for the offspring's survival, and thus the high parental cost is warranted by the evolutionary advantages of raising a child, such as proliferation of one's genes through the offspring and additional manpower to help acquire resources from other kin-based coalitions (Geary & Flinn, 2001). Therefore, it is in the parent's best interest to invest in an offspring who is most likely to survive and reproduce.

Consequently, the offspring who is most likely to survive until and after reproduction may be the child who learns to bully others in order to acquire more resources, sexual partners, and reputation, which are not only the core goals of bullying (Volk et al. 2014) but arguably also instrumental to one's biological fitness. Thus, the transmission of bullying behaviors from the parent to the child may benefit the child and indirectly the parent. In the same vein, bullying behavior within kin networks, such as sibling bullying, may be adaptive for benefitting the entire kin group by coaching bullying behavior that prepares them to acquire assets from unrelated groups through political intimidation and warfare (Barry, Josephson, Lauer, & Marshall, 1976; Geary & Flinn, 2001). Beyond passing on genes correlated with bullying, there are several other ways for parents to influence the bullying behavior of their children.

Studies have found that children could be learning bullying behavior by simply observing and/or imitating parents' aggressive behavior (Bandura, 1978). Given their obvious reproductive success and genetic similarity, parents are highly influential role models for children's learning (Geary, 2008). This may be further emphasized by the substantial power difference between parents and their children. This power difference, which puts parents at the highest level on the power hierarchy within the family context, largely stems from parents' role in providing reward and punishment to children (Pepler et al., 2008). Thus, children's bullying behavior, which also occurs in the presence of power imbalance between the bully and victim, may be strongly influenced by the modeling of parental behaviors within the context of a power imbalance.

Parenting Style

Of the four parenting styles outlined by Baumrind (1991), authoritarian parenting, which is identified as high demandingness, high in conflict, low warmth, and low responsiveness, is shown to be the strongest predictor for the early development of children's bullying behavior in western societies (Baldry & Farrington, 2000; Barry et al., 1976; Chao, 2001), while parents' involvement in family violence, harsh disciplinary practices, and physical punishment is shown to further perpetuate it (Espelage, Bosworth, & Simon, 2000). The latter can be explained by traditional theories on aggressive behaviors which suggest that aggressive behavior is influenced by imitating aggressive role models (Bandura, 1978). Parents serve as aggressive role models when the family comprises coercive interactions (Patterson, Chamberlain, & Reid, 1982). These coercive interactions tend to become increasingly aggressive over time leaving children to feel helpless, which inadvertently leads them to also react in aggressive ways. In addition, families high in conflict and in which both parents are low in warmth are likely to influence "defensive identification" in children (Sarnoff, 1951), where the child has no one else to turn to for support and consequently copes by identifying with the aggressor (Freud, 1989). The child then imitates the aggressive behavior that extends into their peer relationships at school, leading to bullying. From an adaptive point of view, this parenting style is used by parents to convey important general information to children about how to adaptively behave in their environment using the parent as a model for successful behavior (Konner, 2010). This occurs regardless of the social desirability of the behavior (Ellis et al., 2012).

Parent–Child Attachment

The child's early attachment to the primary caregiver is known to guide the child's relationships throughout his/her life (Bowlby, 1969). Bowlby's ethological theory stresses the importance of infant–caregiver attachment in developing children's emotional regulation, social competence, and notions of ideal relationships with others by internalizing the quality of the relationship with their primary caregiver (Elicker, Englund, & Sroufe, 1992). Children with insecure attachments may have experienced unresponsive and inconsistent parenting, and as a result may have developed antisocial views about themselves and others (i.e., they may expect others to also be unresponsive and unrewarding). These children may show reductions in social warmth and empathy that further facilitate engaging in aggressive behavior (MacDonald, 1992). These negative preconceptions of others lead them to interpret ambiguous cues in social situations as deliberate acts of negative behavior, and consequently influence them to react in aggressive ways, which may heighten their propensity for aggressive behaviors such as bullying (Renken, Egeland, Marvinney, Mangelsdorf, & Sroufe, 1989). These responses, while maladaptive in a societal sense, may serve the perceived goals of the adolescents who use them (Ellis et al., 2012).

The influence of parents on children's bullying behavior is clearly substantial and attests to the need for extensive parental involvement in bullying interventions. However, the efficacy of parental involvement in current bullying interventions, such as parent trainings, parent information sessions, and parent–teacher interviews, has been shown to reduce school reported rates of bullying by only 20 to 30 % (Ttofi et al., 2012). This low efficacy rate may be largely due to parents' minimal awareness of their child's involvement in school bullying (Pepler, Craig, Ziegler, & Charach, 1993; Stockdale, Hangaduambo, Duys, Larson, & Sarvela, 2002) as parents do not have direct access to or information regarding their child's peer relationships in the school setting. Further, children are also less likely to disclose their bullying behaviors to their parents (Holt, Kaufman Kantor, & Finkelhor, 2008), compared to victimization experiences (Houndoumadi & Pateraki, 2001).

Thus, in order to further decrease rates of school bullying, we suggest that interventions should focus on comprehensively educating parents about the implications of their behavior so that parents will be able to recognize when they themselves are practicing, and endorsing bullying behavior in the home. Unfortunately, if bullying works for parents as it does for adolescents at school, then it may also prove difficult in altering parents' behaviors.

Bullying Educationfor the Educators

Teachers are modern inventions who are expected to meet certain criteria and complete different kinds of training in order to practice within the school system (Geary, 2008; Lancy, this volume). They perform a role that is in some ways similar to the evolutionary model of alloparents, as nonparents who invest in others' children (Hrdy, 2009). It may be that as a modern and artificial construct, teachers are not endowed with the tools that earlier adults possessed when dealing with children, such as shared genes and a longer history of cohabitation and/or interdependence as part of a small hunter-gatherer group (Konner, 2010). In this view, teachers may not have a strong motivation (due to lack of inclusive fitness; Trivers, 1972) or knowledge (of the children) required to effectively intervene. Perhaps unsurprisingly, Bradshaw, Wassdorp, O'Brennan, and Gulemetova (2013) found that nearly half of the teachers in their sample reported uncomfortable feelings of ineptness in dealing with bullying, which translates to thousands of teachers feeling unprepared to deal with these important instances in young peoples' lives and illuminates the urgent need for more extensive bullying training (Bradshaw et al., 2013). Confidence is a key factor that enables teachers to feel ready to take on bullying; in order for teachers to be prepared, bully education must include teachers as a primary focus (Collier, Bos, & Sandfort, 2015; Duong & Bradshaw, 2013).

Using a sample of 1062 teachers, Duong and Bradshaw (2013) explored whether teachers' perceptions on the severity of the bullying situation, as well as their perceptions on the likelihood that their intervention would produce a desirable outcome, influenced the probability that teachers would intervene. More experienced teachers were also more likely to intervene while taking both perceived threat and perceived efficacy into consideration (Burger, Strohmeier, Sprober, Bauman, & Rigby, 2015; Duong & Bradshaw, 2013). These beliefs and experience thus coincide with what one might expect from a community of unrelated alloparents tasked with disciplining children within their village (Hrdy, 2009). Yet the problem remains as a large Canadian survey highlighted that 19 % of students felt that teachers almost never intervened in bully situations, even when the students had mentioned it previously to their teachers (Craig, Pepler, & Atlas, 2000). This reveals the potential modern mismatch between teachers and more traditional alloparental roles where adults could potentially intervene more freely in children's affairs and were more likely to have a genetic interest in the outcomes of the children in their care (Hrdy, 2009; Konner, 2010).

But there are other avenues for teachers to influence their students' bullying behaviors. As with parents, adolescents tend to look to their teachers to exemplify the behaviors that combat bullying and support victims (Veenstra, Lindenberg, Huitsing, Sainio, & Salmivalli, 2014). Recent studies have shown that teachers who take an active stance against bullying (e.g., enhanced punishment and/or explicit denouncement of bullying), especially groups of teachers, are able to create impactful school-wide awareness that effectively decreases bullying among students (Smith & Smith, 2014; Veenstra et al., 2014; Wang, Swearer, Lembeck, Collins, & Berry, 2015). Once more, this highlights how children and adolescents appear to be adapted to learn via observation and imitation (Flinn & Ward, 2005).

Teachers' effectiveness and willingness to intervene increases the costs of bullying (reducing the net benefit) that in turn, influences the behavior of their students, leading to the possibility of enhanced dividends from teacher intervention programs. In addition, teachers' ability to effectively intervene in bullying depends on their own education and experience (Bradshaw et al., 2013; Burger et al., 2015). However, there is one very important caveat to consider when talking about adult-focused interventions—adults are generally poor at detecting bullying. The covert nature of bullying means that as much as 96 % of schoolyard bullying lacks any kind of adult intervention (Craig & Pepler, 1998). In stark contrast, 80–85 % of observed school bullying featured peers in some role (Craig & Pepler, 1998; Craig et al., 2000). This is important, as teachers cannot intervene in a situation if they do not see it or know that it is happening, even if they do have a considerable amount of knowledge about bullying. Consequently, teachers should be the targets of intervention not only to increase bully education, but to bring forth the idea that teachers may not always be able to spot bullying (Craig et al., 2000; Veenstra et al., 2014). This means that other methods of detecting bullying are important to work on, such as building trusting relationships between teachers and students. Also, an evolutionary perspective would suggest that due to a nongenetic relationship, teachers may not be as motivated about the welfare of their students, particularly in comparison with parents who have a stronger (typically genetic) investment in their children (Essock-Vitale & McGuire, 1985). Another important modern group of unrelated individuals related to adolescent school bullying are students' peers (Essock-Vitale & McGuire, 1985).

Bullying in the Peer Context

During the transition to adolescence, peer groups become particularly important influences on the attitudes and behaviors of individuals (Owens, Shute, & Slee, 2000; Rubin, Bukowski, & Parker, 1998) as they spend more time with their peers and less time with their family (Ernst & Hardin, 2009). As mentioned earlier, the increased autonomy typically means exposure to new peer groups and the formation of new social networks (Totura et al., 2009). The structure of these peer groups becomes stratified as adolescents become increasingly concerned with popularity and being accepted by their peers (Espelage, 2002). This need for recognition and peer acceptance within the social group may be taken into account in helping to explain why some individuals engage in bullying at school (Burns, Maycock, Cross, & Brown, 2008). That is, some individuals may need to compete with each other in order to boost their own status and social standing (Gini, 2006; Hawley, this volume). As such, bullying might be a strategy used to gain status within a peer hierarchy (Espelage, Holt, & Henkel, 2003; Scheithauer et al., 2006). Status indicates one's social standing relative to others in the peer group (Keltner, Gruenfeld, & Anderson, 2003). From an evolutionary perspective, higher status individuals may get priority access to resources (i.e., food, protection, and mates) over lower status individuals (Flinn & Ward, 2005; Hawley, 1999). For adolescents in modern societies, high status may facilitate access to sexual partners (Salmivalli, 2010). Considering that intimate relationships become increasingly important during adolescence (Pellegrini & Long, 2002), it is no surprise then that adolescent bullies may be compelled to attain high status in the peer group (Pellegrini & Long, 2002; Salmivalli & Peets, 2008). While bullying for status may be an individual motive (Salmivalli, 2010), it very much operates in the context of the peer group (Espelage et al., 2003).

In other words, the significance of peers in the bullying context indicates that bullying goes beyond the dyadic relationships between bullies and victims (Sutton & Smith, 1999). This group process comprises peers who belong to the group and play various roles that influence bullying behavior (Salmivalli, Lagerspetz, Bjuorkqvist, Osterman, & Kaukiainen, 1996) by either exacerbating the problem or attempting to mitigate it (Hawkins, Pepler, & Craig, 2001). According to Salmivalli et al. (1996), when bystanders witness a bullying episode, there are four different roles that they may play in the bullying process: defenders (i.e., helping and supporting the victim), assistants (i.e., joining in on the bullying), reinforcers (i.e., giving positive feedback to the bully by laughing or cheering), and outsiders (i.e., remaining passive or uninvolved during the bullying episode). It may be adaptive for both male and female peers to assist in the bullying. That is, by copying the behaviors of high status individuals (i.e., bullies), peers may enhance their own status by associating themselves with powerful people (Moffitt, 1993). They may also enhance their own relative *if the victim's status decreases* and may reduce their odds of becoming victims themselves (Volk et al., 2012a, b).

For instance, male peers forming or joining a group of bullies may act as a protective function (Juvonen & Galvan, 2008). By associating with high status male bullies, peers may develop a tough reputation that may serve as a protective factor against future rivals and thus result in less intrasexual competition (Benenson, 2009). However, a male with a tough reputation may also be especially appealing to females because it signals that they can provide protection for both her and their children (Buss, 1988). Meanwhile for females, Owens et al. (2000) found that relational bullying was utilized for enhancing popularity and gaining access to the in-group, which in turn grants a female the power to control who is invited and who is excluded from prominent social gatherings (i.e., parties) that provide opportunities to socialize with potential romantic partners. Thus, it may be socially adaptive for female peers to join the bullying group to enhance their popularity, in turn facilitating access to exclusive social events, which presumably include high status males. They may also be motivated to begin hoarding social and material resources that are useful in providing maternal care to future children (Geary, 2010). Additionally, these early romantic relationships may continue into adulthood or they may serve as important practice for negotiating power and resources in later adult relationships. In either case, this could enhance women's ability to provide for their young (Geary, 2010). Although peers can become part of the bullying group and receive adaptive benefits, they are similar to teachers in that they also have a potential to intervene and stop bullying (e.g., Hawkins et al., 2001; Smith & Smith, 2014; Veenstra et al., 2014; Wang et al., 2015). To understand when and why peers intervene, past evolutionary environments may provide some explanation.

In ancestral environments, banding together to form a group may have ensured survival by providing safety and protection from other hostile groups and animals (Van Vugt & Schaller, 2008). Today, this may take the form of peers coming together to defend against bullying. Prior research has shown that peer interventions were often effective at stopping the bullying episode (Hawkins et al., 2001) and defending the victim reduced the frequency of classroom bullying at school (Salmivalli, Voeten, & Poskiparta, 2011). These behaviors presumably increase the costs (e.g., intervention) and reduce the benefits (e.g., peer approval) of bullying. Despite these encouraging results, peers fail to realize their ability to reduce bullying behavior (Salmivalli, 2010). Most peers hold attitudes that bullying is wrong and hypothetical situations indicate that peers will indeed provide social support for victimized peers (Boulton, Trueman, & Flemington, 2002; Rigby & Johnson, 2006). However, peer reports find that in actual bullying scenarios it is rare that peers will intervene to defend victims, presumably because real costs are much higher than hypothetical costs (Salmivalli, 2010). There may be a number of reasons that can explain this apparent discrepancy between having anti-bullying attitudes and a peer's actual observed behavior (O'Connell, Pepler, & Craig, 1999).

The first possible explanation for why peers remain inactive during bullying episodes is the bystander effect, which refers to the situation when a victim does not receive help even though many individuals are present (Darley & Latane, 1968). This diffusion of responsibility may result in two outcomes: first, expecting others to help a victim of bullying at school leads peers to believe that none of them are responsible (Salmivalli, 2010). Second, peers may look to others' inactivity in stopping the bullying episode and believe that the situation is not that severe (Salmivalli, 2010). Taken together, the diffusion of responsibility diminishes the motivation to intervene (O'Connell et al., 1999).

A second potential explanation for the lack of defending behaviors demonstrated by peers is the idea that most attacks on victims at school may not appear to be that serious (i.e., teasing; Rivers & Smith, 1994), and thus do not warrant intervention. In addition, youth subvert the idea of bullying as harmful through diminishing the seriousness of the hurtful behavior by positioning themselves as a "joker" and reducing bullying to "just joking" (Ryan & Morgan, 2011). Again, this strategy may serve to indicate to peers that the bullying episode is not serious and the victim does not need to be helped.

A third reason that may explain why bystanders are likely to not get involved when others are being bullied is that it may be adaptive for them not to do so (Juvonen & Galvan, 2008) for a few reasons. First, peers may join the bullying group, or at least distance themselves from being associated with victims who are unpopular or rejected, in order to avoid being a target of bullying themselves (Cillessen & Mayeux, 2007). In other words, peers may not intervene to avoid becoming the next victim (O'Connell et al., 1999). Second, witnesses of bullying may choose to not intervene because they are genetically unrelated to the victim(s), that is, the benefits of stopping the bullying of non-kin are less than the benefits of stopping the bullying of a related individual (Barber, 1994; Burnstein, Crandall, & Kitayama, 1994; Fitzgerald & Colarelli, 2009; Kruger, 2001). Peers may not be willing to help each other during bullying episodes because the cost of the defending behavior may be too high especially for helping someone who is non-kin. And third, peers may not intervene and may even allow others to be victimized so as to eliminate them during competition for scarce resources. During food shortages, hunter-gatherers (Turnbull, 1972) would bully each other for access to food resources in order to ensure their own survival (Volk et al., 2014). In modern societies, instead of food, adolescents may compete for scarce resources such as sexual partners or limited scholarships (Jonason, Li, Webster, & Schmitt, 2009). By not intervening, peers may be leaving others to be targeted by bullies, thus reducing the number of competitors for desirable mates or resources. Or worse, bystanders may join the bullying group and attack others to diminish the competition and enhance mating opportunities.

A final reason as to why peers may not intervene may involve the number of victims that bullies target. Bullies often target only a few victims (Schuster, 1999). Targeting one or two victims in the classroom or school is more efficient and safer for the bully as the victim may be less likely to retaliate alone; however, attacking several victims may result in them banding together to support and defend each other (Garandeau & Cillessen, 2006). Moreover, when there is only one target it creates the perception that there is something "wrong" (i.e., a negative personality trait) with a particular victim, which is causing them to be bullied (i.e., the victim's fault) and may communicate to peers that the bullying seems justified (Garandeau & Cillessen, 2006). Therefore, bullying a single victim may deter other peers from intervening.

In sum, even though there are social rewards for peers who provide help and support, such as being well-liked (Salmivalli et al., 1996) and being perceived as popular (Caravita et al., 2009), they still mostly refrain from intervening in bullying episodes (Salmivalli, 2010). If bullying is part of a much larger and complex group process (Gini, 2006), then it may require interventions that involve peers at the group level to counteract bullying rather than focusing on bullies and victims at the individual level (Salmivalli, 2010). That is, preparing peer groups with the right strategies to defend the victim, helping bystanders to realize their role in the bullying process, and having peers empathize with the suffering of victims, are all crucial steps that may help reduce bullying (Kärnä et al., 2013; Salmivalli et al., 2011). Recall that it may not only be the teachers who need to be educated about bullying (Bradshaw et al., 2013), but the bystanders as well. Furthermore, if bullying is being observed by as much as 80–85 % of peers (Craig & Pepler, 1998; Craig et al., 2000) compared to as little as 4 % by teachers or adults (Craig & Pepler, 1998), then this may suggest that peers are the key to effectively stopping bullying because they actually see the behavior happening. Thus, it is the interactions among peers in a group as well as the impact of broader social processes that may partly influence bullying behaviors (Burns et al., 2008). As such, the school atmosphere encompasses these broad social processes that may contribute to bullying.

Bullying and School Atmosphere

Beyond teachers and peers, there are many aspects of a school that may facilitate or discourage bullying. Interactions between adolescents, teachers, and administrators within a school may contribute to how adolescents perceive their school's social and emotional atmosphere (Kasen et al., 2004; Loukas & Robinson, 2004). Perceptions of school atmosphere may affect whether adolescents decide to take advantage of the increased unsupervised school regions, and ultimately bully their peers (Craig & Pepler, 1995; Swearer, Espelage, Vaillancourt, & Hymel, 2010). Adolescents may learn to use bullying as an adaptive tool if they have specific perceptions of school atmosphere, particularly competition and norms.

Academic competition may be an important aspect of school climate that encourages adolescent bullying. Student perceptions of lower academic competition have previously been associated with higher levels of social cohesion, and lower emotional and behavioral problems (Loukas & Robinson, 2004; Loukas, Suzuki, & Horton, 2006). A study by Freeman et al. (2009) found that schools with students who perceived higher rates of academic pressure had higher rates of bullying, even when these schools had higher ratings in other aspects of school climate, such as connectedness and enjoyment. As a result, schools with higher academic competition and lower cohesion may enhance scarcity biases and/or teach adolescents that competition, particularly comparison to peers, is encouraged, and that bullying may be one method of competing (Roseth, Johnson, & Johnson, 2008). It may also signal that there are limited resources available at school that must be competed for, including popularity, teacher favoritism, and grades (Butler & Kedar, 1990; Roseth et al., 2008; Sutton & Keogh, 2000). This appears to be supported by historical examples of competition over school prizes and memberships (Golden, 1990; Rawson, 2003).

Limited resources may signal an environment of inequality. Research has shown that as a whole, income inequality supports more competition for limited resources (Daly & Wilson, 2010). In fact, income inequality has previously been associated with higher school bullying (Elgar et al., 2013). Likewise, in a school with higher levels of competition and inequality, students may compete for social dominance, which would further increase access to additional resources. As discussed earlier in the chapter, the creation and maintenance of dominance hierarchies often reduces the costs of bullying, that is, retaliation by weaker individuals in the hierarchy (Volk et al., 2014). Consequently, students are more likely to use bullying behaviors over time if they perceive more immediate benefits, such as social acceptance and popularity, and fewer immediate costs (Reijntjes et al., 2013). Eventually, if adolescents learn to use bullying as a means to obtain limited resources in a school with higher levels of competition, bullying may become perceived as accepted behavior. In fact, bullying perpetration has often been higher in schools with students who perceived bullying to be a norm (Bradshaw, Waasdorp, & Johnson, 2015; Espelage et al., 2003; Huitsing & Veenstra, 2012; Salmivalli & Voeten, 2004; Totura et al., 2009). Thus, with higher perceptions of school competition, the bullying norms that develop may further reinforce a climate of competition and bullying. Consequently, levels of competition may be an important aspect of school atmosphere that should be targeted in anti-bullying interventions.

Since the primary aspect of school atmosphere that teaches students to use bullying is the level of competition, interventions may want to target methods of reducing competition and instead facilitating higher connectedness through the use of prosocial behaviors (Sutton & Keogh, 2000; Volk et al., 2012a, 2012b). For example, emphasizing class-level grades versus individual grades may reduce individuals' motives for bullying while still encouraging success and achievement (although this could then lead to social loafing). Furthermore, forming positive social relationships at school may aid in increasing the costs of competitive bullying behaviors (Erickson, Mattaini, & McGuire, 2004; Sutton & Keogh, 2000). This may be more effective than preventing school bullying via school punishment, considering modeling rewards versus punishments may often encourage the cycle of school bullying (Erickson et al., 2004). As a result, researchers and practitioners must recognize that interventions cannot be considered as "add-ons" to a single characteristic of the school (Erickson et al., 2004). Instead, prevention and intervention practices should attempt to integrate evidence-based practices (Erickson et al., 2004) into the wider culture that encompasses students. This includes the contribution of multiple key participants including parents, teachers, peers, school, and the wider community.

Conclusions

To summarize, bullying appears to be an adaptive behavior that is caused, at least in part, by evolved predispositions (similar to aggression; Hawley, this volume). This means that to fully understand and prevent bullying requires adopting an evolutionary lens that can help explain the forms and functions of bullying amongst adolescents. And while this article focuses primarily on adolescents, we believe the same adaptive hypotheses generally apply to older and younger populations as well (naturally, we don't expect younger children to seriously compete over dating partners even if they do compete over other resources). More traditional views of bullying have sometimes recognized that it can be adaptive, but fail to explore why the behavior may have arisen in the first place, or what specific benefits can be obtained from it (e.g., Olweus, 1993).

An evolutionary perspective also highlights the importance of ecological context in understanding bullying. Bullying is a contextual phenomenon (Hong & Espelage, 2012) that is influenced by a host of social and environmental factors. Within the adolescent school context, we believe that parents, teachers, peers, and the school atmosphere represent the strongest influences on the expression of bullying behaviors. An evolutionary lens further sharpens and clarifies the importance of these factors as well as how they interact in the modern environment with adolescents' adaptations that are shaped by our evolutionary past.

The ability to understand bullying more clearly is crucial, as the lives of millions of adolescents worldwide are negatively affected by it. By applying an evolutionary approach we believe that researchers can sharpen their study of bullying and in turn aid in the development of more effective anti-bullying initiatives (Ellis et al., 2012). Bullying may have been an important, adaptive behavior in our evolutionary past, but that does not mean that it is required to remain an important, adaptive behavior in our future. An evolutionary analysis will hopefully help to make bullying a non-significant factor in the lives, development, and evolution of future adolescents.

References

Alcock, J. (1988). *Animal behavior* (4th ed.). Sunderland, MA: Sinauer.

Archer, J. (1988). *The behavioral biology of aggression*. Cambridge, England: Cambridge University Press.

Archer, J. (2009). Does sexual selection explain human sex differences in aggression? *Behavioral and Brain Sciences, 32*, 249–311.

Baldry, A. C., & Farrington, D. P. (2000). Bullies and delinquents: Personal characteristics and parental styles. *Journal of Community and Applied Social Psychology, 10*, 17–23.

Ball, H. A., Arseneault, L., Taylor, A., Maughan, B., Caspi, A., & Moffitt, T. E. (2008). Genetic and environmental influences on victims, bullies and bully-victims in childhood. *Journal of Child Psychology and Psychiatry, 49*(1), 104–112.

Bandura, A. (1978). Social learning theory of aggression. *Journal of Communication, 28*, 12–29.

Barber, N. (1994). Machiavellianism and altruism: Effect of relatedness of target person on Machiavellian and helping attitudes. *Psychological Reports, 75*(1), 403–422.

Barboza, G. E., Schiamberg, L. B., Oehmke, J., Korzeniewski, S. J., Post, L. A., & Heraux, C. G. (2009). Individual characteristics and the multiple contexts of adolescent bullying: An ecological perspective. *Journal of Youth and Adolescence, 38*(1), 101–121.

Barry, H., Josephson, L., Lauer, E., & Marshall, C. (1976). Traits inculcated in childhood: Cross-cultural codes 5. *Ethnology, 15*, 83–106.

Baumrind, D. (1991). Parenting styles and adolescent development. In J. Brooks-Gunn, R. Lerner, & A. Petersen (Eds.), *The encyclopedia of adolescence* (pp. 746–758). New York, NY: Garland.

Benenson, J. F. (2009). Dominating versus eliminating the completion: Sex differences in human intrasexual aggression. *Behavioral and Brain Sciences, 32*, 268–269.

Berger, K. S. (2007). Update on bullying at school: Science forgotten? *Developmental Review, 27*, 90–126.

Book, A., Volk, A. A., & Hosker, A. (2012). Adolescent bullying and personality: An adaptive approach. *Personality and Individual Differences, 52*, 218–223.

Boulton, M. J., Trueman, M., & Flemington, I. (2002). Associations between secondary school pupils' definitions of bullying, attitudes towards bullying, and tendencies to engage in bullying: Age and sex differences. *Educational Studies, 28*, 353–370.

Bowlby, J. (1969). *Attachment and loss* (Attachment, Vol. 1). New York, NY: Basic Books.

Bradshaw, C. P., Waasdorp, T. E., & Johnson, S. L. (2015). Overlapping verbal, relational, physical, and electronic forms of bullying in adolescence: Influence of school context. *Journal of Clinical Child & Adolescent Psychology, 44*(3), 494–508.

Bradshaw, C. P., Wassdorp, T. E., O'Brennan, L. M., & Gulemetova, M. (2013). Teachers' and education support professionals' perspectives on bullying and prevention: Findings from a national education association study. *School Psychology Review, 42*(3), 280–297.

Briggs, J. L. (1970). *Never in anger: Portrait of an Eskimo family (Vol. 12)*. Cambridge, MA: Harvard University Press.

Burger, C., Strohmeier, D., Sprober, N., Bauman, S., & Rigby, K. (2015). How teachers respond to school bullying: An examination of self-reported intervention strategy use, moderator effects, and concurrent use of multiple strategies. *Teaching and Teacher Education, 51*, 191–202.

Burns, S., Maycock, B., Cross, D., & Brown, G. (2008). The power of peers: Why some students bully others to conform. *Qualitative Health Research, 18*(12), 1704–1716.

Burnstein, E., Crandall, C., & Kitayama, S. (1994). Some neo-Darwinian rules for altruism: Weighing cues for inclusive fitness as a function of the biological importance of the decision. *Journal of Personality and Social Psychology, 67*, 773–789.

Buss, D. M. (1988). The evolution of human intrasexual competition: Tactics of mate attraction. *Journal of Personality and Social Psychology, 54*(4), 616.

Butler, R., & Kedar, A. (1990). Effects of intergroup competition and school philosophy on student perceptions, group processes, and performance. *Contemporary Educational Psychology, 15*(4), 301–318.

Cappadocia, M. C., Pepler, D., Cummings, J. G., & Craig, W. (2012). Individual motivations and characteristics associated with bystander intervention during bullying episodes among children and youth. *Canadian Journal of School Psychology, 27*, 201–216.
Caravita, S. C. S., Di Blasio, P., & Salmivalli, C. (2009). Unique and interactive effects of empathy and social status on involvement in bullying. *Social Development, 18*, 140–163.
Chao, R. K. (2001). Extending research on the consequences of parenting style for Chinese Americans and European Americans. *Child Development, 72*, 1832–1843.
Cillessen, A. H. N., & Mayeux, L. (2007). Developmental changes in the association between aggression and status in the peer system. In P. Hawley, T. Little, & P. Rodkin (Eds.), *Aggression and adaptation: The bright side to bad behavior* (pp. 135–156). Mahwah, NJ: Lawrence Erlbaum.
Collier, K. L., Bos, H. M. W., & Sandfort, T. G. M. (2015). Understanding teachers' responses to enactments of sexual and gender stigma at school. *Teaching and Teaching Education, 48*, 34–43.
Connolly, J., Pepler, D., Craig, W., & Taradash, A. (2000). Dating experiences of bullies in early adolescence. *Child Maltreatment, 5*, 299–310.
Copeland, W. E., Wolke, D., Angold, A., & Costello, E. J. (2013). Adult psychiatric outcomes of bullying and being bullied by peers in childhood and adolescence. *Journal of the American Medical Association Psychiatry, 70*, 419–426.
Copeland, W. E., Wolke, D., Lereya, S. T., Shanahan, L., Worthman, C., & Costello, E. J. (2014). Childhood bullying involvement predicts low-grade systemic inflammation into adulthood. *Proceedings of the National Academy of Sciences, 111*, 7570–7575.
Craig, W. M., & Pepler, D. J. (1995). Peer processes in bullying and victimization: An observational study. *Exceptionality Education Canada, 5*, 81–96.
Craig, W. M., & Pepler, D. J. (1998). Observations of bullying and victimization in the school yard. *Canadian Journal of School Psychology, 13*, 41–59.
Craig, W. M., Pepler, D., & Atlas, R. (2000). Observations of bullying in the playground and in the classroom. *School Psychology International, 21*(1), 22–36.
Creel, S., & Creel, N. M. (2002). *The African wild dog*. Princeton, NJ: Princeton University Press.
Cunningham, H. (2005). *Children and childhood in western society since 1500* (2nd ed.). Toronto, ON, Canada: Pearson-Longman.
Daly, M., & Wilson, M. (1988). *Homicide*. New Brunswick, NJ: Aldine Transaction.
Daly, M., & Wilson, M. (2010). Cultural inertia, economic incentives, and the persistence of 'southern violence'. In M. Schaller, A. Norenzayan, S. J. Heine, T. Yamagishi, & T. Kameda (Eds.), *Evolution, culture and the human mind* (pp. 229–241). New York, NY: Psychology Press.
Darley, J., & Latane, B. (1968). Bystander intervention in emergencies: Diffusion of responsibility. *Journal of Personality and Social Psychology, 8*, 377–383.
Dawkins, R. (1989). *The selfish gene* (2nd ed.). Oxford, England: Oxford University Press.
de Bruyn, E. H., Cillessen, A. H., & Weisfeld, G. E. (2012). Dominance-popularity status, behavior, and the emergence of sexual activity in young adolescents. *Evolutionary Psychology, 21*(10), 296–319.
de Bruyn, E. H., Cillessen, A. H., & Wissink, I. B. (2010). Associations of peer acceptance and perceived popularity with bullying and victimization in early adolescence. *Journal of Early Adolescence, 30*, 543–566.
Duong, J., & Bradshaw, C. P. (2013). Using the extended parallel process model to examine teachers' likelihood of intervening in bullying. *Journal of School Health, 83*(6), 422–429.
Elgar, F. J., Pickett, K. E., Pickett, W., Craig, W., Molcho, M., Hurrelmann, K., & Lenzi, M. (2013). School bullying, homicide and income inequality: A cross-national pooled time series analysis. *International Journal of Public Health*, 58(2), 237–245.
Elicker, J., Englund, M., & Sroufe, L. A. (1992). Predicting peer competence and peer relationships in childhood from early parent-child relationships. In R. D. Parke & G. W. Ladd (Eds.), *Family-peer relations: Modes of linkage* (pp. 77–106). Hillsdale, NJ: Erlbaum.

Ellis, B. J., Del Giudice, M., Dishion, T. J., Figueredo, A. J., Gray, P., Griskevicious, V., … Wilson, D. S. (2012). The evolutionary basis of risky adolescent behavior: Implications for science, policy, and practice. *Developmental Psychology, 48*, 598–623.

Erickson, C. L., Mattaini, M. A., & McGuire, M. S. (2004). Constructing nonviolent cultures in schools: The state of the science. *Children & Schools, 26*(2), 102–116.

Ernst, M., & Hardin, M. G. (2009). Goal-directed behavior: Evolution and ontogeny. In J. M. Rumsey & M. Ernst (Eds.), *Neuroimaging in developmental clinical neuroscience* (pp. 53–71). New York, NY: Cambridge University Press.

Espelage, D. L. (2002). Bullying in Early Adolescence: The Role of the Peer Group. *ERIC Digest*, 1–7.

Espelage, D. L., Bosworth, K., & Simon, T. (2000). Examining the social environment of middle school students who bully. *Journal of Counseling and Development, 78*, 326–333.

Espelage, D. L., & Holt, M. K. (2007). Dating violence & sexual harassment across the bully victim continuum among middle and high school students. *Journal of Youth and Adolescence, 36*(6), 799–811.

Espelage, D. L., Holt, M. K., & Henkel, R. R. (2003). Examination of peer-group contextual effects on aggression during early adolescence. *Child Development, 74*(1), 205–220.

Essock-Vitale, S. M., & McGuire, M. T. (1985). Women's lives viewed from an evolutionary perspective. II. Patterns of helping. *Ethology and Sociobiology, 6*(3), 155–173.

Fitzgerald, C. J., & Colarelli, S. M. (2009). Altruism and reproductive limitations. *Evolutionary Psychology, 7*, 234–252.

Flanagan, R. (2008). Lucifer goes to law school: Towards explaining and minimizing law student peer-to-peer harassment and intimidation. *Washburn Law Journal, 47*, 453–469.

Flinn, M. V., & Ward, C. V. (2005). Ontogeny and evolution of the social child. In B. J. Ellis & D. F. Bjorklund (Eds.), *Origins of the social mind: Evolutionary psychology and child development* (pp. 19–44). New York, NY: Guilford Press.

Freeman, J. G., Samdal, O., Klinger, D. A., Dur, W., Griebler, R., Currie, D., & Rasmussen, M. (2009). The relationship of schools to emotional health and bullying. *International Journal of Public Health*, *54*(2), 251–259.

Freud, A. (1989). *Normality and pathology in childhood: Assessments of development*. London, England: Karnac Books.

Garandeau, C. F., & Cillessen, A. H. (2006). From indirect aggression to invisible aggression: A conceptual view on bullying and peer group manipulation. *Aggression and Violent Behavior, 11*(6), 612–625.

Garandeau, C. F., Lee, I. A., & Salmivalli, C. (2014). Differential effects of the KiVa anti-bullying program on popular and unpopular bullies. *Journal of Applied Developmental Psychology, 35*, 44–50.

Gavrilets, S. (2012). On the evolutionary origins of the egalitarian syndrome. *Proceedings of the National Academy of Sciences, 109*, 14069–14074.

Geary, D. C. (2008). An evolutionarily informed education science. *Educational Psychologist, 43*, 179–195.

Geary, D. C. (2010). *Male, female: The evolution of sex differences* (2nd ed.). Washington, DC: American Psychological Association.

Geary, D. C., & Flinn, M. V. (2001). Evolution of human parental behavior and the human family. *Parenting, 1*(1–2), 5–61.

Gini, G. (2006). Bullying as a social process: The role of group membership in students' perception of inter-group aggression at school. *Journal of School Psychology, 44*, 51–65.

Gini, G., & Pozzoli, T. (2009). Association between bullying and psychosomatic problems: A meta-analysis. *Pediatrics, 123*, 1059–1065.

Golden, M. (1990). *Children and childhood in classical Athens*. Baltimore, MA: The John Hopkins University Press.

Goodall, J. (1986). *The chimpanzees of Gombe*. Cambridge, MA: Harvard University Press.

Harden, B. (2012). *Escape from Camp 14*. Toronto, ON, Canada: Viking.

Hawkins, D. L., Pepler, D. J., & Craig, W. M. (2001). Naturalistic observations of peer interventions in bullying. *Social Development, 10*(4), 512–527.

Hawley, P. H. (1999). The ontogenesis of social dominance: A strategy-based evolutionary perspective. *Developmental Review, 19*, 97–132.

Haynie, D. L., Nansel, T., Eitel, P., Crump, A. D., Saylor, K., Yu, K., & Simons-Morton, B. (2001). Bullies, victims, and bully/victims: Distinct groups of at-risk youth. *The Journal of Early Adolescence, 21*, 29–24.

Holt, M. K., & Espelage, D. L. (2007). Perceived social support among bullies, victims, and bully-victims. *Journal of Youth and Adolescence, 36*(8), 984–994.

Holt, M. K., Kaufman Kantor, G., & Finkelhor, D. (2008). Parent/child concordance about bullying involvement and family characteristics related to bullying and peer victimization. *Journal of School Violence, 8*(1), 42–63.

Hong, J. S., & Espelage, D. L. (2012). A review of research on bullying and peer victimization in school: An ecological system analysis. *Aggression and Violent Behavior, 17*, 311–322.

Houndoumadi, A., & Pateraki, L. (2001). Bullying and bullies in Greek elementary schools: Pupils' attitudes and teachers'/parents' awareness. *Educational Review, 53*, 19–26.

Hrdy, S. B. (2009). *Mothers and others: The evolutionary origins of mutual understanding*. Cambridge, MA: Harvard University Press.

Hsiung, P. C. (2005). *A tender voyage: Children and childhood in late imperial China*. Stanford, CA: Stanford University Press.

Huitsing, G., & Veenstra, R. (2012). Bullying in classrooms: Participant roles from a social network perspective. *Aggressive Behavior, 38*(6), 494–509.

Hunter, S. C., Boyle, J. M., & Warden, D. (2007). Perceptions and correlates of peer-victimization and bullying. *British Journal of Educational Psychology, 77*, 797–810.

Hymel, S., & Swearer, S. M. (2015). Four decades of research on school bullying: An introduction. *American Psychologist, 70*(4), 293–299.

Irons, W. (1998). Adaptively relevant environments versus the environment of evolutionary adaptedness. *Evolutionary Anthropology, 6*, 194–204.

Jonason, P. K., Li, N. P., Webster, G. D., & Schmitt, D. P. (2009). The dark triad: Facilitating a short-term mating strategy in men. *European Journal of Personality, 23*(1), 5–18.

Juvonen, J., & Galvan, A. (2008). Peer influence in involuntary social groups: Lessons from research on bullying. In M. Prinstein & K. Dodge (Eds.), *Peer influence processes among youth* (pp. 225–244). New York, NY: Guilford Press.

Juvonen, J., & Graham, S. (2014). Bullying in schools: The power of bullies and the plight of victims. *Annual Review of Psychology, 65*, 159–185.

Juvonen, J., Graham, S., & Schuster, M. A. (2003). Bullying among young adolescents: The strong, the weak, and the troubled. *Pediatrics, 112*(6), 1231–1237.

Kahneman, D. (2011). *Thinking, fast and slow*. New York, NY: Macmillan.

Kärnä, A., Voeten, M., Little, T. D., Alanen, E., Poskiparta, E., & Salmivalli, C. (2013). Effectiveness of the KiVa Antibullying Program: Grades 1–3 and 7–9. *Journal of Educational Psychology, 105*, 535.

Kasen, S., Berenson, K., Cohen, P., & Johnson, J. G. (2004). The effects of school climate on changes in aggressive and other behaviors related to bullying. In D. L. Espelage & S. Swearer (Eds.), *Bullying in American schools: A social-ecological perspective on prevention and intervention* (pp. 187–210). Mahwah, NJ: Lawrence Erlbaum.

Keltner, D., Gruenfeld, D. H., & Anderson, C. (2003). Power, approach, and inhibition. *Psychological Review, 110*, 265–284.

Kim, Y. S., Koh, Y. J., & Leventhal, B. L. (2004). Prevalence of school bullying in Korean middle school students. *Archives of Pediatrics & Adolescent Medicine, 158*(8), 737–741.

Kolbert, J. B., & Crothers, L. (2003). Bullying and evolutionary psychology: The dominance hierarchy among students and implications for school personnel. *Journal of School Violence, 2*, 73–91.

Konner, M. (2010). *The evolution of childhood: Relationships, emotion, mind*. Cambridge, MA: Harvard University Press.

Kruger, D. J. (2001). Psychological aspects of adaptations for kin directed altruistic helping behaviors. *Social Behavior and Personality: An International Journal, 29*(4), 323–330.

Liu, J., & Graves, N. (2011). Childhood bullying: A review of constructs, concepts, and nursing implications. *Public Health Nursing, 28*, 556–568.

Lorenz, K. (1966). *On aggression*. Toronto, ON, Canada: Bantam.

Loukas, A., & Robinson, S. (2004). Examining the moderating role of perceived school climate in early adolescent adjustment. *Journal of Research on Adolescence, 14*(2), 209–233.

Loukas, A., Suzuki, R., & Horton, K. D. (2006). Examining school connectedness as a mediator of school climate effects. *Journal of Research on Adolescence, 16*(3), 491–502.

MacDonald, K. (1992). Warmth as a developmental construct: An evolutionary analysis. *Child Development, 63*, 753–773.

Masure, R. H., & Allee, W. C. (1934). The social order in flocks of the common chicken and the pigeon. *The Auk, 51*, 306–327.

Mech, D. L. (1970). *The wolf: The ecology and behavior of an endangered species*. Garden City, NY: Natural History Press.

Moffitt, T. E. (1993). Adolescence-limited and life-course-persistent antisocial behavior: A developmental taxonomy. *Psychological Review, 100*(4), 674–701.

Monks, C. P., Smith, P. K., Naylor, P., Barter, C., Ireland, J. L., & Coyne, I. (2009). Bullying in different contexts: Commonalities, differences and the role of theory. *Aggression and Violent Behavior, 14*(2), 146–156.

O'Connell, P., Pepler, D., & Craig, W. (1999). Peer involvement in bullying: Insights and challenges for intervention. *Journal of Adolescence, 22*(4), 437–452.

Olweus, D. (1993). *Bullying at school: What we know and what we can do*. New York, NY: Wiley-Blackwell.

Orme, N. (2001). *Medieval children*. New Haven, CT: Yale University Press.

Owens, L., Shute, R., & Slee, P. (2000). 'I'm in and you're out': Explanations for teenage girls indirect aggression. *Psychology, Evolution & Gender, 2*(1), 19–46.

Patterson, G. R., Chamberlain, P., & Reid, J. B. (1982). A comparative evaluation of a parent-training program. *Behavior Therapy, 13*(5), 638–650.

Pellegrini, A. D., & Long, J. D. (2002). A longitudinal study of bullying, dominance, and victimization during the transition from primary school through secondary school. *British Journal of Developmental Psychology, 20*(2), 259–280.

Pepler, D. J., Craig, W., Ziegler, S., & Charach, A. (1993). A school-based anti-bullying intervention: Preliminary evaluation. In D. Tattum (Ed.), *Understanding and managing bullying* (pp. 76–91). Oxford, England: Heinemann.

Pepler, D., Jiang, D., Craig, W., & Connolly, J. (2008). Developmental trajectories of bullying and associated factors. *Child Development, 79*(2), 325–338.

Polanin, J. R., Espelage, D. L., & Pigott, T. D. (2012). A meta-analysis of school-based bullying prevention programs' effects on bystander intervention behavior. *School Psychology Review, 41*, 47–65.

Pöyhönen, V., & Salmivalli, C. (2008). New directions in research and practice addressing bullying: Focus on defending behavior. In D. Pepler & W. Craig (Eds.), *Understanding and addressing bullying: An international perspective* (pp. 26–43). Bloomington, IN: Author House.

QMI Agency. (2013). More heartache for Myles Neuts' family. London Free Press. Retrieved from http://www.lfpress.com/2013/03/24/more-heartache-for-myles-neuts-family.

Rawson, B. (2003). *Children and childhood in Roman Italy*. Toronto, ON, Canada: Oxford University Press.

Reijntjes, A., Vermande, M., Goossens, F. A., Olthof, T., van de Schoot, R., Aleva, L., & van der Meulen, M. (2013). Developmental trajectories of bullying and social dominance in youth. *Child Abuse & Neglect*, *37*(4), 224–234.

Renken, B., Egeland, B., Marvinney, D., Mangelsdorf, S., & Sroufe, L. A. (1989). Early childhood antecedents of aggression and passive-withdrawal in early elementary school. *Journal of Personality, 57*, 257–281.

Rigby, K. (2003). Consequences of bullying in schools. *Canadian Journal of Psychiatry, 48*, 583–590.

Rigby, K., & Johnson, B. (2006). Expressed readiness of Australian schoolchildren to act as bystanders in support of children who are being bullied. *Educational Psychology, 26*, 425–440.

Rivers, I., & Smith, P. K. (1994). Types of bullying behavior and their correlates. *Aggressive Behavior, 20*, 359–368.

Roseth, C. J., Johnson, D. W., & Johnson, R. T. (2008). Promoting early adolescents' achievement and peer relationships: The effects of cooperative, competitive, and individualistic goal structures. *Psychological Bulletin, 134*(2), 223–246.

Rubin, K.H., Bukowski, W.M., & Parker, J.G. (1998). Peer interactions, relationships, and groups. In W. Damon (Series Ed.) & N. Eisenberg (Vol. Ed.), *Handbook of child psychology, Vol. 3: Social, Emotional, and Personality Development* (5th ed., pp. 619–700). New York, NY: Wiley.

Ryan, A., & Morgan, M. (2011). Bullying in secondary schools: An analysis of discursive positioning. *New Zealand Journal of Educational Studies, 46*(1), 23–34.

Salmivalli, C. (2010). Bullying and the peer group: A review. *Aggression and Violent Behavior, 15*(2), 112–120.

Salmivalli, C., Lagerspetz, K., Bjuorkqvist, K., Osterman, K., & Kaukiainen, A. (1996). Bullying as a group process: Participant roles and their relations to social status within the group. *Aggressive Behavior, 22*, 1–15.

Salmivalli, C., & Peets, K. (2008). Bullies, victims, and bully-victim relationships. In K. Rubin, W. Bukowski, & B. Laursen (Eds.), *Handbook of peer interactions, relationships, and groups* (pp. 322–340). New York, NY: Guilford Press.

Salmivalli, C., & Voeten, M. (2004). Connections between attitudes, group norms, and behavior in bullying situations. *International Journal of Behavioral Development, 28*(3), 246–258.

Salmivalli, C., Voeten, M., & Poskiparta, E. (2011). Bystanders matter: Associations between reinforcing, defending, and the frequency of bullying behavior in classrooms. *Journal of Clinical Child & Adolescent Psychology, 40*(5), 668–676.

Sarnoff, I. (1951). Identification with the Aggressor: Some personality correlates of anti-semitism among Jews. *Journal of Personality, 20*(2), 199–218.

Scheithauer, H., Hayer, T., Petermann, F., & Jugert, G. (2006). Physical, verbal, and relational forms of bullying among German students: Age trends, gender differences, and correlates. *Aggressive Behavior, 32*(3), 261–275.

Schuster, B. (1999). Outsiders at school: The prevalence of bullying and its relation with social status. *Group Processes & Intergroup Relations, 2*, 175–190.

Slonje, R., & Smith, P. K. (2008). Cyberbullying: Another main type of bullying? *Scandinavian Journal of Psychology, 49*, 147–154.

Smith, P. K., Mahdavi, J., Carvalho, M., Fisher, S., Russell, S., & Tippett, N. (2008). Cyberbullying: Its nature and impact in secondary school pupils. *Journal of Child Psychology and Psychiatry, 49*, 376–385.

Smith, R. W., & Smith, K. (2014). Creating the cougar watch: Learning to be proactive against bullying in schools. *Middle School Journal, 46*(1), 13–19.

Smokowski, P. R., & Kopasz, K. H. (2005). Bullying in school: An overview of types, effects, family characteristics, and intervention strategies. *Children & Schools, 27*(2), 101–110.

Solberg, M. E. (2003). Prevalence estimation of school bullying with the Olweus Bully/Victim Questionnaire. *Aggressive Behavior, 29*(3), 239–268.

Sourander, A., Helstelä, L., Helenius, H., & Piha, J. (2000). Persistence of bullying from childhood to adolescence: A longitudinal 8-year follow-up study. *Child Abuse & Neglect, 24*, 873–881.

Stewart-Williams, S. (2007). Altruism among kin vs. non-kin: Effects of cost of help and reciprocal exchange. *Evolution and Human Behavior, 28*, 193–198.

Stockdale, M. S., Hangaduambo, S., Duys, D., Larson, K., & Sarvela, P. (2002). Rural elementary students', parents' and teachers' perceptions of bullying. *American Journal of Health Behavior, 26*, 266–277.

Sutton, J., & Keogh, E. (2000). Social competition in school: Relationships with bullying, Machiavellianism, and personality. *British Journal of Educational Psychology, 70*, 443–456.

Sutton, J., & Smith, P. K. (1999). Bullying as a group process: An adaptation of the participant role approach. *Aggressive Behavior, 25*, 97–111.

Swearer, S. M., Espelage, D. L., Vaillancourt, T., & Hymel, S. (2010). What can be done about school bullying? Linking research to educational practice. *Educational Researcher, 39*(1), 38–47.

Symons, D. (1990). Adaptiveness and adaptation. *Ethology and Sociobiology, 11*, 427–444.

Totura, C. M. W., MacKinnon-Lewis, C., Gesten, E. L., Gadd, R., Divine, K. P., Dunham, S., & Kamboukos, D. (2009). Bullying and victimization among boys and girls in middle school. *Journal of Early Adolescence, 29*(4), 571–609.

Trivers, R. L. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), *Sexual selection and the descent of man* (pp. 136–179). London, England: Heinemann.

Ttofi, M. M., & Farrington, D. P. (2011). Effectiveness of school-based programs to reduce bullying: A systematic and meta-analytic review. *Journal of Experimental Criminology, 7*, 27–56.

Ttofi, M. M., Farrington, D. P., & Lösel, F. (2012). School bullying as a predictor of violence later in life: A systematic review and meta-analysis of prospective longitudinal studies. *Aggression and Violent Behavior, 17*(5), 405–418.

Turnbull, C. M. (1972). *The mountain people*. New York, NY: Touchstone.

Vaillancourt, T. (2013). Do human females use indirect aggression as an intrasexual competition strategy? *Philosophical Transactions of the Royal Society, B: Biological Sciences, 368*(1631), 20130080.

Vaillancourt, T., Hymel, S., & McDougall, P. (2003). Bullying is power: Implications for school-based intervention strategies. *Journal of Applied School Psychology, 19*, 157–176.

Vaillancourt, T., Trinh, V., McDougall, P., Duku, E., Cunningham, L., Cunningham, C., Short, K. (2010). Optimizing population screening of bullying in school-aged children. *Journal of School Violence, 9,* 233–250.

Van Vugt, M., & Schaller, M. (2008). Evolutionary approaches to group dynamics: An introduction. *Group Dynamics: Theory, Research, and Practice, 12*(1), 1.

Veenstra, R., Lindenberg, S., Huitsing, G., Sainio, M., & Salmivalli, C. (2014). The role of teachers in bullying: The relation between antibullying attitudes, efficacy, and efforts to reduce bullying. *Journal of Educational Psychology, 106*(4), 1135–1143.

Veenstra, R., Verlinden, M., Huitsing, G., Verhulst, F. C., & Tiemeier, H. (2013). Behind bullying and defending: Same-sex and other-sex relations and their associations with acceptance and rejection. *Aggressive Behavior, 39*, 462–471.

Volk, T., & Atkinson, J. (2008). Is child death the crucible of human evolution? *Journal of Social, Evolutionary, and Cultural Psychology, 2*(4), 247.

Volk, A. A., & Atkinson, J. A. (2013). Infant and child death in the human environment of evolutionary adaptation. *Evolution and Human Behavior, 34*, 182–192.

Volk, A. A., Camilleri, J. A., Dane, A. V., & Marini, Z. (2012a). Is adolescent bullying an evolutionary adaptation? *Aggressive Behavior, 38*(3), 222–238.

Volk, A., Camilleri, J., Dane, A., & Marini, Z. (2012b). If, when, and why bullying is adaptive. In T. Shackelford & V. Shackelford (Eds.), *Oxford handbook of evolutionary perspectives on violence, homicide, and war* (pp. 270–288). Toronto, ON, Canada: Oxford University Press.

Volk, A., Craig, W., Boyce, W., & King, M. (2006). Adolescent risk correlates of bullying and different types of victimization. *International Journal of Adolescent Medicine and Health, 18*(4), 575–586.

Volk, A. A., Dane, A. V., Marini, Z. A., & Vaillancourt, T. (in press). Adolescent bullying, mating, and dating: Testing an evolutionary hypothesis. *Evolutionary Psychology*.

Volk, A. A., Dane, A., V., & Marini, Z. A. (2014). What is bullying? A theoretical redefinition. *Developmental Review, 34*, 327–343.

Volk, A. A., Della Cioppa, V., Earle, M., & Farrell, A. H. (2015). Social competition and bullying: An adaptive socioecological perspective. In V. Zeigler-Hill, L. Welling, & T. Shackelford (Eds.), *Evolutionary Perspectives on Social Psychology* (pp. 387–399). New York, NY: Springer.

Wang, J., Iannotti, R. J., & Nansel, T. R. (2009). School bullying among adolescents in the United States: Physical, verbal, relational, and cyber. *Journal of Adolescent Health, 45*(4), 368–375.

Wang, C., Swearer, S. M., Lembeck, P., Collins, A., & Berry, B. (2015). Teachers matter: An examination of student-teacher relationships, attitudes toward bullying, and bullying behavior. *Journal of Applied School Psychology, 31*, 219–238.

Williams, G. C. (1966). *Adaptation and natural selection*. Princeton, NJ: Princeton University Press.

Winsper, C., Lereya, T., Zanarini, M., & Wolke, D. (2012). Involvement in bullying and suicide-related behavior at 11 years: A prospective birth cohort study. *Journal of the American Academy of Child & Adolescent Psychiatry, 51*, 271–282.

Wolke, D., Woods, S., Bloomfield, L., & Karstadt, L. (2000). The association between direct and relational bullying and behavior problems among primary school children. *Journal of Child Psychology and Psychiatry, 41*(08), 989–1002.

Ybarra, M. L., Espelage, D. L., & Mitchell, K. J. (2014). Differentiating youth who are bullied from other victims of peer-aggression: The importance of differential power and repetition. *Journal of Adolescent Health, 55*, 293–300.

Zimmer-Gembeck, M. J., Geiger, T. C., & Crick, N. R. (2005). Relational and physical aggression, prosocial behavior, and peer relations: Gender moderation and bidirectional associations. *Journal of Early Adolescence, 25*, 421–452.

Chapter 8
Fairness: What It Isn't, What It Is, and What It Might Be For

Alex Shaw

Both children and adults appear to be concerned with the fairness of resource distributions. They dislike when resources are distributed unequally and sometimes distribute resources equally themselves. For example, if two children do a good job cleaning up the classroom and a teacher has four jellybeans to distribute, most people would think the best thing to do is to give two to each child. Here, distributing the candies fairly makes perfect sense, since doing so is also the most efficient and generous way to distribute the candies. However, fairness does not always make such good sense. Imagine instead the teacher had five jellybeans to give out. After giving two to each child she then decides to throw the additional jellybean in the trash in order to keep things fair. Why would anyone ever choose to do something like this?

Wasting resources is particularly puzzling from an evolutionary perspective: Why would people have evolved mechanisms that cause them to waste perfectly usable resources for the sake of fairness? If a psychological system was shaped by natural selection, then it must have solved some adaptive problem—a recurrent problem that influenced one's chance of passing on one's genes, or copies of one's genes that exist in relatives (Tooby & Cosmides, 1992).

In this chapter, I review recent developmental findings along with some adult work on how and why people share resources with others and begin to sketch out an account of why people are concerned with fairness (even in contexts when it goes against being generous or reciprocally cooperative). More specifically, I propose that people's concerns with fairness are integrated with their alliance psychology and that people are fair at the ultimate level in order to avoid being condemned by third parties for demonstrating or initiating alliances through preferential sharing. I conclude by suggesting what this account of fairness can tell us about how teachers

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can increase fairness and possibly decrease bullying among their students (see also Hawley, this volume; Volk, this volume).

At the broadest level, I will attempt to provide answers to two big questions about fairness: What adaptive problem does fairness solve? How do fairness concerns emerge developmentally? However, before answering these questions, it is important to differentiate fairness from another motivation that may lead to destruction of resources and reductions in inequality, namely envy.

The Difference Between Envy and Fairness Concerns

The comedian Louis C.K nicely articulated the tension between envy and fairness: "My 5-year-old… the other day, one of her toys broke and she demanded that I break her sister's toy *to make it fair*…and I did." Indeed, although research has shown that young children and adults are motivated to create equal outcomes (Hook & Cook, 1979), all reductions of inequality are not created equal—there are cases in which reductions in inequality can be explained by concerns other than fairness. Louis' daughter, for example, might be motivated by fairness, but it seems that her behavior could just as easily be explained by simple envy. In order to study fairness it is important to differentiate fairness from other related concerns, especially envy that might make someone want to reduce inequality (to see why one must also control for social welfare preferences, see Shaw & Olson, 2012). For example, adults and even young children prefer that they and others get nothing rather than allow someone else to get more than them (Blake & McAuliffe, 2011; Fehr & Schmidt, 1999) and are much happier if they are paid equally to others rather than less (Boyce, Brown, & Moore, 2010; LoBue, Nishida, Chiong, DeLoache, & Haidt, 2011). Findings like these have been used as evidence for a concern with fairness since such behaviors lead to reductions in inequality (Fehr, Bernhard, & Rockenbach, 2008).

However, such behaviors could be explained just as easily by envy as by fairness (Nichols, 2010; Shaw & Olson, 2012). Envy, negative reactions to others who have more, is clearly a motivating factor in many individuals' lives that contributes to a social arms race and drives exorbitant spending on designer clothing, big screen TVs, and other luxury items (Frank, 1985). Human envy in this form of "Keeping up with the Joneses" may often reduce inequality between oneself and others; however, creating equal outcomes does not appear to be the real goal of envy since people may be even happier to be way ahead of the Joneses rather than equal to them (Frank, 1985).

Developmental and comparative work supports the suggestion that negative reactions to having less than others are not necessarily about fairness. Young children (aged 3–5) and nonhuman animals respond negatively when they receive less than others but are happy to get more than others (Brosnan, 2011; LoBue et al., 2011). These results suggest that young children and some nonhuman animals may have envy but do not have a systematic concern with fairness since they only care about inequality when they have less. Indeed, a concern with fairness in the absence of envy may not emerge in humans until later in development. Blake and McAuliffe (2011) investigated children's fairness concerns by placing 4- to 8-year-old children in pairs and giving one child the option of deciding whether to accept or reject different distributions of candies set up by an experimenter. If the decider accepted the distribution, the two children received the candies; if the decider rejected, both children received nothing. Consistent with previous research, the authors found that 4- to 7-year-old children rejected unequal distributions in which they received less than others, but happily accepted distributions in which they got more—displaying envy but not fairness. Only 8-year-old deciders rejected distributions that would have meant that they got more in favor of equality (see also Shaw & Olson, 2012), suggesting that by this age children have a sense of fairness (i.e., they appear to care about inequality or partiality) that goes beyond envy.

Unlike fairness, destruction of resources in the name of envy has a relatively straightforward evolutionary rationale. From the standpoint of natural selection, the most important thing for getting one's genes into the next generation is whether one's genes are doing relatively better than one's competitors' (West, El Mouden, & Gardner, 2011). Therefore, having a motivational system that pushes individuals to refrain from falling behind when they see that their competitors have more than them would be extremely beneficial and could easily evolve (for review see Flinn, Geary, & Ward, 2005). These negative reactions to others receiving more could also be quite useful for negotiating and bargaining, but they do not necessarily require any sense of fairness. Indeed, ruthless businessmen can be quite adept at negotiating and bargaining without having any sense of fairness. In the remainder of this chapter, I will attempt to develop an account of why children (and adults) would be motivated to be fair in cases that cannot be explained by envy—cases where people are compelled to favor fair resource distributions at the expense of their own resources or in situations involving third parties.

Fairness Does Not Appear Well Designed for Promoting Cooperation

Some have argued that concerns with fairness evolved to promote cooperation (e.g., André & Baumard, 2011; Fehr et al., 2008). Cooperation can be quite beneficial—if two individuals cooperate with each other, they will often be better off than if they did not cooperate. Cooperation can also be risky, since in any single interaction it often pays to defect—take the benefits of cooperation without paying the costs of cooperating (Axelrod & Hamilton, 1981). This fact may make cooperation appear to be a bad strategy; however, cooperation can be beneficial if other individuals are using a strategy of reciprocity (Trivers, 1971) such as tit-for-tat, in which individuals repay cooperation with cooperation and defection with defection, or if individuals can identify and avoid defectors (Barclay & Willer, 2007). Indeed, mathematical models have demonstrated that avoiding defection against others can be a profitable strategy, even when future interaction is unlikely, because the benefits of short-term defection are vastly outweighed by the costs that come from missing out on a potential fruitful long-term cooperation (Delton, Krasnow, Cosmides, & Tooby, 2011). Some have argued that fairness concerns evolved as a means of restraining individuals' tendency to be selfish, causing them to be more generous, which can foster reciprocity and attract cooperative partners (for further discussion, see Baumard, André, & Sperber, 2013).

If the function of fairness concerns are to maximize cooperative (or reciprocity-based) interactions, what kinds of behaviors should result from having a sense of fairness? First, cooperative accounts of fairness predict that a person should like and choose to interact with others who exhibit generosity, and especially others who show a willingness to be generous and cooperate with that person specifically—reciprocity requires such discriminative generosity. Second, cooperative accounts of fairness predict that people should be generous to others in order to promote cooperative interactions with them.

Fostering cooperation by being generous and liking those who are generous is certainly important, but we must ask whether concerns with fairness actually lead people to value generosity and favoritism. Human beings likely do have evolved systems that push them to be somewhat generous to others in order to promote reciprocity and cooperative interactions with others (Barclay & Willer, 2007; Delton et al., 2011) and drive them to prevent others from receiving particularly low outcomes (Aktipis, Cronk, & de Aguiar, 2011; Charness & Rabin, 2002; Engelmann & Strobel, 2004). However, the notion that others should receive equal payoffs (i.e., fairness concerns) does not appear necessary for promoting cooperation and can actually impede cooperation, reciprocity, and overall economic efficiency.

It is true that fairness and cooperation based in reciprocity are perfectly aligned when one considers only two agents interacting with one another. For example, imagine that Adam is generous to Bill by allowing him to use his beach house. Then, at a later date, Bill is asked to divide a work-related bonus, baseball tickets, between himself and Adam. Being generous to Adam and giving him the lion's share of the tickets makes Bill fair and a good reciprocal cooperator. However, this tight fit between fairness and reciprocity breaks down once three individuals are involved. Imagine again that Adam is generous to Bill by allowing him to use his beach house. Then, at a later date, Bill is asked to divide baseball tickets as a work-related bonus, but this time between Adam and another coworker. Reciprocity predicts that Bill should give Adam a larger share of the tickets in order to pay back his previous generosity (Trivers, 1971). Fairness, on the other hand, would suggest that Bill should give an equal number of tickets to both coworkers (Shaw & Keysar, 2015; Shaw & Knobe, 2013).

Shaw, DeScioli, and Olson (2012) investigated similar scenarios with children as a way to evaluate the first prediction of the cooperative account: fairness concerns should cause a person to like those who are generous and especially those who are selectively generous to that person herself. The authors tested this hypothesis in 6- to 8-year-old children, an ideal population for studying fairness intuitions, as they are old enough to have had experience sharing resources with others, but very likely have not been exposed to philosophical or economic theories of fairness. As noted, this is also an age range during which children seem to be developing a deeper sense of fairness (Hook & Cook, 1979). In these experiments, children were presented with two distributors who shared toy erasers between the child participant and another non-present child. They were then asked to choose which distributor they liked better. In one experiment, the two distributors were equally generous (each giving 4 toy erasers), but one of them showed favoritism by preferentially sharing more erasers with the participant (giving all 4 to the participant), and the other shared equally between the two children (giving 2 to the participant and 2 to the other child). If a sense of fairness was designed to promote cooperation through reciprocity, then children should show a strong preference for the distributor who showed favoritism toward them since this person has demonstrated a stronger desire to be specifically generous and cooperative toward the child recipient.

However, contrary to this idea, the authors hypothesized that fairness concerns should instead *interfere* with reciprocity, causing children's responses to be divided; a sense of fairness should drive them to like the equal sharer, and a sense of reciprocity and favoritism should drive them to like the distributor who gave them more. This is indeed what the authors found. About half the children liked the distributor who showed favoritism and half liked the distributor who was fair. The authors further found that reducing the benefits of favoritism by equating the total number of resources given to the child participant by each distributor (with one distributor giving 4 to the child participant and 4 to the other recipient and the other distributor giving 4 to the child and 0 to the other recipient) increased children's tendency to pick the fair distributor. At least when the child was in a noncompetitive context, when the overall benefits given by each distributor was the same, children picked the fair person. This preference, however, disappeared when children were placed in a competitive context. That is, competition caused the participant to prefer the distributor who gave her relatively more resources than another child rather than the distributor who gave resources equally, even when both distributors gave the participant the same absolute number of resources. Finally, Shaw and colleagues (2012) found that fairness is sometimes valued more highly than generosity. For instance, they found that children prefer a distributor who shares equally between two third parties over another distributor who was more generous (giving more resources overall) but distributed unequally. Recent work in adults points to a similar tension between fairness and reciprocity—adults think a distributor is more fair (at least in some contexts) if they divide resources equally between two recipients rather than if the distributor engages in reciprocity by paying more to a recipient who had been previously generous to the donor (Shaw & Keysar, 2015).

These findings militate against the cooperative account of fairness. They suggest that fairness actually *undermines* the sound evolutionary logic of wanting to associate with others who are generous and who discriminately deliver benefits to oneself—essential features of cooperation based in reciprocity.

Additionally, if fairness evolved in order to promote cooperation, it is unclear why it would cause individuals to destroy resources rather than distribute resources to others. Giving resources to others is an effective means of engendering reciprocity (e.g., Trivers, 1971) from others and therefore the cooperative accounts of fairness predict that upholding fairness should prevent people from destroying resources that could go to others. Shaw and Olson (2012) demonstrated that children endorse fairness over generosity. Specifically, they found that 6- to 8-year-old children were willing to discard a resource in the trash in order to avoid inequality. In one condition, children were asked to distribute five toy erasers to two third-party recipients. Children were told that each recipient had received two toys and were then asked what the experimenter should do with one extra toy—give it to one of the potential recipients or throw the toy into the trash. In this study most children opted to throw the remaining toy in the trash rather than share unequally, even in a follow-up study in which they were told that the two recipients did not know each other and would not know what the other received. This latter result suggests that children were not endorsing fairness because they were worried that the disadvantaged recipient would be upset (since she wouldn't know about the unfairness) and instead that they wanted to avoid creating unfairness between the two recipients (in a similar task they were perfectly happy to give other children more resources when they would not create inequality). In another study, in an analogous situation in which the five toys were split between the child participant and another child, children were even willing to throw a toy in the trash that could go to them, if doing so would create unfairness (see also Blake & McAuliffe, 2011). Adults, too, endorse this destructive sense of fairness, preferring not to give one of two equally hard-working employees a bonus if there was no option of giving a raise to both (Choshen-Hillel, Shaw, & Caruso, 2015; Shaw & Knobe, 2013). Again, if fairness functions to promote cooperation, it is unclear why individuals would throw away resources that could go to others, since being generous to others is an effective way to promote future cooperation. Thus, the question still remains: what adaptive problem does fairness solve?

Fairness is for Avoiding the Appearance of Partiality

Why are children concerned with being fair? One initial pass at this question is to determine if children have a preference (taste) for fairness or if they are fair in order to signal something to others. One possibility is that children and adults have a social preference (or taste) for fair outcomes—being fair for fairness's sake. Another possibility is that they have a motivation to appear fair to the experimenter in order to signal some quality to others. This latter view predicts that people are more likely to be fair when there is a good signaling opportunity (e.g., when others are watching).

Signaling is useful and important in situations in which an organism conveys an underlying trait that is not easily observable and is costly for others to display. One problem with signals of unobservable underlying qualities is that they can be easily faked if they are cost-free (Zahavi, 1975). For example, anyone can say, "I love you" in an attempt to reap the benefits of having a committed partner, but saying these words does not mean the feeling is genuine. One way to reduce the possibility that a signal could be faked is to make it costly, so that only individuals who actually have the underlying trait will be willing or able to display the signal.

One well-known example of this type of signal is the behavior of stotting in some gazelles (e.g., FitzGibbon & Fanshawe, 1988), a peculiar action of jumping high into the air when a predator approaches. This behavior seems irrational because it must draw attention to the stotting gazelle, but in fact predators rarely pursue gazelles that perform this jumping motion. The reason is costly signaling: only gazelles that are particularly fit and highly energetic (likely to outrun predators) are able to expend the resources necessary to jump high into the air (Zahavi & Zahavi, 1997). The gazelles presumably do not engage in this very costly behavior because of a general preference for stotting. They do so in order to signal to the predator, "Hey, I'm really fast and there is no way you'll catch me, so why don't you eat my non-stotting friend" (Bird & Smith, 2005). Three pieces of evidence supporting the conclusion that this behavior is driven by signaling are (1) predators are more likely to pursue non-stotters, (2) when gazelles do stot, they do so almost exclusively in front of predators, and (3) if a predator does chase a stotting gazelle, they are much less likely to be successful than if they chase a non-stotter (FitzGibbon & Fanshawe, 1988).

I reviewed stotting in some detail here to make a point. Stotting is interesting even though gazelles only spend a small fraction of their life stotting—this clearly wasteful behavior demands explanation and signaling appears to provide the best explanation. Similarly, even if humans only waste resources in a small set of interactions, this behavior is still fascinating and demands explanation.

Equal sharing could potentially serve as a costly signal of fairness concerns since it satisfies the necessary conditions for signaling to arise. Signaling should be favored when members of a social group vary in some underlying attribute or motivation (the tendency to behave fairly), when observers can benefit from accurate information about this motivation (observers should choose to interact with fair people), and when signalers have a reason to deceive others (if unfair people can deceive others into thinking they are fair, they can potentially benefit) (Bird & Smith, 2005). One feature of social signaling models is that costly signals should be displayed more prominently when other individuals can observe the quality being signaled. Applied to fairness concerns, this makes the prediction that, just as gazelles are more likely to stot when predators can observe them, people should be more likely to be fair when others can observe their behavior. In keeping with the signaling hypothesis, adults are considerably less fair when they believe that others will not know how they behaved (Andreoni & Bernheim, 2009).

Recently, Shaw and colleagues (2014) found that children similarly modify their behavior in order to appear fair to others. When children knew that an experimenter would be aware of their choice, they preferred to discard a resource in the trash rather than create inequality by taking it for themselves (just as they had in Shaw & Olson, 2012). However, when children believed that the experimenter would not be aware of their choice, they were considerably more likely to take the additional resource for themselves. Furthermore, children chose to use a procedure that would make them appear fair to an experimenter (flipping a coin) in order to determine whether they or another recipient would receive the better prize; but many lied about the outcome of the procedure (which only they were aware of) in order to take the better prize for themselves. These experiments indicate that children's concerns with fairness are at least partially driven by a motivation to signal something to others, but this leaves unanswered the question of what people are trying to signal to others with their fair behavior.

One possibility is that fairness is a useful way for people to signal to others that they are not partial. People may want to avoid appearing partial because others have negative reactions to partiality (Tyler, 2000) and open displays of favoritism could cause conflicts between friends (DeScioli & Kurzban, 2011). It may therefore be a good strategy to conceal open displays of favoritism (DeScioli & Kurzban, 2011; Shaw, 2013). This of course does not explain why people react negatively to partiality and favoritism in the first place, which is something that I will return to later in this chapter.

This partiality account of fairness (Shaw, 2013), that people are fair in order to avoid the appearance of partiality, is consistent with the data reviewed so far and explains why people endorse unequal outcomes that are determined using impartial procedures. The hypothesis that fairness pushes people to avoid partiality can explain why children would choose fair distributors over those who might be better cooperators toward them and why they would waste resources to uphold the appearance of fairness. Although being fair by wasting resources forces one to forgo a possible cooperative opportunity, it also allows one to avoid condemnation and anger from others for being unfair. If fairness concerns are about avoiding condemnation from others, then people should continue to be fair even at the expense of cooperative opportunities in some contexts (e.g., those in which condemnation is more likely).

The partiality account of fairness predicts that factors that make unequal distributions appear less partial to others should be viewed as less unfair. Consistent with the notion that fairness is about impartiality, adults think inequality is acceptable if it is achieved using an impartial procedure (Bolton, Brandts, & Ockenfels, 2005; Choshen-Hillel et al., 2015; Tyler, 2000). Shaw and Olson (2014) investigated whether 5- to 8-year-old children also endorse inequitable outcomes determined by an impartial procedure. Children were told that two recipients had an equal number of resources and were asked what to do with an extra resource: discard it (keeping things equal), or spin a wheel to assign the resource to one recipient. In the Impartial Condition, the wheel was divided in half, giving both recipients a 50 % (equal) chance to get the resource. In the Partial Condition, the wheel was devoted entirely to one recipient, giving that recipient a 100 % chance to get the resource. In all age groups, children used the impartial wheel rather than throwing the resource away, and children were more likely to use the impartial wheel than the partial one. Further, as children grew older, they became much less likely to spin the partial wheel, demonstrating an increasing appreciation for partiality demonstrated by previous research (Mills & Grant, 2009). This work provides preliminary support for the hypothesis that fairness concerns are driven more by an aversion to partiality than to inequity per se, by suggesting that children consider inequity to be fair if it is determined by an impartial procedure.

Why Would People Care About Other People's Partiality?

Thus far, I have argued that people are fair to avoid condemnation from others for partiality, but I have not yet explained why people would condemn others for partiality in the first place. In order to understand why people would be motivated to prevent others from pursuing partiality (at least in some contexts), it is important first to understand the structure of human alliances (friendships) and to consider how the formation of a new alliance represents a potential threat to those who are outside of that alliance (DeScioli & Kurzban, 2009a, 2013). Humans are an extremely social species and are very dependent on others. Being ostracized from one's social connections can be devastating psychologically and life threatening in natural contexts (for review, see Kurzban & Leary, 2001). People participate in a number of relationships based on kinship, exchange, mating, and friendship. There has been considerable work in psychology and evolutionary theory examining the first three relationship types in humans (for review, see Buss, 1999). However, there has been relatively little work examining the unique features of friendship in humans (for exceptions, see Benenson, 2014; Clark & Mills, 1979; 1993; DeScioli & Kurzban, 2009a; Silk, 2003; Tooby & Cosmides, 1996), though there has been work examining the unique features of friendship in nonhuman primates (Chapais, 1992; Harcourt, 1992; Schino, 2001; Seyfarth, 1977; Silk, 1999; Tomasello & Call, 1997). There has also been considerable research on peer relationships in psychology (e.g., Rose & Asher, 1999; Rose & Rudolph, 2006), but most of this has not been informed by evolutionary theory. The majority of the work in psychology focused on human friendship tends to explain friendship in terms of exchange relationships, reciprocity, or just simple familiarity (Cole & Teboul, 2004; Homans, 1958; McPherson, Smith-Lovin, & Cook, 2001). However, these explanations fail to capture the unique aspects of friendship.

While it is true that people may like others who can provide them with resources, this tendency does not explain many key features of friendship such as the importance of friendship ranking, and the finding that people provide aid to their friends when they are unlikely to be paid back. DeScioli and Kurzban (2009a) investigated how people rank their friends and found that variables measuring similarity, reciprocity, or the potential for future exchange are not the best predictors of how a person will rank his or her friends. Instead, the best predictor of how highly a person ranks a friend is the person's belief about how highly that friend ranks them (for a replication of this effect in naturalistic circumstances using the social networking website MySpace, see DeScioli, Kurzban, Koch, & Liben-Nowell, 2011). Another problem for exchange accounts of friendship is that they do not predict another important characteristic of friendship: a willingness to help someone when that person is unlikely to pay back the help because of sickness, injury, or other hardship (Tooby & Cosmides, 1996). If friendship was about making good investments on the basis of possible future exchanges, then people should be fair-weather friends and quickly abandon close friends when they become bad investments or need serious help. However, this notion does not accord with most people's sense of friendship. Instead, people value friends who will stick with them, especially when they are down, rather than friends who will be able to benefit them in the near future (DeScioli & Kurzban, 2011).

Drawing on insights from international relations research, DeScioli and Kurzban (2009a) suggested that human friendships function more like alliances than like exchange relationships. One of the important features of alliances is that they are explicitly focused on relative standing, which means that alliances are always zero-sum—to the extent that one person values an ally more highly, that person must value another ally less highly (Liska, 1962). If friendships function like alliances, then it makes sense that one would use other people's relative ranking of one to determine how to rank one's friends (DeScioli & Kurzban, 2009a). The reason for this is that the goal of having allies, as opposed to exchange partners, is to have people on one's side in a potential conflict or time of hardship. A person who claims to be everyone's ally is really no one's ally, because this person has no reason to take anyone's side in a potential conflict. Obviously, people can be more useful allies to the extent that they are high status, formidable, and have strong allies themselves. However, there is no sense in talking about someone being a good ally in general; an ally is only good in their specific relationships with particular allies. A great ally to one person is an enemy to another person because a great ally will be quite willing to harm others who harm their ally (DeScioli & Kurzban, 2011).

Alliances (friendships) are an important part of human life, and having relatively weak alliances places one at a strategic disadvantage. Having a large alliance network of friends provides a huge advantage in terms of one's ability to win potential conflicts and control information. Although physical formidability certainly influences one's chance of winning a conflict (Parker, 1974; Sell et al., 2009), the sheer number of allies that one has is a much better predictor (Adams & Mesterton-Gibbons, 2003; Harcourt, 1992), especially in human conflicts. Having a larger alliance network not only provides clear advantages in physical confrontations, it also provides clear advantages in reputational warfare through spreading gossip (Lind, Da Silva, Andrade, & Herrmann, 2007) and buffers against unpredictable events, such as when one is sick, injured, or unlucky (Aktipis, Cronk, & de Aguiar, 2011). To the extent that one has few allies or is a very low-ranked ally, one may miss out on the benefits of alliances and run the risk of being ganged up on by others.

Although having allies is extremely beneficial, it can often engender conflict as people vie to have more allies than others have (Snyder, 1984). Because alliances are zero-sum, whenever a non-ally forms a new alliance, one's own position weakens (Liska, 1962). The formation of new alliances is obviously threatening when one's adversary forms a new alliance or adds additional members to an existing alliance; however, the formation of new alliances should be threatening even when one is unacquainted with the two allied individuals. To the extent that the alliance formation is successful, the members of this alliance now have additional social power that they could potentially use to exploit individuals who are not a part of their alliance. Even if the person forming a new alliance or strengthening an existing alliance is one's own ally, this could be threatening if one loses relative standing with one's current allies based on this new alliance. Because of the threat posed by nascent alliance formation, people may pay especially close attention to the formation or strengthening of alliances and may be motivated to prevent this alliance building. One effective way to curtail others' alliance formation would be to condemn those who engage in this behavior and to mobilize other third parties to condemn this behavior as well (DeScioli & Kurzban, 2013). Third parties should be motivated to engage in this type of condemnation since they too should perceive alliance formation as a potential threat.

Condemnation from others should be effective at preventing strong alliance formation in two ways. First, condemnation should make people more reluctant to engage in alliance building behaviors in general for fear of being condemned at least in some contexts, which will straightforwardly reduce the strength of new alliances. Second, when people do engage in alliance building behavior, the condemnation may force them to engage in private rather than public preferential treatment. This type of private alliance building is less effective since the alliances are no longer common knowledge to other members of one's alliance network or to members outside the alliance. The lack of common knowledge can create coordination problems in the event of a potential conflict. If some of one's allies do not know that one has other powerful allies, then they may be reluctant to take one's side. Such discoordination can be disastrous for alliances (DeScioli & Kurzban, 2013).

If the function of this "partiality aversion" (negative reactions to partiality) is to condemn the formation of alliances, then why do people focus their accusations of partiality so much on the unequal distribution of resources? The answer may be that partiality in resource sharing can be used to initiate new alliances or strengthen existing alliances, and it is a clear public symbol (i.e., people can very easily track how many resources one had and distributed) of favoritism that people can condemn. Obviously, favoritism in terms of unequal time spent helping others could also be used as a signal of partiality that could be condemned, but unequal resource distribution seems to be a more common area for accusations of partiality (at least if one looks at research done on the topic: Adams, 1965; Fehr & Schmidt, 1999; Shaw, 2013). The fact that unequal distributions are easily observable by others may be the reason that resource distribution is so frequently condemned. Condemnation is often focused on publicly observable acts that provide evidence the condemner can use to convince third parties that a transgression has occurred (DeScioli, Bruening, & Kurzban, 2011).

One can readily observe unequal resource distribution and thus easily rally others to condemn this display of partiality. In line with this fact, most tasks used by researchers (Hook & Cook, 1979) highlight that there is some set of resources that can be given to one or two recipients, which makes the favoritism more apparent. Thus, when a distributor shares unequally, it is clear that the distributor was choosing to give a resource to one recipient over another. However, it is important to note that the partiality account of fairness is not focused on resources specifically. Any type of partiality could be negatively evaluated, whether the partiality is expressed through unequal resource distribution or through other preferential treatment (indeed, later I will suggest that one context where avoiding partiality is particularly important is when assigning punishments for crimes).

This line of reasoning explains why people would condemn others for unequal resource sharing and can also explain why people engage in fair behavior themselves. Of course, if third parties begin to condemn others for being partial because they are worried about alliance formation, it is straightforward to explain why people begin to stop engaging in partial behavior, at least in public: they do so to avoid condemnation (DeScioli & Kurzban, 2009b). Forming new alliances is clearly advantageous, but so is avoiding condemnation from others, since being condemned by others can negatively impact one's reputation and even one's life in some circumstances (DeScioli & Kurzban, 2009b, 2013). Therefore, while people clearly still try to build alliances, they likely try to do so in ways that are more private in order to make it less obvious to others that they are trying to form such alliances. This is why people are publicly concerned with avoiding partiality, especially if giving preferential treatment can be construed as trying to initiate or strengthen an alliance.

In sum, alliance formation could be threatening to any person who is not a member of the alliance because alliances are zero-sum and the size of one's alliance network is a decisive factor in winning conflicts (DeScioli & Kurzban, 2011; Harcourt, 1992). Therefore, people should respond negatively to partiality, which can be used to form new alliances, by condemning this behavior, and they should rally others to do the same. Once people begin judging others for being partial, individuals should begin to act impartially—at least publicly—in order to avoid accusations of partiality. In the next section, I discuss different possibilities for how concerns with fairness (impartiality) might develop ontogenetically from a tendency to condemn others for partiality.

The Importance of Developmental and Cross-Cultural Work

Several critical questions remain to be addressed to fully evaluate the partiality account of fairness: What precise built-in rules constrain people's fairness concerns? What relevant experiences are needed to develop adult-like concerns with fairness? And how does one's culture influence the kinds of situations where fairness is relevant? Answering these questions requires understanding the development of fairness concerns as well as how this development varies (or remains constant) across cultures.

Although children do not destroy resources in the name of fairness until about age 6 or 7, even infants show precursors to fairness concerns. Humans appear to have some early emerging expectations that resources will be distributed equally among agents, and young children respond negatively to those who create inequality. Research with infants using looking-time measures suggests that by as early as 12 months, infants expect resources to be distributed equally between two agents (Geraci & Surian, 2011; Schmidt & Sommerville, 2011; Sloane, Baillargeon, & Premack, 2012), and 15-month-old infants also prefer those who share equally (Burns & Sommerville, 2014). By 3 years of age, children negatively evaluate distributors who share unequally with third parties (Svetlova & Brownell, 2013), and at this age, children themselves share resources equally with third parties when asked to divide resources between two others (Olson & Spelke, 2008). These data provide preliminary evidence that there may be built-in negative reactions to other people creating inequality or at least that infants learn these reactions quite early and are sensitive to the distribution of resources.

Children's responses to partiality are obviously shaped by their social context, which likely influences the weight that children place on avoiding partiality or inequality. Although 3 year olds opt to divide resources equally (Olson & Spelke, 2008), they do not become willing to incur much personal cost to avoid partiality until they are 5 or 6 (Hook & Cook, 1979). In some cultures, even adults may have little to no willingness to pay costs in order to avoid partiality (Henrich, Heine, & Norenzayan, 2010). That is, although all humans may come equipped with an early emerging dislike of inequality or partiality, the weight they place on avoiding partiality may vary. The developmental and cross-cultural differences in people's drive to avoid partiality may result from different exposure to accusations of (and negative responses to) unfairness. To the extent that accusations of partiality are infrequent in the environment, people will be more hesitant to pay high costs to avoid partiality than if accusations of partiality are frequent in the environment.

To say it another way, other people's negative reactions to partiality (or the relative lack thereof) may help calibrate the system so that one knows how valuable fairness (i.e., avoiding accusations of partiality) is in one's social group, and hence what kinds of costs one should pay to avoid the appearance of partiality. In support of this view, Svetlova and Brownell (2013) used a task similar to the fairness versus favoritism task used by Shaw and colleagues (2012) and found that 3 year olds overwhelmingly prefer a person who shows them favoritism over someone who is fair (impartial). However, by the time they are 5 years old, children show an increased preference for the fair person, suggesting again that children are developing a decreased preference for favoritism (at least when observed), possibly because of inputs they are receiving from their environment that make it clear impartiality is valued. Additionally, people's current circumstances may also lessen the extent to which they focus on fairness—when resources are scarce, competition is high, or group conflict is imminent, people may be more focused on alliance-building than on signaling their impartiality (e.g., Macfarlan, Walker, Flinn, & Chagnon, 2014). In support of this idea, children value favoritism more strongly than fairness in a competitive context (Shaw et al., 2012).

The early emerging default equality preference in young children (Baumard, Mascaro, & Chevallier, 2012; Hook & Cook, 1979; Olson & Spelke, 2008) may suggest that children start out with some bias toward impartiality (or equality) at least in third party situations. However, two things that appear to develop much later in life are an appreciation for the fact that inequality is not always unfair (indicative of partiality) and an increasing knowledge of the kinds of factors that allow inequality to be excused. As early as age 3, children understand the connection between merit and resource distribution, but this understanding only extends to children being more willing to share equally with those who do equal work (i.e., they will give more of a reward they could monopolize to another person if that person helped with the work), not a willingness to give more than an equal amount to those who do additional work (Hamann, Warneken, Greenberg, & Tomasello, 2011; Kanngiesser & Warneken, 2012). That is, young children understand the principle of equal work deserving equal pay (Hamann et al., 2011), but they do not think that unequal work deserves unequal pay until about age 5 or 6 (Hook & Cook, 1979; Sigelman & Waitzman, 1991).

Although 3- to 4-year-old children will reward someone who did more work with more pay when no equal option is possible (Baumard et al., 2012), they are extremely reluctant to do so, and if an equal option is possible, they will default to giving equally rather than based on merit until they are 5- to 6 years old (Hook & Cook, 1979). This default toward equality (at least for in-group members) may make good sense, since both adults and children sometimes attribute unfair (partial) intentions to a person who creates an unequal distribution, even if this was done by accident (Donovan & Kelemen, 2011). Indeed, when people encounter inequality between two people, they might first attribute partiality and only later override this initial judgment of partiality (e.g., if they determine that the inequality was based on some culturally agreed-upon justification). Throughout early childhood, children may develop a motivation and an ability to seek out justifications for inequality, as well as knowledge of what those culturally agreed-upon justifications are.

Importantly, the partiality account predicts that inequality per se should not be seen as unfair—only inequality that could appear to be predicated on some form of partiality, such as inequality based on one's individual allegiances. That is, the inequality should be seen as fair if it is based on some factor that is commonly acknowledged in one's society as a reason for unequal distributions (e.g., need or work).

One of the most interesting cross-cultural research questions stemming from this partiality account is how the acceptable justifications for inequality may vary across cultures. "Acceptable justifications" are factors that people within a group commonly acknowledge are justifications for inequality and that people agree are not based on anyone's personal identity or allegiances. One socially agreed-upon rule that justifies inequality in many societies is the notion of merit—people think it is fair to pay people more than others if they work harder (Adams, 1965; Hook & Cook, 1979). Correspondingly, in cases in which two people have done different amounts of work, people do not tend to think it is partial to pay more money to the person who has done more work. For the partiality account of fairness, what allows merit to excuse inequality is that it is a factor that people commonly acknowledge does not indicate partiality or favoritism.

Although merit may be a special type of justification for inequality (one that people recognize relatively early in development and which is culturally widespread), in principle anything can be used to justify inequality so long as many people in one's society agree upon that rule. (That is, you can have a rule that says "I get more because I am more in need," but not "I get more because I am me," because it is unlikely that people would agree to the latter rule). In order to test this claim, it is important to investigate fairness concerns in cultures in which factors that our society does not consider to be legitimate justifications (e.g., nepotism, gender, race, group status, or social status) are used as legitimate justifications that are not seen as partial by individuals in those cultures. The partiality account of fairness would be falsified if reductions in the extent to which people see inequality as partial do not result in corresponding reduction in claims of unfairness (DeScioli & Kurzban, 2013; Shaw, 2013). However, if this account is correct, there should be considerable correspondence between actions that evidence partiality and actions that are commonly acknowledged to be unfair.

The partiality account of fairness can also potentially explain disagreements over what constitutes fair behavior between groups within a single society. Groups may have different interests that influence the rules that they endorse. People will often try to get others to agree to rules that benefit themselves (DeScioli & Kurzban, 2013); indeed, people more readily endorse equity over equality if they are the one who happened to do more work (DeScioli, Massenkoff, Shaw, Petersen, & Kurzban, 2014). In many cases people will agree that partiality is a bad thing, but may disagree about what constitutes partiality. For example, the partiality account of fairness may explain some differences between liberals' and conservatives' attitudes about welfare programs and affirmative action (Haidt & Graham, 2007). Perhaps liberals see such programs as decreasing partiality (leveling the playing field that is biased against people born into underprivileged circumstances), whereas conservatives see it as a form of partiality (giving resources to people who have not earned it). Future research should investigate this possibility.

Another interesting question is the universality of these partiality concerns. While there has been little research on the specific role of impartiality in resource sharing cross-culturally, there has been considerable evidence to suggest that even small-scale societies value impartiality in the domains of morality and punishment, especially when someone is placed in a position of authority (Beckett, 1967; for review, see DeScioli & Kurzban, 2009b). One possibility is that being placed in a position of power or being forced to choose sides on a contentious moral issue highlights the fact that one is choosing one person over the other—making one's potential partiality more obvious. In such situations, when one's decision will be under greater scrutiny, people may shy away from evidencing such partiality. If this explanation is correct, then one should be able to increase the extent to which people make accusations of unfairness by making the partiality and alliance-building motives of resource sharing more salient (unless the lower rates of impartiality are explained by factors such as scarcity, conflict, and competition). Future research should investigate these nuances of the partiality account of fairness.

Avoiding Partiality or Just Selfishness?

We do not know specifically what fairness concerns are meant to signal; however, people's fairness concerns do not seem to function as a signal of their concerns with welfare or generosity, since throwing resources in the trash obviously does not reflect these concerns. Although I explored the partiality account of fairness here, there is a second viable possibility for why people might waste resources in the name of fairness, at least when unfairness involves giving more resources to the self.

It is possible that children and adults are fair in order to avoid appearing selfish by taking more for themselves. Economic models suggest that people are motivated to share with others because they do not like to give others less than what they reasonably expect, or less than what others typically give (Andreoni & Bernheim, 2009; Bicchieri & Mercier, 2013; Bicchieri & Xiao, 2009). People may avoid violating others' expectations of fairness and generosity in order to avoid appearing like selfish defectors. In support of this notion, there is considerable evidence from the lab showing that people punish those who are uncooperative and selfish (DeScioli, Bruening, et al., 2011; Kurzban, DeScioli, & O'Brian, 2007; Yamagishi, 1986) and from the field demonstrating that people use ostracism and gossip as forms of punishment for selfish defectors (for review, see Guala, 2012). According to this view, a person will split resources equally because she thinks that others expect an equal split, based on knowing that others are often envious of those who have more than them (Festinger, 1954). This explanation, based on wanting to avoid looking selfish, could explain the decision to throw one's own resource away in the name of fairness. People may want to avoid taking more for themselves because of an implicit worry that others will assume that a person who takes more for themselves is selfish, even if the alternative was throwing the resource in the trash as was the case in some of the experiments mentioned above. Taking more for oneself is highly correlated with defection in most social contexts. People may therefore be concerned that they would gain a reputation as a defector if they took more for themselves, since others may wonder why the resource was not split in half or even given to the other recipient. This account would suggest that it is simply the appearance of selfishness that people are trying to avoid by being fair and by preferring to interact with others who are fair.

This account of fairness offers a simple explanation for the developmental trajectory of children's fairness concerns. For instance, Blake and McAuliffe (2011) have suggested that the development of children's seemingly fair behaviors is predicated upon the development of inhibitory control (Davidson, Amso, Anderson, & Diamond, 2006; Knoch, Pascual-Leone, Meyer, Treyer, & Fehr, 2006). This inhibitory control, they argue, is needed to prevent children from pursuing their own self-interest. Thus, the reason that children become increasingly fair as they get older is that they become increasingly able to inhibit their self-interest in order either to be or to appear unselfish to others (Blake & McAuliffe, 2011). This account could be true, but recent evidence suggests that the age-related changes in distribution behavior when they are asked to share some stickers with others are not mediated by changes in children's inhibitory control (Smith, Blake, & Harris, 2013).

People certainly do attempt to avoid looking selfish, but this explanation cannot be the entire story since it would not explain why people are fair, even at the expense of generosity, when dividing resources between third parties. Giving an additional resource to a third party cannot be construed as a selfish act on its face. If anything, such sharing could make the giver look more generous. Because of the overlap in dyadic sharing interactions between a desire to signal that one is not partial and a desire to signal that one is not selfish, it may be best to study fairness concerns in situations in which people are distributing resources between two other third parties. Using third party distributions will eliminate the overlap between avoiding appearing partial and selfish because in third party distributions being unfair does not mean being selfish. However, third party distributions introduce another potential problem: it may be difficult to detect signaling motivations in completely third party interactions because people will likely default to being impartial, even when not being watched, if they have nothing to gain from being unfair. That is, because people have a distaste for unfairness, they will do the fair thing if there is zero cost to themselves. It is only when the behavior is costly that signaling may become relevant.

One can get around this problem by examining how individuals share with their allies. In such cases, people have an incentive to be unfair, but this incentive is not tied to simply gaining additional resources for the self and would therefore be less readily explained by a simple selfishness account. (Note that giving more to one person than another can certainly benefit the giver by strengthening a preexisting alliance or forming a new one, as discussed above. However, if one wants to construe such alliance formation as "selfish" and argue that people are trying to avoid the selfishness that is associated with such alliance formation, then the selfishness account is not interestingly different from the partiality account). Such experiments would allow one to investigate whether individuals explicitly try to avoid appearing partial to others. For example, imagine an experiment in which the participant is asked to assign some rewards to her ally and another stranger for completing some task. Also, imagine that the participant observes that her ally does a slightly better job than the stranger. In one condition, no one is aware of the ulterior motive (no one knows that the two are friends). In this condition, the participant will likely give more to her ally. In fact, she might even give more to her ally even if her ally did equal work as someone else, especially if there is some ambiguity about who did a better job. Compare this condition to another condition in which the ulterior motive (one's alliance) is common knowledge. In this second condition, the participant may instead split the resources equally, even if her ally did a better job, because of a worry that she will appear partial. Experiments like these which explicitly manipulate participants' partiality and others' knowledge of this partiality will provide the best test of the partiality account of fairness.

Conclusions and Implications for Educators

In this chapter, I have argued that when people are fair, it is to avoid being condemned by others for being partial. I have further suggested that one potential reason that people dislike partiality in the first place is that partiality can be used to form alliances, which can be threatening to others. I explored how these concerns with fairness are "learned" and emerge over the course of development. It seems that children's early conception of impartiality is more focused on equality, but as they grow older they begin to understand that all inequality does not entail partiality (that assigning unequal resources based on work and impartial procedures can make inequality acceptable). One final question: How can educators and parents use these insights to improve children's interactions with others? There are three potential lessons to learn from this chapter.

First of all, children's conception of inequality changes over development. When distributing resources unequally in the classroom, it is important to emphasize that the resource distribution does not necessarily entail partiality. By the time children are 6 years old, they understand the relation between work and pay, and thus one way to avoid negative social consequences is to explicitly link differences in performance or work (e.g., homework turned in, participation in class) to differences in rewards. Although removing partiality will not remove children's negative reactions based in envy, it should substantially reduce their negative reaction to unequal resource distribution.

Second, if children's early emerging fairness concerns are concentrated on avoiding condemnation from others (especially their peers) for their unfairness, then this suggests an interesting tactic that teachers can use in order to increase children's concerns with fairness. This account suggests that teachers merely telling children that they should be fair might not be the most effective way to motivate children to do so. Instead, parents and teachers should try to make clear to children the negative ways that their peers will respond to unfairness—emphasizing the condemnation they will encounter in response to their unfairness. To the extent that parents can make it clearer that peers will respond negatively to unfairness, children may more strongly endorse fairness norms, which could potentially be helpful in battling the insular cliques that are so common on the playground. Researchers should attempt some simple intervention studies to determine if these kinds of interventions will prove helpful.

Finally, it is important to understand that fairness can sometimes lead to destructive behaviors (wasting resources in the name of fairness) and is not always a virtue. Although fairness and impartiality can be useful, powerful concepts for preventing favoritism and cliques, it can always be problematic in some circumstances if children get overly fixated on the idea of impartiality. Many people seem to regard fairness as a synonym for being generous or being kind. However, as the research above indicates, fairness can often lead to ungenerous behavior like wasting resources. Thus, teachers should be really clear about the language they use with children. Telling children to be nice to others may be the wrong message in situations where "being nice" to one child can mean excluding other children. Similarly, if one wants to encourage children to share with others, then it might be better to tell children to be generous or nice rather than to be fair because "fairness" need not recommend sharing, especially if that sharing with others will entail partiality.

There is still much work to be done on fairness and related concerns with resource distribution. In this chapter, I have focused on one of these concerns: fairness. I demonstrated that fairness concerns motivate behavior in the absence of envy and even when being fair goes against being generous. I then argued that these concerns are partly rooted in a motivation to signal some trait to others, and that people's fair behavior is specifically aimed at signaling impartiality. I hope that future research can build upon the theoretical and empirical work that was outlined here to produce a more complete picture of how people decide to spend their time and resources on others.

References

Adams, J. (1965). Inequity in social exchange. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 2, pp. 267–299). New York, NY: Academic.

Adams, J., & Mesterton-Gibbons, M. (2003). Lanchester's attrition models and fights among social animals. *Behavioral Ecology, 14*, 719–723.

Aktipis, C. A., Cronk, L., & de Aguiar, R. (2011). Risk-pooling and herd survival: an agent-based model of a Maasai gift-giving system. *Human Ecology, 39*, 131–140.

André, J. B., & Baumard, N. (2011). Social opportunities and the evolution of fairness. *Journal of Theoretical Biology, 289*, 128–135.

Andreoni, J., & Bernheim, B. D. (2009). Social image and the 50–50 norm: A theoretical and experimental analysis of audience effects. *Econometrica, 77*, 1607–1636.

Axelrod, R., & Hamilton, W. D. (1981). The evolution of cooperation. *Science, 211*, 1390–1396.

Barclay, P., & Willer, R. (2007). Partner choice creates competitive altruism in humans. *Proceedings of the Royal Society B, 272*, 749–753.

Baumard, N., André, J. B., & Sperber, D. (2013). A mutualistic approach to morality: The evolution of fairness by partner choice. *Behavioral and Brain Sciences, 36*, 59–78.

Baumard, N., Mascaro, O., & Chevallier, C. (2012). Preschoolers are able to take merit into account when distributing goods. *Developmental Psychology, 48*, 492–498.

Beckett, J. (1967). Elections in a small Melanesian community. *Ethnology, 6*, 332–344.

Benenson, J. F. (2014). *Warriors and worriers: The survival of the sexes*. New York, NY: Oxford University Press.

Bicchieri, C., & Mercier, H. (2013). Self-serving biases and public justifications in trust games. *Synthese, 190*, 909–922.

Bicchieri, C., & Xiao, E. (2009). Do the right thing: But only if others do so. *Journal of Behavioral Decision Making, 22*, 191–208.

Bird, B. R., & Smith, E. A. (2005). Signaling theory, strategic interaction, and symbolic capital. *Current Anthropology, 46*, 221–248.

Blake, P. R., & McAuliffe, K. (2011). "I had so much it didn't seem fair": Eight-year olds reject two forms of inequity. *Cognition, 120*, 215–224.

Bolton, G. E., Brandts, J., & Ockenfels, A. (2005). Fair procedures: Evidence from games involving lotteries. *Economic Journal, 115*, 1054–1076.

Boyce, C. J., Brown, G. D. A., & Moore, S. C. (2010). Money and happiness: Rank of income, not income, affects life satisfaction. *Psychological Science, 21*, 471–475

Burns, M. P., & Sommerville, J. A. (2014). "I pick you": The impact of fairness and race on infants' selection of social partners. *Frontiers in Psychology, 5*, 93.

Buss, D. M. (1999). *Evolutionary psychology: The new science of the mind*. Boston, MA: Allyn & Bacon.

Brosnan, S. F. (2011). A hypothesis of the co-evolution of cooperation and responses to inequity. *Frontiers in Neuroscience, 5*, 43

Chapais, B. (1992). The role of alliances in social inheritance of rank among female primates. In A. H. Harcourt & F. B. M. de Waal (Eds.), *Coalitions and alliances in humans and other animals* (pp. 29–59). Oxford, England: Oxford Science.

Charness, G., & Rabin, M. (2002). Understanding social preferences with simple tests. *Quarterly Journal of Economics, 117*, 817–869.

Choshen-Hillel, S., Shaw, A., & Caruso, E. (2015). Waste management: How reducing partiality can promote efficient resource allocation. *Journal of Personality and Social Psychology, 109*(2), 210–231.

Clark, M. S., & Mills, J. (1979). Interpersonal attraction in exchange and communal relationships. *Journal of Personality and Social Psychology, 37*, 12–24.

Clark, M. S., & Mills, J. (1993). The difference between communal and exchange relationships: What it is and is not. *Personality and Social Psychology Bulletin, 19*, 684–691.

Cole, T., & Teboul, J. C. B. (2004). Non-zero-sum collaboration, reciprocity, and the preference for similarity: Developing an adaptive model of close relational functioning. *Personal Relationships, 11*, 135–160.

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia, 44*, 2037–2078.

Delton, A. W., Krasnow, M. M., Cosmides, L., & Tooby, J. (2011). Evolution of direct reciprocity under uncertainty can explain human generosity in one-shot encounter. *Proceedings of the National Academy of Sciences, 108*, 13335–13340.

DeScioli, P., Bruening, R., & Kurzban, R. (2011). The omission effect in moral cognition: Toward a functional explanation. *Evolution and Human Behavior, 32*, 204–215.

DeScioli, P., & Kurzban, R. (2009a). The alliance hypothesis for human friendship. *PLoS One, 4*, e5802.

DeScioli, P., & Kurzban, R. (2009b). Mysteries of morality. *Cognition, 112*, 281–299.

DeScioli, P., & Kurzban, R. (2011). The company you keep: Friendship decisions from a functional perspective. In J. I. Krueger (Ed.), *Social Judgment and Decision Making* (pp. 205–224). New York, NY: Psychology Press.

DeScioli, P., & Kurzban, R. (2013). A solution to the mysteries of morality. *Psychological Bulletin, 139*, 477–496.

DeScioli, P., Kurzban, R., Koch, E. N., & Liben-Nowell, D. (2011). Best friends, alliances, friend ranking, and the MySpace social network. *Perspectives on Psychological Science, 6*, 6–8.

DeScioli, P., Massenkoff, M., Shaw, A., Petersen, M. B., & Kurzban, R. (2014). Equity or equality? Moral judgments follow the money. *Proceedings of the Royal Society of London B: Biological Sciences, 281*, 20142112.

Donovan, E., & Kelemen, D. (2011). Just rewards: Children and adults equate accidental inequity with intentional unfairness. *Journal of Cognition and Culture, 11*, 137–150.

Engelmann, D., & Strobel, M. (2004). Inequality aversion, efficiency, and maximin preferences in simple distribution experiments. *American Economic Review, 94*(4), 857–869.

Fehr, E., & Schmidt, K. M. (1999). A theory of fairness, competition, and cooperation. *The Quarterly Journal of Economics, 114*, 817–868.

Fehr, E., Bernhard, H., & Rockenbach, B. (2008). Egalitarianism in young children. *Nature, 454*, 1079–1083.

Festinger, L. (1954). A theory of social comparison processes. *Human Relations, 7*, 117–140.

FitzGibbon, C. D., & Fanshawe, J. H. (1988). Stotting in Thomson's gazelles: An honest signal of condition. *Behavioral Ecology and Sociobiology, 23*, 69–74.

Flinn, M. V., Geary, D. C., & Ward, C. V. (2005). Ecological dominance, social competition, and coalitionary arms races: Why humans evolved extraordinary intelligence. *Evolution and Human Behavior, 26*, 10–46.

Frank, R. H. (1985). *Choosing the right pond. Human behavior and the quest for status*. New York, NY: Oxford University Press.

Geraci, A., & Surian, L. (2011). The developmental roots of fairness: Infants' reactions to equal and unequal distributions of resources. *Developmental Science, 14*, 1012–1020.

Guala, F. (2012). Reciprocity: Weak or strong? What punishment experiments do (and do not) demonstrate. *Behavioral and Brain Sciences, 35*, 1–15.

Haidt, J., & Graham, J. (2007). When morality opposes justice: Conservatives have moral intuitions that liberals may not recognize. *Social Justice Research, 20*, 98–116.

Hamann, K., Warneken, F., Greenberg, J. R., & Tomasello, M. (2011). Collaboration encourages equal sharing in children but not in chimpanzees. *Nature, 476*, 328–331.
Harcourt, A. H. (1992). Cooperation in conflicts: Commonalities between humans and other animals. *Politics and the Life Sciences, 11*, 251–259.
Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences, 33*, 1–75.
Homans, G. C. (1958). Social behavior as exchange. *American Journal of Sociology, 63*, 597–606.
Hook, J., & Cook, T. D. (1979). Equity theory and the cognitive ability of children. *Psychological Bulletin, 86*, 429–445.
Kanngiesser, P., & Warneken, F. (2012). Young children consider merit when sharing resources with others. *PLoS One, 7*, e43979.
Knoch, D., Pascual-Leone, A., Meyer, K., Treyer, V., & Fehr, E. (2006). Diminishing reciprocal fairness by disrupting the right prefrontal cortex. *Science, 314*, 829–832.
Kurzban, R., DeScioli, P., & O'Brien, E. (2007). Audience effects on moralistic punishment. *Evolution and Human Behavior, 28*, 75–84.
Kurzban, R., & Leary, M. R. (2001). Evolutionary origins of stigmatization: the functions of social exclusion. *Psychological Bulletin, 127,* 187–208.
Lind, P. G., da Silva, L. R., Andrade Jr, J. S., & Herrmann, H. J. (2007). Spreading gossip in social networks. *Physical Review E, 76*, 036117.
Liska, G. (1962). Nations in alliance: The limits of interdependence. Baltimore, MD: Johns Hopkins Press.
LoBue, V., Nishida, T., Chiong, C., DeLoache, J., & Haidt, J. (2011). When getting something good is bad: Even three-year-olds react to inequality. *Social Development, 20*, 154–170.
Macfarlan, S. J., Walker, R. S., Flinn, M. V., & Chagnon, N. A. (2014). Lethal coalitionary aggression and long-term alliance formation among Yanomamö men. *Proceedings of the National Academy of Sciences, 111*, 16662–16669.
McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology, 27*, 415–444.
Mills, C. M., & Grant, M. G. (2009). Biased decision-making: Developing an understanding of how positive and negative relationships may skew judgments. *Developmental Science, 12*, 784–797.
Nichols, S. (2010). Emotions, norms, and the genealogy of fairness. *Politics, Philosophy & Economics, 9*, 275–296.
Olson, K. R., & Spelke, E. S. (2008). Foundations of cooperation in young children. *Cognition, 108*, 222–231.
Parker, G. A. (1974). Assessment strategy and the evolution of fighting behaviour. *Journal of Theoretical Biology, 47*, 223–243.
Rose, A. J., & Asher, S. R. (1999). Children's goals and strategies in response to conflicts within a friendship. *Developmental Psychology, 35*, 69–79.
Rose, A. J., & Rudolph, K. D. (2006). A review of sex differences in peer relationship processes: Potential trade-offs for the emotional and behavioral development of girls and boys. *Psychological Bulletin, 132*, 98–131.
Schino, G. (2001). Grooming, competition and social rank among female primates: a meta-analysis. *Animal Behaviour, 62,* 265–271.
Schmidt, M. F., & Sommerville, J. A. (2011). Fairness expectations and altruistic sharing in 15-month-old human infants. *PLoS One, 6*, e23223.
Sell, A., Cosmides, L., Tooby, J., Sznycer, D., von Rueden, C., & Gurven, M. (2009). Human adaptations for the visual assessment of strength and fighting ability from the body and face. *Proceedings of the Royal Society B, 276*, 575–584.
Seyfarth, R. M. (1977). A model of social grooming among adult female monkeys. *Journal of Theoretical Biology, 65*, 671–698.
Shaw, A. (2013). Beyond "To share or not to share": The impartiality account of fairness. *Current Directions in Psychological Science, 22*, 413–417.

Shaw, A., DeScioli, P., & Olson, K. R. (2012). Fairness versus favoritism in children. *Evolution and Human Behavior, 33*, 736–745.
Shaw, A. & Keysar, B. (2015). Fairness vs. reciprocity: When retaliation is better than quid pro quo. Talk presented at the Society for Personality and Social Psychology Conference, Long Beach, CA.
Shaw, A., & Knobe, J. (2013). Not all mutualism is fair and not all fairness is mutualistic. *Behavior and Brain Sciences, 36*, 100–101.
Shaw, A., Montinari, N., Piovesan, M., Olson, K. R., Gino, F., & Norton, M. I. (2014). Children develop a veil of fairness. *Journal of Experimental Psychology: General, 143*, 363–375.
Shaw, A., & Olson, K. R. (2012). Children discard a resource to avoid inequity. *Journal of Experimental Psychology: General, 141*, 382–395.
Shaw, A., & Olson, K. R. (2014). Fairness as an aversion to partiality: The development of procedural justice. *Journal of Experimental Child Psychology, 119*, 40–53.
Sigelman, C. K., & Waitzman, K. A. (1991). The development of distributive justice orientations: Contextual influences on children's resource allocations. *Child Development, 62*, 1367–1378.
Silk, J. B. (1999). Male bonnet macaques use information about third party rank relationships to recruit allies. *Animal Behaviour, 58*, 45–51.
Silk, J.B. (2003). Cooperation without counting: The puzzle of friendship. In P. Hammerstein (Ed.), *The genetic and cultural evolution of cooperation* (pp. 37–54), Dahlem Workshop Report 90. Cambridge, MA: MIT Press.
Sloane, S., Baillargeon, R., & Premack, D. (2012). Do infants have a sense of fairness. *Psychological Science, 23*, 196–204.
Smith, C. E., Blake, P. R., & Harris, P. L. (2013). I should but I won't: Why young children endorse norms of fair sharing but do not follow them. *PLoS One, 8*, e59510.
Snyder, G. H. (1984). The security dilemma in alliance politics. *World Politics, 36*, 461–495.
Svetlova, M. & Brownell, C. (2013). Fair or nice? Preschoolers prefer fair partners, but only when it doesn't affect their own interests. Talk presented at Society for Research in Child Development Conference, Seattle, Washington.
Tomasello, M. J., & Call, J. (1997). *Primate cognition*. Oxford, England: Oxford University Press.
Tooby, J., & Cosmides, L. (1992). The psychological foundations of culture. In J. H. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind* (pp. 19–136). New York, NY: Oxford University Press.
Tooby, J., & Cosmides, L. (1996). Friendship and the Banker's Paradox: Other pathways to the evolution of adaptations for altruism. In W. G. Runciman, J. Maynard Smith, & R. I. M. Dunbar (Eds.), *Evolution of social behaviour patterns in primates and man. Proceedings of the British academy* (Vol. 88, pp. 119–143).
Trivers, R. (1971). Evolution of reciprocal altruism. *Quarterly Review of Biology, 46*, 35–57.
Tyler, T. R. (2000). Social justice: Outcome and procedure. *International Journal of Psychology, 35*, 117–125.
West, S. A., El Mouden, C., & Gardner, A. (2011). 16 common misconceptions about the evolution of cooperation in humans. *Evolution and Human Behavior, 32*, 231–262.
Yamagishi, T. (1986). The provision of a sanctioning system as a public good. *Journal of Personality and Social Psychology, 51*, 110–116.
Zahavi, A. (1975). Mate selection—A selection for a handicap. *Journal of Theoretical Biology, 53*, 205–214.
Zahavi, A., & Zahavi, A. (1997). *The handicap principle: A missing piece of Darwin's puzzle*. New York, NY: Oxford University Press.

Part III
Evolved Biases and Cognition and Learning in the Modern World

Chapter 9
Evolution and Children's Cognitive and Academic Development

David C. Geary and Daniel B. Berch

Natural selection is the unifying theory for all of the life sciences and one of humanity's most important scientific accomplishments (Darwin, 1859). As living organisms, human behavior, cognitive biases, and other traits are necessarily a reflection of the survival and reproductive pressures experienced by our ancestors, and as such, the study of the here-and-now development and expression of these traits can be situated in an evolutionary context. This is not to say that social context does not influence human behavior; it does. Rather, a deep understanding of how evolution works will provide insights into human behavior and development that are not fully achievable from other theoretical perspectives. Unfortunately, the power of evolutionary theory has not been fully appreciated by many psychologists or social scientists more generally, with of course the exceptions represented in this volume and a few others. In this chapter, we examine cognitive and academic development from an evolutionary perspective to provide a cohesive framework for understanding children's ability and motivation to learn evolutionarily novel competencies in modern schools, such as reading, writing, and arithmetic.

Cognitive Development

A complete understanding of any trait requires evolutionary analysis on four levels, as outlined by Tinbergen (1963): The ultimate selection pressures that resulted in the evolution of the trait; the function of the trait in terms of increasing survival

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prospects; the proximate, reductive mechanisms that support the here-and-now operation of the trait; and the development of the trait. As Tinbergen noted, “All concerned agree that a complete understanding of behavior requires an understanding of its ontogeny, just as morphologists agree that it is not sufficient to understand the adult form, but also the way in which this develops during ontogeny” (Tinbergen, 1963, p. 423). Our focus is on development, specifically aspects of children’s cognitive development that are likely to be universal and the experiences and mechanisms that support this development. One cannot actually study development without first determining or at least speculating as to what it is that develops. We do this in the next two sections and then move to a discussion of how cognition develops in children and finally the evolution and function of the domain general abilities of working memory and fluid intelligence.

Function of Mind and Brain

Evolution shapes brains and minds such that they are biased to attend to and process the classes of information that were correlated with survival and reproductive outcomes during the species’ evolutionary history. Brains and minds also organize behavior toward the achievement of these outcomes, which Geary (2005) described as a “motivation to control.” This is not an explicit motivation, but rather a heuristic that allows us to more easily understand the function of behavior. Consider as an example the well-documented differences in beak size and shape across the many species of finch that reside on the Galapagos islands (Darwin, 1845; Grant, 1999), as shown in Fig. 9.1. These reflect differences in species’ specialization in different types of food, such as smaller or larger seeds. When combined with a bias to attend to the appropriate seeds and engage in associated foraging behaviors (e.g., cracking open seed shells), these physical traits allow the birds to gain control of these foods. Having birdbrains, they of course have no explicit awareness of what they are doing or an explicit motivation to control. This heuristic nevertheless allows one to readily see how these perceptual, behavioral, and physical traits coevolved because they enable successful seed foraging or more abstractly successful resource control.

The developmental period is an evolved trait in and of itself, and any lengthening of this period necessarily results in delayed reproduction. The costs of delayed reproduction generally include fewer offspring during the reproductive lifespan and elevated risk of dying before having the opportunity to reproduce at all. An extended period of immaturity must therefore result in cognitive, behavioral, or social changes that enhance resource control in adulthood. Bjorklund and Beers (this volume) refer to these as deferred adaptations—skills that emerge over the course of development that function to improve outcomes in adulthood—and this is our focus here; ontogenetic adaptations, those that enable developing organisms to negotiate specific developmental tasks, are important as well but are not considered here (see Bjorklund & Ellis, 2014). We begin by outlining broad classes of information, or folk domains, that were likely important for survival and reproductive prospects during our

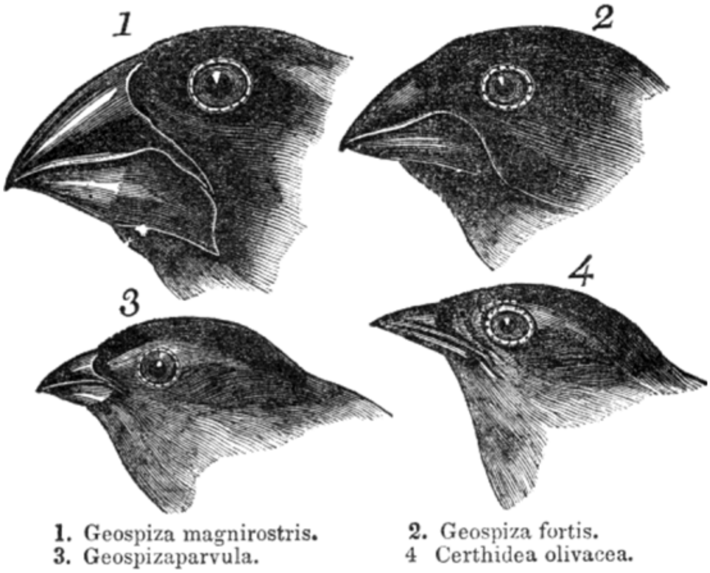

Fig. 9.1 Four species of finch from the Galápagos islands; (1) Large ground finch (*Geospiza magnirostris*); (2) Medium ground finch (*G. fortis*); (3) Small tree finch (*Camarhynchus parvulus*); (4) Warble finch (*Certhidea olivacea*) from *Journal of researches into the natural history and geology of the countries visited during the voyage of H.M.S. Beagle round the world, under the Command of Capt. Fitz Roy, R.N. (2nd edition), by C. Darwin, 1845, London:* John Murray, p. 379

evolutionary history, followed by a discussion of children's behavioral and cognitive biases and developmental changes in these competencies that likely enhanced these prospects.

Folk Domains

All living organisms have to cope with the competing interests of members of their own species, need to exploit (prey) and avoid being exploited by other species (predators), as well as cope with the realities of the physical world. These classes of information have also emerged in studies of children's unschooled cognition and in studies of unschooled adults in traditional populations and are often termed folk psychology, folk biology, and folk physics, respectively (Atran, 1998; Geary, 2005; Gelman, 2003; Leslie, Friedman, & German, 2004; Medin & Atran, 1999; Mithen, 1996; Wellman & Gelman, 1992). *Folk domains* represent universal forms of knowledge and competencies that emerge from a combination of inherent cognitive biases and evolutionarily expectant experiences. The latter results from self-initiated activities that give rise to experiences that in turn elaborate on inherent biases and flesh out folk knowledge such that it is adapted to local conditions (Gelman, 1990; Greenough, Black, & Wallace, 1987), as elaborated in *Mechanisms*. In Fig. 9.2, we

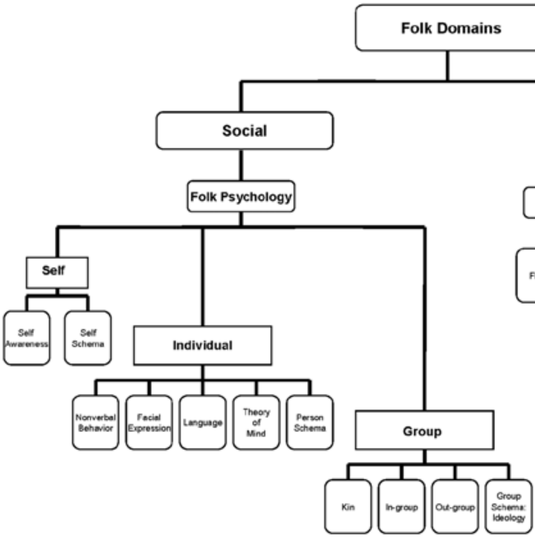

Fig. 9.2 Evolutionarily salient information-processing domains and associated cognitive modules that compose the domains of folk psychology, folk biology, and folk physics. Adapted from "*The origin of mind: Evolution of brain, cognition, and general intelligence*," by D. G. Geary, 2005, p. 129. Copyright 2005 by American Psychological Association

present a taxonomy of folk competencies and knowledge (Geary, 2005; Geary & Huffman, 2002). Functionally, these abilities evolved because they allowed our ancestors to focus their behavior on attempts to achieve access to and control of the social (e.g., finding a mate), biological (e.g., food), and physical (e.g., control of rich territory) resources that tended to enhance survival or reproductive prospects during human evolution.

Folk Psychology

The evolution of this complex system of cognitive, emotional, and behavioral traits was almost certainly driven by intense social competition and the cooperation that often facilitates competitive ability (e.g., Alexander, 1989; Bailey & Geary, 2009; Dunbar, 1998; Flinn, Geary, & Ward, 2005; Geary, 2005; Humphrey, 1976). This constellation of traits allows people to negotiate social interactions and relationships, and the corresponding social cognitions are largely organized around the self, relationships, and interactions with other people, and group-level relationships (see also Shaw, this volume; Hawley, this volume).

Self. Humans are very likely to be unique among species in their awareness of their emotional and mental states and their ability to compare and contrast their unobservable traits (e.g., personality, intelligence) with those of others. *Self-awareness* is a conscious representation (in working memory) of the self as a social being and of one's relationships with other people (e.g., Harter, 2006), and may have been evolutionarily preceded by visual self-recognition (Butler & Suddendorf, 2014). Self-awareness is tightly related to the ability to mentally time travel; specifically to project oneself backward in time to recall and relive episodes that are of personal importance and to project oneself forward in time to create a self-centered mental simulation of potential future states (Suddendorf & Corballis, 1997; Tulving, 2002), as we elaborate in Variation and the Evolution of Domain General Abilities. *Self-schema* is a long-term memory network of information that organizes knowledge and beliefs about the self, including positive (accentuated) and negative (discounted) traits (e.g., warmth), memories of personal experiences (Fiske & Taylor, 1991; Markus, 1977), and self-efficacy—beliefs about one's ability to achieve a goal in various domains (Bandura, 1997). Self-schemas can regulate, at least to some extent, goal-related behaviors; specifically, where one focuses effort and whether or not one will persist in the face of failure.

Individual. Common one-on-one human relationships can be found across societies, including attachment between a parent and a child and friendships (Bugental, 2000; Caporael, 1997). Although there are emotional and motivational differences across these relationships, they are all supported by the same suite of folk competencies shown in Fig. 9.2, including the ability to read nonverbal communication signals (e.g., body posture), facial expressions, language, and theory of mind (Adolphs, 2003; Baron-Cohen, 1995; Brothers & Ring, 1992; Humphrey, 1976; Leslie, 1987; Pinker, 1994; Wellman, 2014: Wellman, Fang, Liu, Zhu, & Liu, 2006; Wellman, Fang, & Peterson, 2011; Wellman & Liu, 2004). Theory of mind represents the ability to make inferences about others' desires, beliefs, and emotional states, and awareness that other people can differ on these. This is a set of competencies that may be especially developed in humans (Leslie et al., 2004) and are important in educational contexts (e.g., in students' making inferences about the intentions of teachers and teachers' understanding of the beliefs of students; Gopnik & Wellman, 2012). In any case, all of these competencies are engaged during the dynamics of one-on-one social interactions and provide the functional competencies needed to understand and modulate the dynamics of the interaction.

The integration of these cognitive systems with motivational and emotional systems provides the basis for the development and maintenance of long-term relationships and the development of *person schema*. People develop these schemas for familiar people and people for whom future social relationships are expected (Fiske & Taylor, 1991). The schema is a long-term memory network that includes representations of the other persons' physical attributes, especially race, sex, and age, as well as memories for specific behavioral episodes, and the same warmth and competence traits associated with the self-schema (Schneider, 1973). This knowledge allows people to better understand and predict the behavior of familiar others (Kahneman & Tversky, 1982).

Group. In all cultures, people parse the world into social groups, largely in terms of kinship, in-groups and out-groups, and group schema. An evolved bias to differentially favor kin over nonkin is found in all species and should not be surprising (Hamilton, 1964). In-groups and out-groups are constellations of people with whom one has shared interests and cooperative relationships and people with competing interests, respectively; out-groups need not be competing groups, but the salience of "our group" and "the other group" is more prominent during times of conflict (Fiske, 2002). In traditional societies, in-groups and out-groups are often determined by kinship, but this is not always the case (e.g., Macfarlan, Walker, Flinn, & Chagnon, 2014). People have more positive attitudes and beliefs about members of their in-group and more negative and often hostile attitudes and beliefs about members of out-groups, especially when the groups are competing (Fiske & Taylor, 1991; Hewstone, Rubin, & Willis, 2002; Horowitz, 2001). *Group schema* is an ideologically based social identification, as exemplified by nationality and religious affiliation (Abrams & Hogg, 1990). These ideologies allow for the formation of larger groups than would be possible based only on personal relationships. These large cooperative groups are particularly advantageous during between-group conflicts, given the competitive advantage that results from being a member of a large group (Alexander, 1990).

Folk Biology

Analogous to species' variation in beak size among Darwin's finches, there are species-specific brain, cognitive and behavioral specializations that enable the location and manipulation (e.g., raccoons, *Procyon lotor*, cleaning of food) of edible plants, fruits, and nuts, as well as the location and capture of prey species (e.g., Barton & Dean, 1993; Huffman, Nelson, Clarey, & Krubitzer, 1999). The folk biological competencies represent the most rudimentary cognitive specializations that support humans' ability to learn about, identify, and secure biological resources in the wide range of ecological niches occupied by our species (Atran, 1998; Caramazza & Shelton, 1998; Malt, 1995; Medin & Atran, 2004). These competencies emerge from a combination of biases and experiences in the ecology and support hunting, gathering, and horticulture in traditional societies.

There is both cross-cultural variation in the extent and organization of folk biological knowledge and a universal core. As a reflection of the latter, people throughout the world are able to categorize the flora and fauna in their local ecologies and show similar categorical and inferential biases when reasoning about these species (Atran, 1998; Berlin, Breedlove, & Raven, 1966). Through the study of this knowledge across traditional societies, "it has become apparent that, while individual societies may differ considerably in their conceptualization of plants and animals, there are a number of strikingly regular structural principles of folk biological classification which are quite general" (Berlin, Breedlove, & Raven, 1973, p. 214). Bailenson, Shum, Atran, Medin, and Coley (2002) asked groups of novices and bird experts from the United States and Itza' Maya Amerindians (Guatemala) to classify about 100 birds from their region and from the region of the other group. There were similarities in the classifications of all three groups, as well as differences. The classification system of US experts and the Itza' Maya was more similar to the scientific taxonomy of these species than that of the US novices. For the Itza' "their consensual sorting agrees more with (western) scientific taxonomy than does the consensual sort of US non-experts. This difference held for both US birds and Tikal birds" (Bailenson et al., 2002, p. 24).

Bailenson et al.'s (2002) findings for novices are not unique; without sufficient experience with the natural world (e.g., children living in modern urban areas), only rudimentary aspects of folk biology develop (Medin & Atran, 2004). With sufficient experience, people develop at least a three-level organization to their knowledge of the biological world. The most general level—corresponding to the kingdom level in the scientific classification—is shown in Fig. 9.2. People further subdivide flora and fauna into classes of related species, including birds, mammals, and trees, and then more specific species, such as bluebirds (*Sialia*) and robins (*Turdus*).

Knowledge of the species' morphology, behavior, growth pattern, and ecological niche (e.g., arboreal versus terrestrial) help to define the *essence* of the species (Atran, 1994; Malt, 1995). The essence is a species schema, analogous to the person schema, and includes knowledge of salient and stable characteristics (e.g., Medin et al., 2006). This knowledge enables use of mental models of flora and fauna for representing and predicting the likely behavior of these organisms (e.g., seasonal growth in plants). The combination of folk biological categories, inferential biases, and knowledge of the species' essence allows people to use these species in evolutionarily significant ways (Figueiredo, Leitão-Filho, & Begossi, 1993, 1997).

Folk Physics

Folk physics, as noted, enables organisms to negotiate the physical world, as in finding food, shelter, or mates and avoiding potential threats (Dyer, 1998). Our inclusion of movement and representation in Fig. 9.2 is based in part on Milner and Goodale's (1995) analysis of the functional and anatomical organization of the visual system. They argue that the systems for movement and representation are functionally and anatomically distinct, but interact. Indeed, there are examples of distinct visuomotor pathways for a variety of movement-related functions, such as predator avoidance and navigating around obstacles. Barton and Dean (1993), for instance, examined the relations among the number and size of neurons in one specific visual pathway and predatory behaviors within four groups of mammals, *Rodentia*, *Primates*, *Carnivora*, and *Marsupials*. Within each of these groups, species were classified as more (i.e., diet heavily based on prey capture) or less (e.g., heavy reliance on fruits) predatory. Predatory species had more and larger neurons in this visual pathway than did their less predatory cousins, but there were no cross-species differences in the volume of adjacent visual pathways not related to prey capture.

The search for prey, shelter, and other resources requires systems for navigating in three-dimensional space (Gallistel, 1990; Shepard, 1994). Studies of a variety of mammalian species reveal that organisms have egocentric and allocentric views of this space (Byrne, Becker, & Burgess, 2007; Maguire et al., 1998). The egocentric representation is what the organism sees, including objects and locations with respect to itself (Byrne et al., 2007). The allocentric system codes for large-scale geometric relations and positioning of objects in space independent of the organism. Both systems work conjointly to enable the organism to remain oriented and goal-focused while moving in space. The allocentric representation may result in an implicit three-dimensional analog map that codes the geometric relations among features of the environment and enables navigation by means of dead reckoning; movement from one place to another on the basis of geometric coordinates (Gallistel, 1990). Human navigation involves both the egocentric and allocentric systems, but for different aspects of navigation (Byrne et al., 2007). A few species, especially humans, can also generate explicit cognitive representations of egocentric and allocentric physical space in working memory (Kuhlmeier & Boysen, 2002).

Tool use is found in one form or another in all human cultures and enables people to more fully control biological resources in the local ecology (Murdock, 1981). The neural, perceptual, and cognitive systems that support tool use have not been as systematically studied as the systems that support movement and representation in space. On the basis of brain imaging studies and cognitive deficits following brain injury, Johnson-Frey (2003) concluded that homologous brain regions are involved in basic object grasping and manipulation in humans and other primates. At the same time, it is clear that humans have a much better conceptual understanding of how objects can be used as tools (Pellegrini, this volume; Povinelli, 2000), and their definition of how these objects can be used is influenced by the inferred intentions of potential tool users (Bloom, 1996). At the core, human tool use involves the ability to mentally represent an object as a potential tool, to manipulate this mental representation to explore the different ways in which the object might be used, and finally to integrate such representations with active tool use (Lockman, 2000; Pellegrini, this volume).

Finally, we have classified organisms' intuitive sense of time and number—for instance the approximate quantity of food available in two distinct foraging patches—as an aspect of folk physics. These competencies support the representation and discrimination of the exact quantity of small collections of items and the approximate quantity of larger collections or continuous quantities (e.g., area; Feigenson, Dehaene, & Spelke, 2004; Geary, Berch, & Mann Koepke, 2015) and appear to be integrated with systems for representing the passage of time (Meck & Church, 1983).

Folk Heuristics and Attributional Biases

The behavioral features of folk domains can be described as "rules of thumb" (Gigerenzer, Todd, & ABC Research Group, 1999). The information to which the folk systems are sensitive is processed implicitly and the behavioral component is more or less automatically executed (Simon, 1956), although people have the ability to override these if necessary (below). Barton and Dean's (1993) analysis of the visuomotor pathway in mammals as related to prey-capture illustrates the point. Cells in this system are likely to be sensitive to the movement patterns of prey species and enable the coordination of these perceptions with behaviors necessary to capture this prey. The organization of this integrated neural system results in built-in attentional and perceptual biases and an implicit understanding of how to catch prey. Competence at prey capture is likely to improve with experience, including play behavior during development for many species of mammal, but the foundation is built-in (Burghardt, 2005).

The same applies to folk knowledge more generally. For instance, during face processing the pattern generated by the shape of the eyes and nose provides information about the sex of the individual, whereas the pattern generated by the configuration of the mouth provides information about the individual's emotional state (Schyns, Bonnar, & Gosselin, 2002). The receiver automatically and implicitly processes this information, and in turn, expresses corresponding emotional and other social signals (e.g., smile) as appropriate. The receiver may also make implicit decisions regarding the interaction, but these do not need to be explicitly represented in working memory and made available to conscious awareness (see below). These quick, rule-of-thumb decisions can be based on automatically generated feelings and other social information. Angry facial expressions, for example, often generate fear and behavioral avoidance and can do so in a matter of seconds (Damasio, 2003).

Explicit inferential and attributional biases are also features of folk heuristics, as least for humans. People often attribute their failures to achieve desired goals, for instance, to bad luck or biases in other people. The tendency to make attributions of this type has the benefit of maintaining effort and control-related behavioral strategies in the face of inevitable failures (Heckhausen & Schulz, 1995). Social attributional biases that favor members of the in-group and derogate members of out-groups are well-known (Fiske, 2002) and facilitate intergroup competition (Horowitz, 2001). The folk-biological essence allows people to make inferences (e.g., during the act of hunting) about the behavior of members of familiar species and about the likely behavior of less familiar but related species (Atran, 1998). Attributions about causality in the physical world are also common (Clement, 1982).

From an educational perspective, it is important to note that these biases may provide good enough explanations for day-to-day living and self-serving explanations for social and other phenomena. However, an evolved functional utility in terms of everyday living in traditional settings does not mean the explanations are necessarily scientifically accurate, as aptly described by Sinatra and Danielson (this volume; also Shtulman, 2006). In fact, *descriptions* of psychological, physical, and biological phenomena are often correct (Wellman & Gelman, 1992), but many of the explicit *explanations* of the *causes* of these phenomena are objectively and scientifically inaccurate. People can, for instance, describe the trajectory of a thrown object, but they do not understand the forces that produce this motion (Clement, 1982).

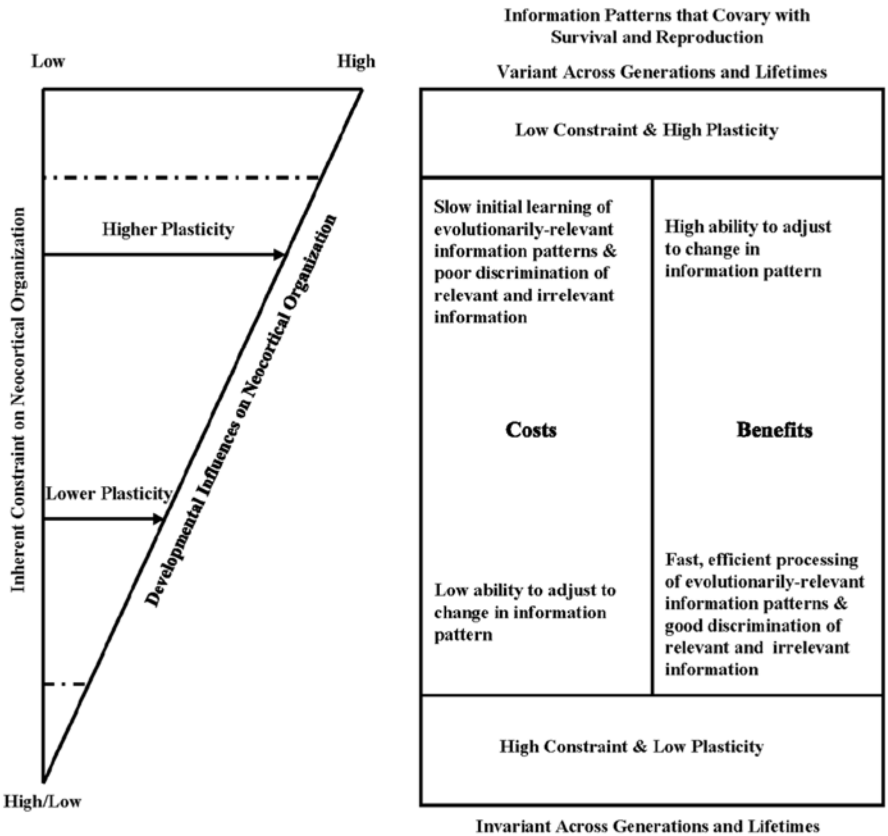

Fig. 9.3 The triangle represents the relation between inherent constraint and the influence of developmental experience on brain organization and cognitive functions. The length of the line segments with arrows represents the corresponding degree of plasticity. The area above (no inherent constraint) and below (no plasticity) the dashed lines represents extreme views that few theorists posit for humans. The rectangle highlights cost-benefit trade-offs that are predicted to influence the evolution of brain and cognitive plasticity. Adapted from "Brain and cognitive evolution: Forms of modularity and functions of mind," by D. C. Geary and K. J. Huffman, 2002, Psychological Bulletin, 128, p. 668. Copyright 2002 by the American Psychological Association

Mechanisms

Given the wide range of ecological and social niches occupied by humans, it is unlikely that most folk knowledge is "prepackaged" either fully or unfolds in a predetermined manner across development. Rather, the extent of inherent constraint or developmental plasticity might vary with the temporal and spatial variability in the associated ecological or social pressures and attendant information patterns that need to be processed to cope with these (Geary, 2005; Geary & Huffman, 2002). These tradeoffs are represented in Fig. 9.3. Strong neurobiological and cognitive constraints direct attention and behavior toward evolutionarily significant information patterns, and in doing so, reduce the number of false positives (Gelman, 1990). The cost is reduced plasticity of these systems. Weak constraints increase the risk of false positives, but result in enhanced system flexibility. The cost-benefit tradeoffs should be modulated by the variability of associated information patterns.

The three-dimensional structure of the physical world results in stable information patterns that would, in theory, result in the evolution of constrained systems for detecting and acting on this information (Gallistel, 1990; Shepard, 1994). Of course, movement in space creates variation in the information to which the organism is exposed and advantages to systems for remembering location and for navigating, systems that would be anchored by the more constrained folk physics systems (O'Keefe & Nadel, 1978). Human social dynamics, in contrast, are necessarily more dynamic and we would anticipate greater plasticity in folk psychological systems, but constraints are still needed. As noted, variation in facial expression provides dynamic information about the individuals' current emotional state, but would be missed if not anchored by attentional focus to specific facial features (Baron-Cohen, 1995; Schyns et al., 2002).

In the context of the tradeoffs associated with constraint and plasticity, the developmental period provides opportunity to adjust folk systems to the nuances of the local geography, flora and fauna, and social relationships (Geary, 2004; Geary & Bjorklund, 2000). The mechanisms for adapting folk systems to local variation must include behaviors that result in exposure to this variation, as we describe in the first section. In the second, we provide discussion of the nature of the plasticity of folk systems during cognitive development.

Behavioral. In theory, children's self-initiated engagement of the ecological and social contexts in which they are embedded provides the experiences needed to flesh out the plastic components of folk domains (Bjorklund & Pellegrini, 2002; Gopnik & Wellman, 2012; Greenough et al., 1987; Scarr, 1992). These behavioral biases are common juvenile activities, including social play, exploration of the ecology, and experimentation and play with objects (see also Bjorklund & Beers, this volume; Lancy, this volume; Toub et al., this volume; Pellegrini, this volume). A critical aspect of these experience-expectant processes is that they result in automatic and effortless modification of plastic features of folk systems and implicit knowledge.

An example is provided by infants' early attentional and behavioral biases. They attend to human faces, movement patterns, and speech in ways that reflect the inherent organizational and motivational structure of the associated folk psychological systems (Freedman, 1974). These biases evolved because of the evolutionary significance of social relationships and result in the re-creation of the microconditions (e.g., parent–child interactions) associated with the evolution of the corresponding systems (Caporael, 1997). Attention to and processing of this information provides exposure to the within-category variation needed to adapt the architecture of these systems to variation in parental faces, behavior, and so forth (Gelman & Williams, 1998). In this example, these experience-dependent modifications allow infants to discriminate the voice of their parents from the voice of other people with only minimal exposure. When human fetuses (gestation age of about 38 weeks) are exposed in utero to human voices, their heart-rate patterns suggest they are sensitive to and learn the voice patterns of their mother and discriminate her voice from that of other women (Kisilevsky, 2003).

In some ways, the experience-dependent fleshing out of folk systems is similar to the constructivist view of learning, but with a very important difference (Geary, 1995). A strict constructivist view does not discriminate learning in school from elaboration of folk knowledge resulting from engagement in evolutionarily expectant activities (see Gray, this volume). In our view, it does not follow that there are inherent anchors and behavioral biases to guide the learning of algebra or most other evolutionarily novel academic material in the same way there are anchors and social biases that allow children to learn about their social world, for instance (see Geary, 2007; Sweller, 2012, 2015, this volume). As we elaborate below, there may well be a gray area in which evolutionarily expectant activities, such as play, can be used to facilitate some aspects of biologically secondary (i.e., evolutionarily novel) learning, as touched upon in Bjorklund and Beer's (this volume) and Toub et al.'s (this volume) chapters. It does not follow, however, that all aspects of secondary learning can be acquired in this way, and *determining the strengths as well as limitations of evolved behavioral biases in the promotion of secondary learning has profound implications for how to improve educational outcomes*.

Cognitive. Debate regarding the origins of human knowledge have spanned several millennia and continue to this day (Carey, 2009; Gelman, 1990; Gelman, 2003; Gopnik & Wellman, 2012; Newcombe, 2011; Spelke & Kinzler, 2007, 2009; Spencer et al., 2009). There is some debate regarding whether or not human cognition and cognitive development is influenced by inherent constraints at all (Spencer et al., 2009), but the focus of debate largely centers on the extent and nature of any such constraints, in keeping with the tradeoffs between constraint and plasticity noted above (Fig. 9.3).

There is agreement that inherent constraints are found for some domains but not others; they are based on at least implicit concepts (e.g., of quantity or living vs. nonliving things) applied to categories of natural things (vs. man-made) and they support inferences about causality related to these things. As an example, young children and even infants discriminate between objects that produce self-generated movement, as do living organisms, and those that only move when acted upon by some other object (e.g., movement after being struck by another object) or a person. Moreover, they implicitly infer that living things have causal intentions—infants and young children behave as if they expect movement of living things to be directed toward a goal—and that living things have "innards" that represent their "essence" (e.g., all elephants have the same essence) and that enable goal-directed behavior (e.g., Gelman, 1990; Gelman, 2003; Setoh, Wu, Baillargeon, & Gelman, 2013). Nonliving things do not have an essence per se, but they do have physical properties, such as solidity (two objects cannot occupy the same space at the same time), that infants appear to implicitly expect (Spelke, Breinlinger, Macomber, & Jacobson, 1992).

There is also agreement that infants' and young children's early conceptual constraints either become elaborated during development and with experience, or they are superseded by more powerful concepts, that is, concepts that provide a more functional and accurate understanding of the organism or object (Carey, 2009; Gelman, 1990; Gelman, 2003; Gopnik & Wellman, 2012; Spelke & Kinzler, 2007); this does not necessarily mean that the original naïve concept disappears, as it may exist alongside the new conceptual understanding. How to best represent initial constraints and associated conceptual change is debated, but regardless of the details the key idea is that inherent constraints and concepts form the scaffolding for children's emerging understanding of natural things, that is, the physical world, other species, and our own species. There is not yet a consensus on the extent of core domains and their organization, but we believe the folk domains shown in Fig. 9.2 are a reasonable approximation.

In any case, an experience-dependent elaboration of nascent folk domains melds easily with humans' long developmental period (Bogin, 1999), and children's self-initiated behaviors described in the section above. In this view, behavioral and cognitive development coevolved and is co-expressed during childhood. Early constraints result in attentional and behavioral biases that in turn result in the experiences needed to adapt these systems to the nuances of local conditions. In keeping with Lancy's (this volume) description of the ethnographic record, children's self-initiated activities do indeed result in their acquisition of human universals (e.g., language) and culture-specific competencies needed to be successful in adulthood in traditional societies without much adult intervention. A fundamental and critical issue is whether the activities that result in the acquisition of culture-specific competencies in traditional societies are sufficient for the acquisition of culture-specific competencies in modern societies.

Variation and the Evolution of Domain General Abilities

Humans can inhabit multiple social and ecological niches, in part because folk systems can be adapted to variation in local conditions during development. These folk systems and associated heuristics enable people to effortlessly cope with a variety of ecological and social demands, as represented by the left section of Fig. 9.4. The associated folk heuristics are toward the invariant end of the continuum because developmental adaptation of these systems is in the context of inherent constraints, that is, the systems (e.g., language) are plastic but only to some extent. If this were not the case, the folk abilities shown in Fig. 9.2 would not be universal, but they appear to be. To be sure, elaboration of one folk domain (e.g., folk biology) or another or the extent to which some attributional biases are favored over others—for instance, the belief that people from other groups are hostile rather than cooperative—varies from one context to the next, but all of this variation is anchored by the same skeletal folk structure. These systems, however, are not sufficient for coping with unexpected (or inexperienced) conditions, that is, novelty. Novelty is defined as conditions that cannot be coped with using only evolved or learned heuristics. For instance, most social dynamics are routine and do not require explicit evaluation of

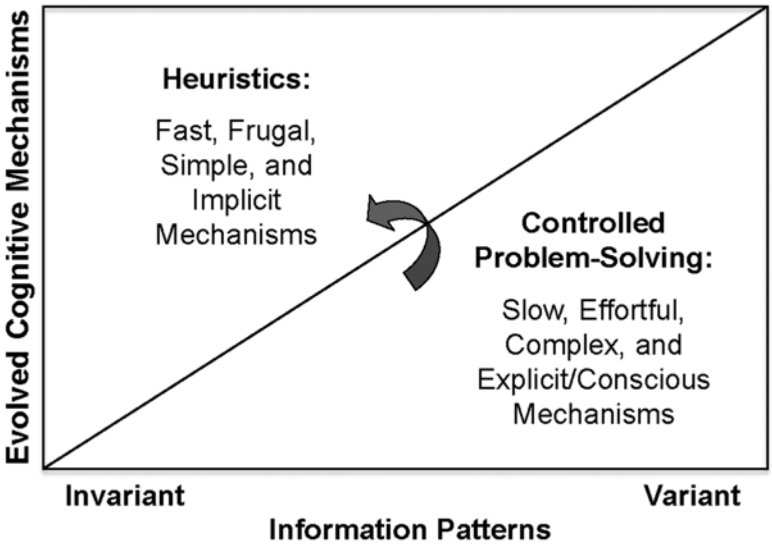

Fig. 9.4 The types of cognitive mechanisms that operate on ecological or social information. These are predicted to vary with the extent to which that information tended to be invariant (resulting in evolved heuristics) or variant (resulting in evolved problem-solving mechanisms) during the species' evolutionary history and during a typical lifetime. Adapted from "*The origin of mind: Evolution of brain, cognition, and general intelligence*," by D. C. Geary, p. 168. Copyright 2005 by the American Psychological Association

the behavior and intentions of other people. During times of conflict, however, behavioral predictability can result in a disadvantage and use of novel arguments or behavioral strategies (e.g., tactics during large-scale conflicts) can result in an advantage because competitors will not have readily accessible counter strategies available to them.

The variant end of the continuum shown in Fig. 9.4 represents conditions that are not readily accommodated by evolved heuristics. Coping with these conditions requires explicit problem-solving abilities. Theories regarding the pressures that drove the evolution of these abilities are debated and beyond the scope of this chapter, but include climatic change (e.g., winter), hunting demands, and social competition (Alexander, 1989; Ash & Gallup, 2007; Bailey & Geary, 2009; Geary, 2005; Kaplan, Hill, Lancaster, & Hurtado, 2000; Potts, 1998). The key idea across all of these models is that there are advantages to being able to anticipate and plan behavioral strategies to cope with novelty and change. Geary (2005) proposed that the core mechanism for coping with novelty and change is the *autonoetic mental model*. These are explicit attention-driven mental representations—supported by working memory—of situations that are centered on the self and one's relationship with other people or one's access to biological and physical resources and support the generation and rehearsal of behavioral strategies for gaining access to these resources. As mentioned earlier, the representations often involve a form of mental time travel; specifically, simulations of past, present, or potential future states that can be cast as images, in language, or as memories of personal experiences (Paivio, 2007; Suddendorf & Corballis, 1997; Tulving, 2002).

A key component is the ability to create a mental representation of a desired or fantasized state and to compare this to a mental representation of one's current situation. The fantasized world is one in which the individual is able to control social (e.g., social dynamics), biological (e.g., access to food), and physical (e.g., shelter) resources in ways that would have enhanced survival or reproductive prospects during human evolution. The mental simulation creates a problem space, including an initial state (one's current circumstances) and a goal state (the fantasized outcome). The proposal is that people's ability to explicitly problem-solve in ways that reduced the difference between the initial and goal states evolved as a core feature of autonoetic mental models. The details are described in Geary (2005), but the gist is the evolution of weak problem-solving methods such as means-ends analyses (Newell & Simon, 1972) was driven by the competitive advantage that results from the ability to inhibit evolved or learned heuristics and to then generate and mentally rehearse more novel social-competitive strategies and to mentally generate the strategies that support greater control of nonsocial resources, as with constructing tools and shelters and planning hunts.

Despite the extraordinary ability to mentally simulate future conditions and problem-solve to devise behavioral goal-directed strategies, people's reasoning about such conditions is influenced by many documented biases that often result in incorrect inferences or less-than-optimal solutions (e.g., Evans, 2002; Johnson-Laird, 1983; Oaksford & Chater, 1998; Tversky & Kahneman, 1974). Some of these biases result from presenting experimental tasks in evolutionarily novel contexts (Cosmides, 1989), and others simply reflect beliefs that are good enough for day-to-day living, albeit they are often inaccurate from a scientific perspective (Clement, 1982; Sinatra & Danielson, this volume). In any event, there are individual differences in the ability to inhibit evolved or learned heuristics and prior knowledge and to generate abstract, decontextualized representations of the problem at hand. There may be even more individual variation in the ability to use formal logic (e.g., deduction based on a set of premises) to operate on these abstract representations (Stanovich, 1999). People who are able to do so can eliminate many reasoning biases and thereby produce more optimal solutions (Stanovich & West, 2000).

But even so, people who are capable of formal logical reasoning often commit common reasoning errors (Stanovich & West, 2008). This is because use of formal logic and explicit problem-solving requires the effortful suppression of heuristics and prior knowledge and, as a result, people use these systems only when necessary. This makes sense because folk and learned knowledge and heuristics are typically good enough for achieving most day-to-day goals, and suppression of these to construct new strategies is only necessary when currently available ones are not effective (i.e., the conditions are toward the variant end in Fig. 9.4). Individual differences in the ability to suppress heuristics and prior knowledge and beliefs and engage in formal logical thinking are independently related to measures of general fluid intelligence (below), syllogistic reasoning, and cognitive flexibility, that is, openness to new ideas and alternative explanations of the same phenomenon (Stanovich & West, 2000; West, Toplak, & Stanovich, 2008).

The important point for us is that the ability to logically and critically evaluate evidence and to engage in other forms of formal problem solving, as is necessary for many aspects of learning in school, does not come easily to most people and requires the suppression of folk biases (see Sinatra & Danielson, this volume; Sweller, this volume). In theory, the more evolutionarily novel the academic content—such as systems of equations in algebra versus understanding the cardinal value of count words—the more effortful is the learning (Geary, 2007). This is because the larger the gap between the conceptual base of the academic domain, such as the principles of natural selection, and the conceptual base and biases that are components of folk systems, such as folk biology (see Shtulman, 2006; Sinatra & Danielson, this volume), the more likely folk beliefs will interfere with learning academic content; the scientifically accurate view of how species change across generations in this case. For the latter to occur, folk biases must be inhibited and the mechanisms that enable explicit goal-directed problem solving need to be engaged.

Working Memory, Intelligence, and Evolutionarily Novel Learning

Geary (2005) suggested the working memory and problem-solving competencies that support the use of autonoetic mental models define the core of general fluid intelligence. In other words, more than a century of research on general intelligence has identified the evolved mechanisms that enable humans to cope with and learn from evolutionarily novel situations, those toward the variant end of the continuum in Fig. 9.4, not unlike Cattell's (1963, p. 3) original description, "Fluid general ability … shows more in tests requiring adaptation to new situations, where crystallized skills are of no particular advantage." The details can be found in Geary (2005): The point here is that the result is represented by the arrow at the center of Fig. 9.4, that is, the transfer of information, procedures, and heuristics learned from effortful, controlled problem solving to long-term memory, including semantic and procedural memory. In keeping with Sweller's cognitive load theory (2015, this volume), the eventual result is the learning of new knowledge or problem-solving heuristics that can thereafter be effortlessly applied to solving the once novel problems.

Our main point is that the ability to learn evolutionarily novel information—including reading, writing, and arithmetic—is the result of two types of brain and cognitive plasticity, both of which evolved to enable humans to cope with variation in ecological and social conditions. The first is the plasticity in folk systems that enable them to be adapted to local conditions during development. The second results from the ability to mentally represent and manipulate information in working memory, which in turn creates mental experiences (e.g., rehearsal of information) that enable the top-down modification of folk systems (Damasio, 2003; Geary, 2005). Moreover, the simultaneous activation of multiple folk systems and the representation of corresponding information in working memory appear to result in the ability to link these systems in novel ways (Garlick, 2002; Sporns, Tononi, & Edelman, 2000) and through this create evolutionarily novel, academic competencies (Geary, 2007).

Academic Development

In contrast to universal folk knowledge, most of the knowledge taught in modern schools is culturally specific; that is, it does not emerge in the absence of formal instruction. Geary (1995) termed these competencies biologically secondary because they are built from the biologically primary folk domains discussed earlier. We illustrate the relation between folk domains and secondary abilities in the first section and outline the corresponding premises and principles of evolutionary educational psychology in the second.

Learning to Read

We assume that the building of secondary abilities and knowledge from folk systems is possible because of the two forms of plasticity noted above; plasticity in folk systems themselves and the ability to modify these through top-down processes that support people's generation of autonoetic mental models. In this view and in keeping with Sweller's (2015, this volume) cognitive load theory, the learning of secondary knowledge is supported by the ability to explicitly represent information in working memory and then to use controlled problem solving for learning academic material. Reading provides an example of how this might work.

We assume that reading and writing systems initially emerged, culturally, from the motivation to socially communicate with and attempt to influence the behavior of other people, and if so, they should be built from folk psychological systems (Geary, 2008a; Mann, 1984; Rozin, 1976). Indeed, the core predictors of children's ease of learning to read indicate a strong dependence on language systems (e.g., Bradley & Bryant, 1983; Hindson et al., 2005; Mann, 1984; Stevens, Slavin, & Farnish, 1991; Wagner & Torgesen, 1987). Initially, the critical skills include phonemic awareness—explicit awareness of distinct language sounds—and the ability to decode unfamiliar written words into these basic sounds (e.g., *ba*, *da*). Decoding requires the explicit representation of the sound in phonemic short-term memory and the association of this sound and blends of sounds with letters (e.g., *b*, *d*) and letter combinations, respectively (Bradley & Bryant, 1983).

Individual differences in kindergartners' phonetic processing system (e.g., skill at discriminating similar sounding phonemes) predict the ease with which they learn basic word-decoding skills in first grade (Wagner, Torgesen, & Rashotte, 1994). Children who show a strong explicit awareness of basic language sounds are more skilled than are other children at associating these sounds with the symbol system of their written language. Unlike acquiring a natural language, the majority of children acquire these basic reading competencies most effectively with systematic, organized, and teacher-directed explicit instruction on phoneme identification, blending, and word decoding (e.g., Hindson et al., 2005; Stevens et al., 1991). Skilled reading also requires fluency and text comprehension. Fluency is the fast and automatic retrieval of word meanings as they are read, which is related in part to the frequency with which the word has been encountered or practiced in the past (Sereno & Rayner, 2003). Text comprehension requires an understanding of the meaning of the composition and is dependent, in part, on the ability to identify main themes in the text and distinguish highly relevant from less relevant passages. As with more basic reading skills, many children require explicit instruction in the use of these strategies to aid in text comprehension (Connor, Morrison, & Petrella, 2004; Stevens et al., 1991).

If social communication was the motivation for the development of written systems, then reading comprehension should also be dependent on theory of mind and other folk psychological domains, at least for genres that involve human relationships (Geary, 2010). Most of these stories involve the re-creation of social relationships, complex patterns of social dynamics, and even elaborate person schema knowledge for main characters, as is the focus of literary Darwinism (Carroll, 2011). The theme of many of the most popular genres involves the dynamics of mating relationships (e.g., romance novels) and competition for mates, and often involves use of autonoetic mental models to build social scenarios. One implication is that once people learn to read, they engage in this secondary activity because it allows for the representation of evolutionarily salient themes, particularly the mental representation and rehearsal of social dynamics. Folk biology and folk physics should also result in some people being interested in biological phenomena (e.g., the magazine *Natural History*) and mechanical things (e.g., the magazine *Popular Mechanics*).

The Creation of Culture

All of the academic activities that occur in modern research universities (politics aside) involve the creation of evolutionarily novel information, especially in engineering and the sciences. In fact, scholars of one kind or another have been building an unprecedented store of information and knowledge over the past few thousand years (Murray, 2003; Simonton, 2009). Murray's analysis revealed historical bursts of creative activity (e.g., the Renaissance) that tended to emerge in wealthier cultures with mores that supported individual freedom and that socially and financially rewarded creative expression. The exceptional accomplishments that have produced the modern world have been made by individuals situated in these cultures and who have a unique combination of traits; specifically, high fluid intelligence, creativity (e.g., ability to make remote associations), an extended period of preparation in which the basics of the domain are mastered, long work hours, advantages in certain folk domains, ambition, and sustained output of domain-related products, such as scientific publications (Ericsson, Krampe, & Tesch-Römer, 1993; Lubinski, 2004; Sternberg, 1999).

These components of accomplishment illustrate the interplay between folk knowledge, fluid intelligence, motivation, and the generation of secondary knowledge and illustrate why children's intuitive folk knowledge and learning biases are not sufficient for secondary learning. Modern physics is one of humanity's most significant accomplishments and yet is understood by only a very small fraction of humanity. One reason is that people's naïve understanding of physical phenomena is influenced by the biases that are aspects of folk physics, but differ from the scientific understanding of the same phenomena (McCloskey, 1983). When asked about the motion of a thrown ball, most people believe there is a force propelling it forward, something akin to an invisible engine, and another force propelling it downward. The downward force is gravity, but there is in fact no force propelling it forward, once the ball leaves the thrower's hand (Clement, 1982). The concept of a forward-force, called "impetus," is similar to pre-Newtonian beliefs about motion prominent in the fourteenth to sixteenth centuries. The idea is that the act of starting an object in motion creates an internal force (impetus) that keeps it in motion until this impetus gradually dissipates. Although adults and even preschool children often describe the correct trajectory for a thrown or moving object (e.g., Kaiser, McCloskey, & Proffitt, 1986), reflecting their implicit folk competencies, their explicit explanations reflect this naïve understanding of the forces acting upon the object.

Careful observation, use of the scientific method (secondary knowledge itself; Geary, 2012), and use of inductive and deductive reasoning are necessary to move from an intuitive folk understanding to scientific theory and knowledge. In his masterwork, the *Principia* (Newton, 1995, p. 13), Newton said as much: "I do not define time, space, place and motion, as being well known to all. Only I must observe, that the vulgar conceive those quantities under no other notions but from the relation they bear to sensible objects." The "vulgar" only understand physical phenomena in terms of folk knowledge and Newton went well beyond this. Newton corrected the pre-Newtonian beliefs about forces acting on objects, but still appears to have relied on other aspects of folk physical systems to complete this work. His conceptualization of objects in motion and the gravitational and rectilinear forces underlying the pattern of this motion were based on his ability to explicitly use visuospatial systems to construct geometric representations of motion and then to apply Euclidean geometry and formal logic to mathematically prove the scientific accuracy of these representations. The explicit and exacting use of formal logic is associated with high general fluid intelligence (Stanovich, 1999), as noted. Despite popular stories and an assumption of an "Aha" insight, Newton devoted an extended period of sustained effort and attention to this work and appears to have been obsessed with understanding physical phenomena (e.g., Berlinski, 2000; White, 1999).

The point is that Newton's efforts transformed the physical sciences and at the same time created a substantial gap between the scientific understanding of gravity and motion and folk beliefs about these same phenomena. The folk intuitions of the fourteenth century natural philosophers were no longer sufficient after Newton.

Fortunately, it is not necessary for students to reconstruct Newton's efforts; in fact, few could do so. But, it is necessary that they come to understand the basics of Newtonian physics. Cognitive and brain imaging studies indicate that giving up folk-physical intuitions and grasping Newton's insights about motion do not come easily, even for college students (Dunbar, Fugelsang, & Stein, 2007; Zimmerman, 2005). The same is true for the theory of evolution, the scientific method, and many other evolutionarily novel innovations and knowledge (Klahr & Li, 2005; Klahr & Nigam, 2004; Shtulman, 2006; Sinatra & Danielson, this volume).

Evolutionary Educational Psychology

The innovative contributions of Newton and others have altered the society and culture in which we live, including substantive increases in the need for formal education. To live successfully in the modern world, children must now acquire a wide range of evolutionarily novel knowledge. To make matters worse, the requisite knowledge is a moving target, because scientific and technological changes are accruing at an accelerated pace, as is the store of literature, poetry, plays, drama, and so forth. How then do we best prepare children to be successful in the modern world? Of course, the modern field of education is focused on this question, but has not been informed by an evolutionary understanding of cognitive development, nor considered the question of how folk abilities can be modified to create secondary competencies. Evolutionary educational psychology is an attempt to bridge evolutionary insights and educational science (Geary, 2007, 2008a). In the sections below, we outline the basic premises and principles of this approach.

Premises. Evolutionary educational psychology is the study of how educational interventions interact with children's folk abilities, biases, and motivations to create secondary abilities and knowledge. The first premise follows from our discussion of folk domains (Fig. 9.2); children have inherent but not fully developed attentional, perceptual, and cognitive systems that support their understanding of universal social, biological, and physical phenomena. The associated concepts and abilities support good enough functioning in traditional contexts, but is not the same as a scientific understanding of the same phenomena.

The second premise is based on the co-evolution of children's behavioral and cognitive development as related to the adaptation of folk domains to local conditions; specifically, children's self-initiated behavioral biases create the same types of experiences that led to the evolution of folk systems and provide the evolutionarily expectant experiences needed for the normal development of these competencies (Caporael, 1997; Greenough et al., 1987; Scarr, 1992). A critical point is that children's primary behavioral activities are directed toward those features of the social, biological, and physical worlds that were recurrent, though variable (e.g., in the facial features of different people), during human evolution, not information relevant to secondary learning. As Lancy (this volume) describes, children also attend to and imitate adults and more competent older children and in this way learn culture-specific knowledge and skills, such as cooking and hunting (e.g., Blurton Jones, Hawkes, & O'Connell, 1997). We have no doubt that children have an evolved motivation to acquire the skills needed to be successful in their culture, but note the gap between the skills needed to be successful in traditional cultures and those needed to integrate into a modern, developed economy. Observation of parental reading may pique children's interest in books, but playing with books does not result in the ability to phonetically decode written words in the same way that playing with a bow and arrow contributes to learning how to use this weapon (Gurven, Kaplan, & Gutierrez, 2006; Toub et al., this volume).

The third premise follows from the first two and the traits of innovators. It is almost certainly the case that these innovators engaged the cognitive systems that support autonoetic mental models—attentional control, working memory, fluid intelligence, explicit problem solving—during the generation of their insights and secondary knowledge. We do not see how it is possible for students to learn this same knowledge without explicitly engaging the same systems (Sweller, this volume).

Principles. Innovators generate new knowledge and technical advances by using fluid intelligence and other less well-understood processes (e.g., creativity) to modify and link together folk systems in novel ways. The useful advances are retained across generations through artifacts (e.g., books) and traditions (e.g., apprenticeships) and accumulate from one generation to the next. The first principle of evolutionary educational psychology is that the cross-generational accumulation of these advances has resulted in a more scientifically accurate understanding of the phenomena that are the foci of folk psychology, folk biology, and folk physics. Darwin's principles of natural selection and Newton's theory of gravity and motion resulted in a gap between people's folk biological and folk physical knowledge and these core principles of modern biology and physics (Clement, 1982; Sinatra & Danielson, this volume). In other words, there is now a substantial and growing gap between the folk knowledge and heuristics that were sufficient for day-to-day living during much of human evolution and the knowledge and competencies needed to function in the modern world.

The second principle is that schools themselves are cultural innovations. They are not found in traditional societies (Lancy, this volume), and only emerged in societies in which scientific and cultural advances created gaps between folk knowledge and the competencies needed to be successful in these societies. In this view, the function of schools is to organize the activities of children, so they can acquire the secondary competencies needed to close the gap between folk abilities and the knowledge needed to be successful in the modern world. The third principle is that secondary competencies are built from primary folk systems, but, unlike the fast implicit learning that adapts folk systems to local conditions, most secondary learning will require the effortful engagement of working memory, explicit problem solving, and fluid intelligence to modify primary systems. As we describe in the next section and as noted by Bjorklund and Beers (this volume) and Toub et al. (this volume), this does not mean that children cannot learn some secondary skills through engagement in primary activities, but we suspect there are limitations to this approach (Gray, this volume, provides a counter argument). Fourth, children's inherent motivational bias to engage in activities that will adapt folk knowledge to local conditions will often conflict with the need to engage in activities that will result in secondary learning. We would then expect the average adolescent to be more interested in peer relationships than high school algebra.

Implications for Research on Instructional Interventions

For the most part, the premises and principles of evolutionary educational psychology are concerned with characterizing the evolved cognitive and motivational biases that may interfere with the acquisition of secondary knowledge and the implications of these dispositions for designing effective instructional methods to enhance secondary learning (see also Sinatra & Danielson, this volume; Sweller, this volume). As Geary (2008a) has previously pointed out, evolutionary educational psychology is not ready for translation into school curricula, although as Sweller notes (2015, this volume) the framework does help to explain many previously documented instructional effects. More generally, "it provides a theoretical foundation for (a) conceptualizing children's learning in school and their motivation to engage in this learning, (b) generating empirically testable hypotheses about learning and motivation, and (c) *discussing implications for understanding and ultimately improving educational outcomes*" (Authors' emphasis; Geary, 2008a, p. 179). In this section, we move beyond a discussion of educational implications by proposing an evolutionarily informed pedagogical framework for generating explicit hypotheses concerning the types of instruction that would most likely improve the acquisition of secondary knowledge, taking into account: (a) the degree to which the secondary information is evolutionarily novel; (b) the species-typicality of the contexts and settings (physical and social) in which these skills are to be learned; and (c) individual differences in various cognitive competencies, motivational dispositions, personality traits, and demographic characteristics that could potentially moderate the effectiveness of any given instructional approach.

Which Is Better: Explicit Formal Instruction or Discovery Learning?

The relative effectiveness of different instructional strategies has been hotly debated in both the academic educational literature and the popular press and touched upon by many of the chapters in this volume (Bjorklund & Beers, this volume; Gray, this volume; Lancy, this volume; Sweller, this volume; Toub et al., this volume). Not infrequently, two opposing types of methods are pitted against one another, as exemplified by the paradigmatic case of whether direct or explicit instruction leads to better learning than unstructured discovery learning (cf. Kirschner, Sweller, & Clark, 2006). Berch (2007) has discussed the limitations of taking such a binary approach to these matters, as originally outlined by Newell (1973), who argued that this is a poor model for doing science. Berch concluded that a more productive approach would be to examine the conditions under which specific types of instructional methods are most effective in facilitating the learning of various types of secondary knowledge for children of differing ages and abilities.

Additionally, Berch (2007) discussed some interesting comments made by David Klahr subsequent to his earlier and highly controversial report demonstrating the unequivocal superiority of explicit instruction over discovery learning with respect to children's understanding of control variables in carrying out experimental manipulations (CVS) (Klahr & Nigam, 2004). Namely, Klahr acknowledged that based on a series of such studies he and his colleagues had conducted, the best they could say was that their "*particular specification* of learning via explicit instruction worked better than an *extreme form* of learning via discovery for learning CVS" (Authors' emphasis, p. 234). They concluded that "[we] certainly do not know if our CVS instruction is the 'best way' to teach CVS, or if Direct Instruction is the best way to teach *all* process skills" (Klahr & Li, 2005, p. 234). Similarly, Geary (2008b) has previously concluded that "It is unlikely that teacher-directed, peer-assisted, or self-discovery alone will be the most effective way to learn secondary academic material" (p. 224), and that "only empirical studies will allow us to determine the best mix of methods for different academic domains and for different children" (p. 224). Although this assertion is most certainly true, a more comprehensive evolutionary educational psychology should be able to offer a theoretical framework from which explicit, testable hypotheses can be generated to guide the design of such empirical studies.

Elsewhere, Geary (2008a) has argued that the mechanisms he has previously outlined (Geary, 2005, 2007) "provide a means for generating empirically testable hypotheses about children's academic motivation and their ease of learning in school, *as well as equally important hypotheses about the effectiveness of alternative instructional methods*" (Authors' emphasis, p. 192). In the next section, we elaborate on how these ideas can contribute to the formation of testable instructional hypotheses (see also Sweller, 2015, this volume).

Toward an Evolutionarily Informed Pedagogical Framework

Figure 9.5 illustrates what we refer to as an evolutionarily informed pedagogical framework. As can be observed, there are three axes: (a) The *x*-axis is the Degree of Systematic Instruction (DSI), ranging from Low to High, with the lowest form being unstructured or child-centered and the highest being teach-directed, explicit instruction; (b) the *y*-axis is the Classroom Context (CC) reflecting the physical and social setting along with the goal-related orientation, ranging from species-typical, real-world problem solving (e.g., how to equally share limited acquired resources with playmates) (Shaw, this volume) to species-atypical learning for its own sake (e.g., reading popular novels) (Bjorklund & Bering, 2002); and c) the *z*-axis is the

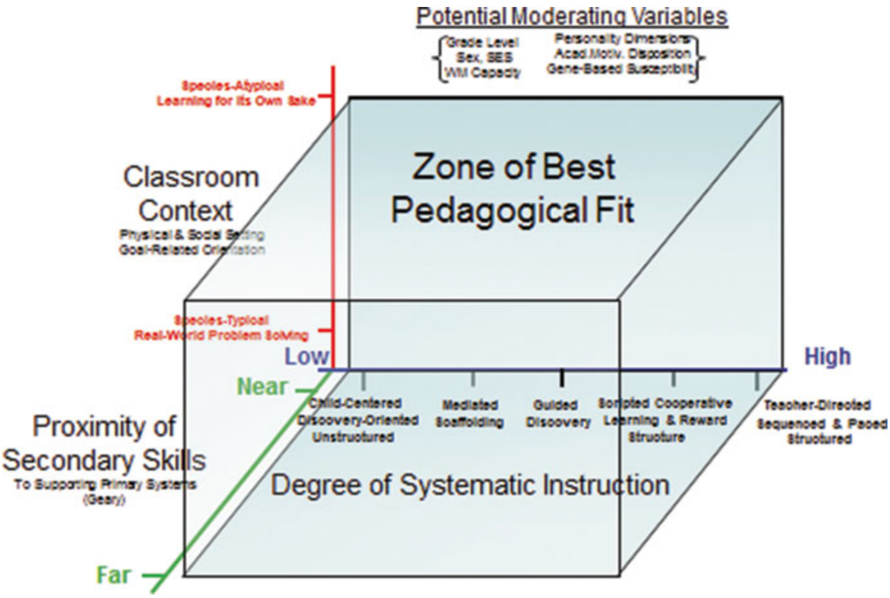

Fig. 9.5 Toward an evolutionarily informed pedagogical framework (after Berch, 2008)

Proximity of Secondary Skills (PSS) to supporting primary systems, ranging from near (e.g., language and reading) to far (e.g., folk biology and natural selection). Finally, a number of variables are proposed as factors that will moderate the effects of the DSI, CC, and PSS, including grade level, sex, and working memory capacity, among others.

Taken together, this framework can be used to generate testable hypotheses concerning what we refer to as the "Zone of Best Pedagogical Fit." In other words, when considering a test of the type of instruction that might be most effective for improving learning, one should simultaneously consider the nature of the CC, the PSS, and the multiple factors that could potentially moderate the value of its impact. For example, following the pedagogical framework outlined above, *we have suggested that structured, explicit, teacher-directed instruction should be most effective when acquiring secondary skills that are remote from supporting primary systems and that take place in a species atypical, classroom context where the goal is oriented toward acquiring knowledge for its own sake*. Note, however, that this framework is not prescriptive; rather, it offers researchers a detailed, systematic, and multidimensional tool that permits both the generation of specific hypotheses for empirical testing and a way of organizing and consolidating the outcomes of such studies to arrive at judgments concerning the Zone of Best Pedagogical Fit.

Among other questions that arise from this framework is the degree to which the various potential moderating variables influence the effectiveness of any given instructional method, either alone or in combination with others. For example, if high working memory capacity is needed for use of a relatively unstructured technique (e.g., guided discovery) to learn abstract information that is remote from its supporting primary systems, its effectiveness is very likely to be different for students with lower than higher working memory capacity. Another example would be Gray's (2013; this volume) assertion that children learn best in mixed-age settings. In a sense, he considers this a more "species-typical setting" than contemporary, age-graded classrooms. Yet the extent to which this hypothesis would hold true is highly likely to depend on: (a) the remoteness of the to-be-acquired secondary content from supporting primary systems; (b) the extent to which the principal instructional methods employed are more or less structured or explicit; and (c) the variability of the students' personality traits, cognitive capacities, motivational dispositions, or other potential moderating factors. To the best of our knowledge, no empirical studies testing these ideas have been published in a refereed journal.

As another example, there has been a major push in mathematics education for students to learn to solve "real-world" mathematics problems concerning everyday objects and settings in order to motivate them to learn abstract concepts and symbols. On the one hand, it could be argued that trying to concretize abstract concepts may reduce the remoteness of the secondary knowledge to be acquired (i.e., abstract symbols), thereby helping engage students' supporting primary systems; but even if true, there is evidence that learning from concrete examples as compared with abstract symbols can limit transferring knowledge to new problems (Kaminski, Sloutsky, & Heckler, 2006, 2008). On the other hand, use of real-world problems may stimulate students' interest in learning abstract mathematics if the problem-solving contexts evoke children's evolved motivational biases to engage in activities such as socializing with peers or intergroup competition. In other words, even a mathematics problem about a real-world context such as sports should be more likely to arouse motivational biases if it concerns using to-be-acquired computational skills for determining the likelihood of a baseball team beating their arch rival than just calculating the square footage of a major league stadium's outfield. To the best of our knowledge, no published studies have been carried out comparing the motivational effectiveness of employing real-world problem-solving contexts that differ not by the degree of authenticity of the real-world contexts themselves, but rather by evolutionarily informed differences in the extent to which these contexts evoke evolved motivational biases.

In sum, the framework we present here permits us to add a number of postulates to the premises and principles of evolutionary educational psychology described earlier. These are shown in Table 9.1 and should be useful in moving the field toward theoretically informed empirical studies (see also Sweller, this volume; Toub et al., this volume).

Conclusion

Humans have the extraordinary ability to create knowledge-based culture supported by shared beliefs (e.g., of the groups' origins) and rules for social behavior that in turn enables the formation of large cooperative groups (Baumeister, 2005;

Table 9.1 Postulates of evolutionary educational psychology

1.	The effectiveness of specific forms of instructional methods will be dependent on: a) the proximity of the secondary skills to their supporting primary systems, b) the classroom context (i.e., the physical and social setting, and the goal orientation), and c) the moderating influences of various developmental (e.g., grade level), demographic (e.g., SES), and individual differences factors (e.g., working memory capacity, academic motivational disposition, personality traits)
2.	The effectiveness of adopting more or less unstructured (i.e., informal, child-centered, discovery-oriented) approaches for improving the learning of secondary knowledge will be a direct function of: (a) the proximity of the to-be-acquired content to its supporting, primary folk domains (other things being equal) (b) the extent to which the physical and social setting of the classroom context is species-typical (c) the degree to which the problem-solving goal is real-world oriented as contrasted with learning for its own sake
3.	The potential advantage of employing real-world contexts for learning secondary, abstract knowledge will be a direct function of the degree to which they evoke evolved motivational biases

Richerson & Boyd, 2005). It is almost certain that children and adults have corresponding learning and motivational mechanisms that support the cross-generational transfer of these beliefs and other culturally useful knowledge. These mechanisms include child-initiated play, observational learning, and adults' use of stories to convey cultural knowledge to children (Lancy, this volume). Over the past several millennia, however, groups have increased substantially in size and economic diversification and some individuals within these groups have discovered better ways of producing food (e.g., agriculture crops), conducting commerce (e.g., monetary systems), and understanding the natural world (i.e., science). These advances have provided many benefits, but many of them have outpaced evolution's ability to adapt cognitive and motivational systems such that children easily learn the associated competencies. In other words, cultural innovations and brain and cognitive evolution are out of sync, creating a gap between what we are motivated to learn and what we easily learn and the competencies needed to live well in the modern world.

Schools are one of these innovations; schools do not exist in traditional societies where day-to-day living does not require reading, writing, or arithmetic (Lancy, this volume). Within the modern world, these are now considered rudimentary competencies, and we expect all children, not just the elite, to acquire them. The goal of universal schooling is very recent (<200 years), with respect to evolutionary time and it is very unlikely that humans have the same cognitive and motivational biases to support learning to read, write, and do arithmetic in the same way they have biases that allow them to form and maintain social relationships (i.e., folk psychology). Yet, learning the three *R*s must be based on the ability to adapt folk systems for acquiring these evolutionarily novel abilities.

Evolutionary educational psychology is the study of how children's evolved cognitive, learning, and motivational biases influence their ability and motivation to learn novel academic abilities and knowledge in school. As illustrated by the diversity of opinion across the chapters of this volume, the best approach for melding evolved biases with educational goals is vigorously debated. At the same time, all of the authors in this volume agree that there is a value-added to framing educational goals (among others) within an evolutionary context, and most importantly, they provide direction for future empirical studies. The ultimate, so to speak, benefit of this approach will be in its ability to generate testable hypotheses about instructional approaches and based on these improve the educational outcomes of all children. In other words, evolutionary educational psychology will flourish or flounder based on its contributions to our ability to meet the goals of a universal education.

References

Abrams, D., & Hogg, M. A. (Eds.). (1990). *Social identity theory: Constructive and critical advances*. New York, NY: Springer.

Adolphs, R. (2003). Cognitive neuroscience of human social behaviour. *Nature Reviews Neuroscience, 4*, 165–178.

Alexander, R. D. (1989). Evolution of the human psyche. In P. Mellars & C. Stringer (Eds.), *The human revolution: Behavioural and biological perspectives on the origins of modern humans* (pp. 455–513). Princeton, NJ: Princeton University Press.

Alexander, R. D. (1990). *How did humans evolve? Reflections on the uniquely unique species.* Museum of Zoology (Special Publication No. 1, pp. 1–38). Ann Arbor: The University of Michigan.

Ash, J., & Gallup, G. G., Jr. (2007). Paleoclimatic variation and brain expansion during human evolution. *Human Nature, 18*, 109–124.

Atran, S. (1994). Core domains versus scientific theories: Evidence from systematics and Itza-Maya folkbiology. In L. A. Hirschfeld & S. A. Gelman (Eds.), *Mapping the mind: Domain specificity in cognition and culture* (pp. 316–340). New York, NY: Cambridge University Press.

Atran, S. (1998). Folk biology and the anthropology of science: Cognitive universals and cultural particulars. *Behavioral and Brain Sciences, 21*, 547–609.

Bailenson, J. N., Shum, M. S., Atran, S., Medin, D. L., & Coley, J. D. (2002). A bird's eye view: Biological categorization and reasoning within and across cultures. *Cognition, 84*, 1–53.

Bailey, D. H., & Geary, D. C. (2009). Hominid brain evolution: Testing climatic, ecological, and social competition models. *Human Nature, 20*, 67–79.

Bandura, A. (1997). *Self-Efficacy: The Exercise of Control*. San Francisco, CA: Freeman.

Baron-Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind*. Cambridge, MA: MIT Press/Bradford Books.

Barton, R. A., & Dean, P. (1993). Comparative evidence indicating neural specialization for predatory behaviour in mammals. *Proceedings of the Royal Society of London B, 254*, 63–68.

Baumeister, R. F. (2005). *The cultural animal: Human nature, meaning, and social life*. New York, NY: Oxford University Press.

Berch, D. B. (2007). Instructing evolved minds: Pedagogically primary strategies for promoting biologically secondary learning. In J. S. Carlson & J. R. Levin (Eds.), *Educating the evolved mind* (Psychological perspectives on contemporary educational issues, Vol. 2, pp. 109–118). Greenwich, CT: Information Age.

Berch, D. B. (2008, November). *The emerging field of "evo-edu": Questions, challenges, constraints, and caveats*. Presented at the Evolution Institute Workshop on Early Childhood Education, Miami, FL.

Berlin, B., Breedlove, D. E., & Raven, P. H. (1966). Folk taxonomies and biological classification. *Science, 154*, 273–275.

Berlin, B., Breedlove, D. E., & Raven, P. H. (1973). General principles of classification and nomenclature in folk biology. *American Anthropologist, 75*, 214–242.

Berlinski, D. (2000). *Newton's gift*. New York, NY: Touchstone.

Bjorklund, D. F., & Bering, J. M. (2002). The evolved child: Applying evolutionary developmental psychology to modern schooling. *Learning and Individual Differences, 12*, 347–373.

Bjorklund, D. F., & Ellis, B. J. (2014). Children, childhood, and development in evolutionary perspective. *Developmental Review, 34*, 225–264.

Bjorklund, D. F., & Pellegrini, A. D. (2002). *The origins of human nature: Evolutionary developmental psychology*. Washington, DC: American Psychological Association.

Bloom, P. (1996). Intention, history, and artifact concepts. *Cognition, 60*, 1–29.

Blurton Jones, N. G., Hawkes, K., & O'Connell, J. F. (1997). Why do Hadza children forage? In N. L. Segal, G. E. Weisfeld, & C. C. Weisfeld (Eds.), *Uniting psychology and biology: Integrative perspectives on human development* (pp. 279–313). Washington, DC: American Psychological Association.

Bogin, B. (1999). *Patterns of human growth* (2nd ed.). Cambridge, England: Cambridge University Press.

Bradley, L., & Bryant, P. E. (1983). Categorizing sounds and learning to read—A causal connection. *Nature, 301*, 419–421.

Brothers, L., & Ring, B. (1992). A neuroethological framework for the representation of minds. *Journal of Cognitive Neuroscience, 4*, 107–118.

Bugental, D. B. (2000). Acquisition of the algorithms of social life: A domain-based approach. *Psychological Bulletin, 126*, 187–219.

Burghardt, G. M. (2005). *The genesis of animal play: Testing the limits*. Cambridge, MA: Bradford/MIT Press.

Butler, D., & Suddendorf, T. (2014). Reducing the neural search space for hominid cognition: What distinguishes human and great ape brains from those of small apes? *Psychonomic Bulletin & Review, 21*, 590–619.

Byrne, P., Becker, S., & Burgess, N. (2007). Remembering the past and imagining the future: A neural model of spatial memory and imagery. *Psychological Review, 114*, 340–375.

Caporael, L. R. (1997). The evolution of truly social cognition: The core configurations model. *Personality and Social Psychology Review, 1*, 276–298.

Caramazza, A., & Shelton, J. R. (1998). Domain-specific knowledge systems in the brain: The animate-inanimate distinction. *Journal of Cognitive Neuroscience, 10*, 1–34.

Carey, S. (2009). *The origin of concepts*. New York, NJ: Oxford University Press.

Carroll, J. (2011). *Reading human nature: Literary Darwinism in theory and practice*. Albany, NY: SUNY Press.

Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of Educational Psychology, 54*, 1–22.

Clement, J. (1982). Students' preconceptions in introductory mechanics. *American Journal of Physics, 50*, 66–71.

Connor, C. M., Morrison, F. J., & Petrella, J. N. (2004). Effective reading comprehension instruction: Examining child X instruction interactions. *Journal of Educational Psychology, 96*, 682–698.

Cosmides, L. (1989). The logic of social exchange: Has natural selection shaped how humans reason? Studies with the Wason selection task. *Cognition, 31*, 187–276.

Damasio, A. (2003). *Looking for Spinoza: Joy, sorrow, and the feeling brain*. Orlando, FL: Harcourt.

Darwin, C. R. (1845). *Journal of researches into the natural history and geology of the countries visited during the voyage of H.M.S. Beagle round the world, under the Command of Capt. Fitz Roy, R.N* (2nd ed.). London, England: John Murray.

Darwin, C. (1859). *The origin of species by means of natural selection*. London, England: John Murray.

Dunbar, R. I. M. (1998). The social brain hypothesis. *Evolutionary Anthropology, 6*, 178–190.

Dunbar, K., Fugelsang, J., & Stein, C. (2007). Do naïve theories ever go away? In M. Lovett & P. Shah (Eds.), *Thinking with Data: 33rd Carnegie Symposium on Cognition* (pp. 193–205). Mahwah, NJ: Erlbaum.

Dyer, F. C. (1998). Cognitive ecology of navigation. In R. Dukas (Ed.), *Cognitive ecology: The evolutionary ecology of information processing and decision making* (pp. 201–260). Chicago, IL: University of Chicago Press.

Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100*, 363–406.

Evans, J. S. B. T. (2002). Logic and human reasoning: An assessment of the deduction paradigm. *Psychological Bulletin, 128*, 978–996.

Feigenson, L., Dehaene, S., & Spelke, E. S. (2004). Core systems of number. *Trends in Cognitive Sciences, 8*, 307–314.

Figueiredo, G. M., Leitão-Filho, H. F., & Begossi, A. (1993). Ethnobotany of Atlantic forest coastal communities: Diversity of plant used in Gamboa. *Human Ecology, 21*, 419–430.

Figueiredo, G. M., Leitão-Filho, H. F., & Begossi, A. (1997). Ethnobotany of Atlantic forest coastal communities: II. Diversity of plant uses at Sepetiba Bay (SE Brazil). *Human Ecology, 25*, 353–360.

Fiske, S. T. (2002). What we know now about bias and intergroup conflict, the problem of the century. *Current Directions in Psychological Science, 11*, 123–128.

Fiske, S. T., & Taylor, S. E. (1991). *Social cognition* (2nd ed.). New York, NY: McGraw-Hill.

Flinn, M. V., Geary, D. C., & Ward, C. V. (2005). Ecological dominance, social competition, and coalitionary arms races: Why humans evolved extraordinary intelligence. *Evolution and Human Behavior, 26*, 10–46.

Freedman, D. G. (1974). *Human infancy: An evolutionary perspective*. New York, NY: Wiley.

Gallistel, C. R. (1990). *The organization of learning*. Cambridge, MA: MIT Press/Bradford Books.

Garlick, D. (2002). Understanding the nature of the general factor of intelligence: The role of individual differences in neural plasticity as an explanatory mechanism. *Psychological Review, 109*, 116–136.

Geary, D. C. (1995). Reflections of evolution and culture in children's cognition: Implications for mathematical development and instruction. *American Psychologist, 50*, 24–37.

Geary, D. C. (2004). Evolution and cognitive development. In R. Burgess & K. MacDonald (Eds.), *Evolutionary perspectives on human development* (pp. 99–133). Thousand Oaks, CA: Sage.

Geary, D. C. (2005). *The origin of mind: Evolution of brain, cognition, and general intelligence*. Washington, DC: American Psychological Association.

Geary, D. C. (2007). Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology. In J. S. Carlson & J. R. Levin (Eds.), *Educating the evolved mind* (Psychological perspectives on contemporary educational issues, Vol. 2, pp. 1–99). Greenwich, CT: Information Age.

Geary, D. C. (2008a). An evolutionarily informed education science. *Educational Psychologist, 43*, 279–295.

Geary, D. C. (2008b). Whither evolutionarily educational psychology? *Educational Psychologist, 43*, 217–226.

Geary, D. C. (2010). *Male, female: The evolution of human sex differences* (2nd ed.). Washington, DC: American Psychological Association.

Geary, D. C. (2012). The evolved mind and scientific discovery. In J. Shrager & S. M. Carver (Eds.), *From child to scientist: Mechanisms of learning and development* (pp. 87–115). Washington, DC: American Psychological Association.

Geary, D. C., Berch, D. B., & Mann Koepke, K. (Eds.). (2015). *Evolutionary origins and early development of number processing* (Mathematical cognition and learning, Vol. 1). San Diego, CA: Elsevier Academic Press.

Geary, D. C., & Bjorklund, D. F. (2000). Evolutionary developmental psychology. *Child Development, 71*, 57–65.

Geary, D. C., & Huffman, K. J. (2002). Brain and cognitive evolution: Forms of modularity and functions of mind. *Psychological Bulletin, 128*, 667–698.

Gelman, R. (1990). First principles organize attention to and learning about relevant data: Number and animate-inanimate distinction as examples. *Cognitive Science, 14*, 79–106.

Gelman, S. A. (2003). *The essential child: Origins of essentialism in everyday thought*. New York, NY: Oxford University Press.

Gelman, R., & Williams, E. M. (1998). Enabling constraints for cognitive development and learning: Domain-specificity and epigenesis. In D. Kuhl & R. S. Siegler (Vol. Eds.), *Cognition, perception, and language, Vol. 2* (pp. 575–630). W. Damon (Gen. Ed.), *Handbook of child psychology* (5th Ed.). New York, NY: Wiley.

Gigerenzer, G., Todd, P. M., & ABC Research Group (Eds.). (1999). *Simple heuristics that make us smart*. New York, NY: Oxford University Press.

Gopnik, A., & Wellman, H. M. (2012). Reconstructing constructivism: Causal models, Bayesian learning mechanisms, and the theory theory. *Psychological Bulletin, 138*, 1085–1108.

Grant, P. R. (1999). *Ecology and evolution of Darwin's finches*. Princeton, NJ: Princeton University Press.

Gray, P. (2013). *Free to learn: Why unleashing the instinct to play will make our children happier, more self-reliant, and better students for life*. New York, NY: Basic Books.

Greenough, W. T., Black, J. E., & Wallace, C. S. (1987). Experience and brain development. *Child Development, 58*, 539–559.

Gurven, M., Kaplan, H., & Gutierrez, M. (2006). How long does it take to become a proficient hunter? Implications for the evolution of extended development and long life span. *Journal of Human Evolution, 51*, 454–470.

Hamilton, W. D. (1964). The genetical evolution of social behaviour. II. *Journal of Theoretical Biology, 7*, 17–52.

Harter, S. (2006). The self. In N. Eisenberg (Vol. Ed.), *Social, emotional, and personality development, Vol.* 3 (pp. 505–570). W. Damon & R. M. Lerner (Gen. Eds.), *Handbook of child psychology* (6th Ed.). New York, NY: Wiley.

Heckhausen, J., & Schulz, R. (1995). A life-span theory of control. *Psychological Review, 102*, 284–304.

Hewstone, M., Rubin, M., & Willis, H. (2002). Intergroup bias. *Annual Review of Psychology, 53*, 575–604.

Hindson, B., Byrne, B., Shankweiler, D., Fielding-Barnsley, R., Newman, C., & Hine, D. W. (2005). Assessment and early instruction of preschool children at risk for reading disability. *Journal of Educational Psychology, 97*, 687–704.

Horowitz, D. L. (2001). *The deadly ethnic riot*. Berkeley, CA: University of California Press.

Huffman, K. J., Nelson, J., Clarey, J., & Krubitzer, L. (1999). Organization of somatosensory cortex in three species of marsupials, *Dasyurus hallucatus, Dactylopsila trivirgata*, and *Monodelphis domestica*: Neural correlates of morphological specializations. *Journal of Comparative Neurology, 403*, 5–32.

Humphrey, N. K. (1976). The social function of intellect. In P. P. G. Bateson & R. A. Hinde (Eds.), *Growing points in ethology* (pp. 303–317). New York, NY: Cambridge University Press.

Johnson-Frey, S. H. (2003). What's so special about human tool use? *Neuron, 39*, 201–204.

Johnson-Laird, P. N. (1983). *Mental models*. Cambridge, England: Cambridge University Press.

Kahneman, D., & Tversky, A. (1982). The simulation heuristic. In D. Kahneman, P. Slovic, & A. Tversky (Eds.), *Judgment uncertainty: Heuristics and biases* (pp. 201–208). Cambridge, England: Cambridge University Press.

Kaiser, M. K., McCloskey, M., & Proffitt, D. R. (1986). Development of intuitive theories of motion: Curvilinear motion in the absence of external forces. *Developmental Psychology, 22*, 67–71.

Kaminski, V. M., Sloutsky, V. M., & Heckler, A. F. (2006). Do children need concrete instantiations to learn an abstract concept? In R. Sun & N. Miyake (Eds), Proceedings of the 27th Annual Conference of the Cognitive Science Society (pp. 411–416). Mahwah, NJ: Lawrence Erlbaum.

Kaminski, J. A., Sloutsky, V. M., & Heckler, A. F. (2008). The advantage of abstract examples in learning math. *Science, 230*, 454–455.

Kaplan, H., Hill, K., Lancaster, J., & Hurtado, A. M. (2000). A theory of human life history evolution: Diet, intelligence, and longevity. *Evolutionary Anthropology, 9*, 156–185.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*, 75–86.

Kisilevsky, B. S., Hains, S. M. J., Lee, K., Xie, X., Huang, H., Ye, H. H., … Wang, Z. (2003). Effects of experience on fetal voice recognition. *Psychological Science, 14*, 220–224

Klahr, D., & Li, J. (2005). Cognitive research and elementary science instruction: From the laboratory, to the classroom, and back. *Journal of Science Education and Technology, 14*, 217–238.

Klahr, D., & Nigam, M. (2004). The equivalence of learning paths in early science instruction: Effects of direct instruction and discovery learning. *Psychological Science, 15*, 661–667.

Kuhlmeier, V. A., & Boysen, S. T. (2002). Chimpanzees (*Pan troglodytes*) recognize spatial and object correspondences between a scale model and its referent. *Psychological Science, 13*, 60–63.

Leslie, A. M. (1987). Pretense and representation: The origins of "theory of mind". *Psychological Review, 94*, 412–426.

Leslie, A. M., Friedman, O., & German, T. P. (2004). Core mechanisms in "theory of mind". *Trends in Cognitive Sciences, 8*, 528–533.

Lockman, J. J. (2000). A perception-action perspective on tool use development. *Child Development, 71*, 137–144.

Lubinski, D. (2004). Introduction to the special section on cognitive abilities: 100 years after Spearman's (1904) "'general intelligence', objectively determined and measured". *Journal of Personality and Social Psychology, 86*, 96–111.

Macfarlan, S. J., Walker, R. S., Flinn, M. V., & Chagnon, N. A. (2014). Lethal coalitionary aggression and long-term alliance formation among Yanomamö men. *Proceedings of the National Academy of Sciences USA, 111*, 16662–16669.

Maguire, E. A., Burgess, N., Donnett, J. G., Frackowiak, R. S. J., Frith, C. D., & O'Keefe, J. (1998). Knowing where and getting there: A human navigational network. *Science, 280*, 921–924.

Malt, B. C. (1995). Category coherence in cross-cultural perspective. *Cognitive Psychology, 29*, 85–148.

Mann, V. A. (1984). Reading skill and language skill. *Developmental Review, 4*, 1–15.

Markus, H. (1977). Self-schemata and processing information about the self. *Journal of Personality and Social Psychology, 35*, 63–78.

McCloskey, M. (1983). Intuitive physics. *Scientific American, 248*, 122–130.

Meck, W. H., & Church, R. M. (1983). A mode control model of counting and timing processes. *Journal of Experimental Psychology: Animal Behavior Processes, 9*, 320–334.

Medin, D. L., & Atran, S. (1999). *Folkbiology*. Cambridge, MA: MIT Press.

Medin, D. L., & Atran, S. (2004). The native mind: Biological categorization and reasoning in development and across cultures. *Psychological Review, 111*, 960–983.

Medin, D. L., Ross, N. O., Atran, S., Cox, D., Coley, J., Proffitt, J. B., & Blok, S. (2006). Folkbiology of freshwater fish. *Cognition, 99*, 237–273.

Milner, A. D., & Goodale, M. A. (1995). *The visual brain in action*. New York, NY: Oxford University Press.

Mithen, S. (1996). *The prehistory of the mind: The cognitive origins of art and science*. New York, NY: Thames and Hudson.

Murdock, G. P. (1981). *Atlas of world cultures*. Pittsburgh, PA: University of Pittsburgh Press.

Murray, C. (2003). *Human accomplishment: The pursuit of excellence in the arts and sciences, 800 B.C. to 1950*. New York, NJ: HarperCollins.

Newcombe, N. S. (2011). What is neoconstructivism? *Child Development Perspectives, 5*, 157–160.

Newell, A. (1973). You can't play 20 questions with nature and win: Projective comments on papers of this symposium. In W. G. Chase (Ed.), *Visual information processing* (pp. 283–308). New York, NY: Academic.

Newell, A., & Simon, H. A. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice-Hall.

Newton, I. (1995). *The principia*. Amherst, NY: Prometheus Books. [Translated by A. Motte]. (Original work published in 1687).

O'Keefe, J., & Nadel, L. (1978). *The hippocampus as a cognitive map*. New York, NY: Oxford University Press.

Oaksford, M., & Chater, N. (1998). *Rationality in an uncertain world: Essays on the cognitive science of human reasoning*. East Sussex, England: Psychology Press.

Paivio, A. (2007). *Mind and its evolution: A dual coding theoretical approach*. Mahwah, NJ: Erlbaum.

Pinker, S. (1994). *The language instinct*. New York, NY: William Morrow.

Potts, R. (1998). Variability selection in hominid evolution. *Evolutionary Anthropology, 7*, 81–96.

Povinelli, D. J. (2000). *Folk physics for apes: The chimpanzees theory of how the world works*. New York, NY: Oxford University Press.

Richerson, P. J., & Boyd, R. (2005). *Not by genes alone: How culture transformed human evolution*. Chicago, IL: University of Chicago Press.

Rozin, P. (1976). The evolution of intelligence and access to the cognitive unconscious. In J. M. Sprague & A. N. Epstein (Eds.), *Progress in psychobiology and physiological psychology* (Vol. 6, pp. 245–280). New York, NY: Academic.

Scarr, S. (1992). Developmental theories of the 1990s: Developmental and individual differences. *Child Development, 63*, 1–19.

Schneider, D. J. (1973). Implicit personality theory: A review. *Psychological Bulletin, 79*, 294–309.

Schyns, P. G., Bonnar, L., & Gosselin, F. (2002). Show me the features! Understanding recognition from the use of visual information. *Psychological Science, 13*, 402–409.

Sereno, S. C., & Rayner, K. (2003). Measuring word recognition in reading: Eye movements and event-related potentials. *Trends in Cognitive Sciences, 7*, 489–493.

Setoh, P., Wu, D., Baillargeon, R., & Gelman, R. (2013). Young infants have biological expectations about animals. *Proceedings of the National Academy of Sciences USA, 110*, 15937–15942.

Shepard, R. N. (1994). Perceptual-cognitive universals as reflections of the world. *Psychonomic Bulletin & Review, 1*, 2–28.

Shtulman, A. (2006). Qualitative differences between naïve and scientific theories of evolution. *Cognitive Psychology, 52*, 170–194.

Simon, H. A. (1956). Rational choice and the structure of the environment. *Psychological Review, 63*, 129–138.

Simonton, D. K. (2009). Varieties of (scientific) creativity: A hierarchical model of domain-specific disposition, development, and achievement. *Perspectives on Psychological Science, 4*, 441–452.

Spelke, E. S., Breinlinger, K., Macomber, J., & Jacobson, K. (1992). Origins of knowledge. *Psychological Review, 99*, 605–632.

Spelke, E. S., & Kinzler, K. D. (2007). Core knowledge. *Developmental Science, 10*, 89–96.

Spelke, E. S., & Kinzler, K. D. (2009). Innateness, learning, and rationality. *Child Development Perspectives, 3*, 96–98.

Spencer, J. P., Blumberg, M. S., McMurray, B., Robinson, S. R., Samuelson, L. K., & Tomblin, J. B. (2009). Short arms and talking eggs: Why we should no longer abide the nativist-empiricist debate. *Child Development Perspectives, 3*, 79–87.

Sporns, O., Tononi, G., & Edelman, G. M. (2000). Connectivity and complexity: The relationship between neuroanatomy and brain dynamics. *Neural Networks, 13*, 909–922.

Stanovich, K. E. (1999). *Who is rational? Studies of individual differences in reasoning*. Mahwah, NJ: Erlbaum.

Stanovich, K. E., & West, R. F. (2000). Individual differences in reasoning: Implications for the rationality debate? *Behavioral and Brain Sciences, 23*, 645–726.

Stanovich, K. E., & West, R. F. (2008). On the relative independence of thinking biases and cognitive ability. *Journal of Personality and Social Psychology, 94*, 672–695.

Sternberg, R. J. (Ed.). (1999). *Handbook of creativity*. Cambridge, England: Cambridge University Press.

Stevens, R. J., Slavin, R. E., & Farnish, A. M. (1991). The effects of cooperative learning and direct instruction in reading comprehension strategies on mean idea identification. *Journal of Educational Psychology, 83*, 8–16.

Suddendorf, T., & Corballis, M. C. (1997). Mental time travel and the evolution of the human mind. *Genetic, Social, and General Psychology Monographs, 123*, 133–167.

Sweller, J. (2012). Human cognitive architecture: Why some instructional procedures work and others do not. In K. R. Harris, S. Graham, & T. Urdan (Eds.), *Educational psychology handbook* (Theories, constructs, and critical issues, Vol. 1, pp. 295–325). Washington, DC: American Psychological Association.

Sweller, J. (2015). In academe, what is learned, and how is it learned? *Current Directions in Psychological Science, 24*, 190–194.

Tinbergen, N. (1963). On aims and methods of ethology. *Zeitschrift für Tierpsychologie, 20*, 410–433.

Tulving, E. (2002). Episodic memory: From mind to brain. *Annual Review of Psychology, 53*, 1–25.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science, 185*, 1124–1131.

Wagner, R. K., & Torgesen, J. K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101*, 192–212.

Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1994). Development of reading-related phonological processing abilities: New evidence of bidirectional causality from a latent variable longitudinal study. *Developmental Psychology, 30*, 73–87.

Wellman, H. M. (2014). *Making minds: How theory of mind develops*. New York, NY: Oxford University Press.

Wellman, H. M., Fang, F., Liu, D., Zhu, L., & Liu, G. (2006). Scaling of theory-of-mind understandings in Chinese children. *Psychological Science, 17*, 1075–1081.

Wellman, H. M., Fang, F., & Peterson, C. C. (2011). Sequential progressions in a theory-of-mind scale: Longitudinal perspectives. *Child Development, 82*, 780–792.

Wellman, H. M., & Gelman, S. A. (1992). Cognitive development: Foundational theories of core domains. *Annual Review of Psychology, 43*, 337–375.

Wellman, H. M., & Liu, D. (2004). Scaling of theory-of-mind tasks. *Child Development, 75*, 523–541.

West, R. F., Toplak, M. E., & Stanovich, K. E. (2008). Heuristics and biases as measures of critical thinking: Associations with cognitive ability and thinking dispositions. *Journal of Educational Psychology, 100*, 930–941.

White, M. (1999). *Isaac Newton: the last sorcerer*. New York, NY: Basic Books.

Zimmerman, C. (2005). *The development of scientific reasoning skills: What psychologists contribute to an understanding of elementary science learning*. Report to the National Research Council's Board of Science Education, Consensus Study on *Learning Science, Kindergarten through Eighth Grade*. Retrieved from http://www7.nationalacademies.org/bose/Corinne_Zimmerman_Final_Paper.pdf.

Chapter 10
Adaptive Memory: Fitness-Relevant "Tunings" Help Drive Learning and Remembering

James S. Nairne

Our capacity to learn is an evolved trait. Few would disagree with this broad claim, but its implications are rarely considered by mainstream educators or scholars in psychological science. As evolved adaptations, learning and memory systems were "selected" by nature because of their fitness-enhancing properties: Traits that increase the likelihood of successful reproduction, either through promoting survival or successful mating strategies, persist and gain traction in an evolving population. From an evolutionary perspective, learning is important because it produces behavior that ultimately enhances fitness (Klein, Cosmides, Tooby, & Chance, 2002; Paivio, 2007).

If our retention systems were "built" using nature's criterion—the enhancement of fitness—then one might reasonably expect to find the footprints of nature's criterion in current functioning. It was undoubtedly beneficial for our ancestors to learn and remember the locations of food, the actions of predators, the behaviors of prospective mating partners, and so forth (Nairne & Pandeirada, 2008). One might anticipate, then, that we would remember better when dealing with fitness-relevant problems than with more evolutionarily recent or irrelevant problems, such as remembering the quadratic formula. In this chapter, I review evidence consistent with this reasoning and demonstrate what appear to be content biases or "tunings" in acquisition and retention.

To preview a simple case, we have shown that animate concepts (e.g., *baby*) are easier to learn and remember than inanimate concepts (e.g., *violin*). For students to learn effectively, our educational strategies should fit the natural design of cognitive systems, so one might profitably use natural tunings to facilitate the learning process where feasible. Indeed, we have shown that it is easier to learn foreign language vocabulary when a novel word is associated with an animate translation target

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(VanArsdall, Nairne, Pandeirada, & Cogdill, 2015). Although it is premature to make broad claims about the application of our research to educational settings, an evolutionarily informed education science has great potential (see Geary, 2002, 2008).

Here, I have chosen to focus on three specific cognitive tunings that are relevant to learning and memory—survival processing, animacy, and potential contamination. In each case, I will demonstrate that fitness-relevant processing leads to excellent retention—better retention, in fact, than what is obtained from most known encoding strategies. From an evolutionary perspective, of course, this result is hardly surprising given that memory evolved subject to nature's criterion. But our findings remain controversial among mainstream cognitive researchers, who tend to believe retention systems are few in number and domain-general, operating in much the same fashion regardless of the input or learning problem.

Memory Is Functionally Designed

Although psychological scientists often make a fuss about evolutionary influences and assume that ancestral selection pressures are either unidentifiable or irrelevant to current functioning, in some sense we are all evolutionary psychologists (although, admittedly, this conclusion might come as a surprise to some). For example, everyone agrees that nature supplied us with basic sensory and perceptual equipment, "tuned" to process particular kinds of input in particular ways, along with basic learning, retention, and inferencing systems. Events that occur contiguously in time and space tend to become associated, and the learning process follows well-defined rules (e.g., Rescorla & Wagner, 1972). No learning theorist would claim that the principles of contiguity, or even informativeness (Kamin, 1969), are "learned" or require experience. Instead, we agree that natural selection crafted a cognitive toolkit that enables people and other species to learn about the important signaling properties of events (Rescorla, 1988).

Nature also supplied us with "crib sheets" that specify the kinds of stimuli that are important to learn about (Ermer, Cosmides, & Tooby, 2007). It is easier to associate neutral stimuli with fitness-relevant events. Bells are easily conditioned to food or shock, but not to bricks or books. The term *unconditioned stimulus*, by definition, refers to an event that automatically elicits a response in the absence of any learning or conditioning. Neither dog nor human needs to be taught to drool to food, or to withdraw reflexively from shock. We know as well that tastes are easily associated with stomach upset, but not to other events such as foot shock (Garcia & Koelling, 1966). These tunings or biases are assumed to be part of our inherited learning equipment. Similar tunings almost certainly exist in other cognitive systems as well, such as a tendency for our attentional systems to be captured by animate motion, novelty, or threat (Scholl & Gao, 2013) or for babies to orient more readily to faces than to wall hangings (Kanwisher, 2010).

Given these widely accepted assumptions, which can be found in any introductory textbook in psychology, it is curious why psychologists and educators do not use evolutionary reasoning as a centerpiece of their research agenda. The reason lies partly in the fact that cognitive psychologists, at least those who study learning and memory, rarely think functionally about their subject matter. Cognitive analyses are typically structural, meaning that the focus is on explaining empirical results that are associated with a particular task—the "how" of remembering—rather than on the function and purpose of the phenomena under investigation—the "why" of remembering (see Nairne, 2005). Memory textbooks are filled with examples of mnemonic effects—e.g., spaced practice is better than massed practice, practicing retrieval benefits long-term retention, forming an interactive visual image aids recall, and so forth—but little, if any, attempt is ever made to explain why our memory systems actually work that way.

The structuralist tradition originated with Ebbinghaus (1885/1964) who tried to reverse engineer memory by systematically analyzing his own attempts at memorizing material. Through a series of heroic self-studies, Ebbinhaus was able to compile a set of empirical regularities, such as the negatively accelerated forgetting function, that remain of interest to psychologists today. As I have argued elsewhere (Nairne, 2015), this approach makes a certain amount of sense, but it is difficult to reverse engineer without knowledge of function. You can query a device—get it to "behave"—but there is no obvious way of determining what the observed behavior means, or even if it is relevant to the system's ultimate design. Reverse engineering is meaningful only in the context of solving a functional problem. Our understanding of the organs of the body, for example, advanced significantly once considerations of function were taken into account (e.g., the heart is a pump).

Just like the organs of the body, which evolved to solve specific adaptive problems (e.g., filtering impurities from the blood), our cognitive capacities likely show similar functional specificity. For some cognitive systems, such as the sensory systems, we know this to be true. Cells in the retina are specialized to process particular forms of electromagnetic energy and the various components of the visual pathway are specialized as well (e.g., Ungerleider & Haxby, 1994). Well-known problems need to be solved, such as extracting color, distance, and maintaining constancy, and recognition of these problems, in turn, enabled researchers to establish solid criteria against which to measure progress (Shepard, 1994). In the case of learning and memory systems, however, the problems to be solved are not immediately obvious. We can all agree that it is adaptive to remember, but the particular mnemonic problems that drove the evolution of learning and retention systems have remained unspecified.

The research that I will be describing shortly was motivated from a functional perspective—that is, we began by assuming that our retention systems were crafted to solve specific problems in the environment, much like other structures in the body. We assumed as well, given what we know about nature's criterion, that our capacity to remember developed at some point in our ancestral past because it helped solve problems related to survival and reproduction. An organism with the capacity to remember the location of food, or categories of potential predators or mating partners, is more likely to survive and reproduce than an organism lacking this capacity. Thus, to the extent that our retention systems are specialized, they are specialized to solve problems related to survival and reproductive fitness.

There is another point about our research program that is worth noting at the outset. Evolutionary psychologists are often criticized for concocting post-hoc adaptive explanations of behavior—so-called "just-so stories"—where observed behaviors are interpreted in terms of their possible adaptive consequences. There are few constraints in this type of reasoning, meaning that one can develop convincing adaptive stories for just about any empirical effect (Gould & Lewontin, 1979). Our research relies instead on a kind of forward engineering in which functional questions take the driving role. Rather than attempting to "explain" existing empirical phenomena, we focus on the recurrent adaptive problems that our memory systems presumably needed to solve, such as remembering the location of food, and then generate a priori predictions about mnemonic behavior. For example, we have proposed a memory bias for animate things. Animate things are inherently relevant to fitness—e.g., as predators, prey, or mating partners—and therefore should be noticed and remembered well. This is not a just-so story; it is an empirical prediction that can then be rigorously tested in the laboratory.

The Mnemonic Value of Survival Processing

As just noted, our functional evolutionary perspective generates a straightforward empirical prediction: People should be able to learn, retain, and transmit fitness-relevant information especially well. In addition to an animacy bias, for example, there should be a general survival information bias in learning and retention. One can interpret cue-to-consequence effects in this way—associations between taste and gastric distress are easily learned, often in a single trial and after long delays (see Domjan & Galef, 1983). Conditioned fear responses are acquired more rapidly and extinguish more slowly to evolutionarily relevant stimuli, such as spiders and snakes, than to neutral stimuli (e.g., flowers; Ohman & Mineka, 2001). People can also retain the spatial locations of ancestral predators (snakes) with greater accuracy than modern threats (guns; see Wilson, Darling, & Sykes, 2011).

There are, in fact, many examples of fitness-relevant stimuli that are remembered well. The transmission of urban legends and oral narratives such as epic ballads (Rubin, 1995) is a case in point. Many urban legends revolve around survival-relevant information, especially food contamination (e.g., a Kentucky fried rat or razor blades in Halloween candy; see Erickson & Coultas, 2014). Stubbersfield, Tehrani, and Flynn (2015) recently demonstrated a survival transmission bias using a version of the classic "telephone" game (also known as "Chinese Whispers"). People were asked to read and recall urban legends previously rated as high in survival-relevant information or control material that was survival-neutral. A linear transmission chain design was used, in which each participant in the chain was presented with material that had been recalled by a previous participant; only the participants at the beginning of the chain read the original legends. Across the different recall generations, the survival-relevant legends were recalled more accurately, meaning that the original legend material was maintained in the recall output, compared to the control materials. Interestingly, legends containing social information, such as a father and daughter accidentally having cybersex, were maintained best of all, although one could certainly consider social information to be fitness-relevant as well.

There is also a well-established connection between emotions and memory. Emotional stimuli are often remembered well and biological relevance appears to be an important component of the emotional memory advantage (Sakaki, Niki, & Mather, 2012). Stimuli that are related to survival and reproduction (e.g., sexual images or predators) capture more attention and induce more automatic processing than social stimuli that have been matched for arousal and valence (e.g., smiling people or pictures of neo-Nazis). Flashbulb memories (Brown & Kulik, 1977) are typically survival-relevant as well. These are highly vivid and confident memories surrounding unusual and emotionally driven events, such as the terrorist attacks in the United States on September 11, 2001. Flashbulb memories consist primarily of "where and when" information, rather than details about the event itself—in other words, where was I and what was I doing when I first heard about the terrorist attacks. Several studies have tracked these memories over years (e.g., Hirst et al., 2015) and, although recall is often inconsistent (and inaccurate) over time, people continue to report elaborate recollections and especially high confidence in their memories after a decade.

Data such as these clearly support a survival information bias. But the concept of fitness-relevance can be rather slippery, primarily because "relevance" is apt to be context-dependent. Think about a pencil. Normally, we would not consider a pencil to be survival-relevant, and we would not expect it to receive any special mnemonic boost, but pencils can be relevant under the right circumstances. If you were suddenly attacked while holding a pencil, it becomes survival-relevant as a weapon, or perhaps a pencil could be used to write notes that were ultimately fitness-relevant. As Nairne and Pandeirada (2008) put it: "food is survival relevant, but more so at the beginning of a meal that at its completion; a fur coat has high s-value at the North Pole, but low at the Equator" (p. 240). Consequently, it is unlikely that we evolved brains filled with content-specific "survival" information; instead, what likely evolved was a sensitivity or tuning to survival *processing*. Once an attribution is made about a survival situation, perhaps engendered by the sudden appearance of a predator, evolved mnemonic machinery kicks into gear and subsequently processed material is remembered well. As I discuss shortly, there is now considerable empirical evidence to support this assertion.

The Survival Processing Paradigm

In 2007, we developed a laboratory procedure to investigate the mnemonic value of survival processing (Nairne, Thompson, & Pandeirada, 2007). Participants were asked to imagine themselves stranded in the grasslands of a foreign land. The instructions specified that, over the next few months, they would need to find steady supplies of food and water and protect themselves from predators. Individual words were then shown, one at a time, and people were asked to rate the relevance of each word to this imagined survival scenario. After the rating period, and a short distractor task, a surprise retention test was given, either free recall of the rated words or a recognition test. For control comparisons, we included a standard deep processing task (rating words for pleasantness) along with an equally complex scenario that was fitness-irrelevant (moving to a foreign land) (see Table 10.1). Strong retention advantages were found for the words processed with respect to the survival scenario.

This survival processing advantage turns out to be quite robust and it has now been replicated in a number of laboratories across the world. The survival advantage holds up well against a variety of control conditions—even against what are typically thought to be the "best of the best" encoding conditions such as forming a visual image or relating information to the self (Nairne, Pandeirada, & Thompson, 2008). Notice in Fig. 10.1, for example, that survival processing produces significantly better retention than intentional learning, where people are purposely trying to learn and remember the material for a later test. The survival advantage has been demonstrated in small children (Aslan & Bäuml, 2012), in elderly populations (Nouchi, 2012), and in populations suffering from cognitive impairment (Pandeirada, Pinho, & Faria, 2014). The effect remains robust in both within- and between-subject designs, in intentional and incidental learning environments, and for both pictures and words. The basic effect has been replicated as well as a part of the Open Science Project (Müller & Renkewitz, 2015).

Notice we are not directly comparing fitness-relevant and fitness-irrelevant events or stimuli in this paradigm—e.g., snakes versus flowers or emotional versus nonemotional events. Instead, we are comparing memory for exactly the same stimulus when that stimulus has been processed with respect to survival or not. This kind of design has certain methodological advantages over the research discussed in the previous section. For example, it solves what are known as item-selection problems. When comparing across stimuli, such as snakes versus flowers, it is important to ensure that the stimuli have been adequately matched across all mnemonically relevant dimensions except for survival relevance—this can be difficult to achieve. Obviously, since the same stimuli are used in both the experimental and control

Table 10.1 Scenarios used in Nairne et al. (2007)

Survival: In this task, we would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you'll need to find steady supplies of food and water and protect yourself from predators. We are going to show you a list of words, and we would like you to rate how relevant each of these words would be for you in this survival situation
Moving: In this task, we would like you to imagine that you are planning to move to a new home in a foreign land. Over the next few months, you'll need to locate and purchase a new home and transport your belongings. We are going to show you a list of words, and we would like you to rate how relevant each of these words would be for you in accomplishing this task
Pleasantness: In this task, we are going to show you a list of words, and we would like you to rate the pleasantness of each word

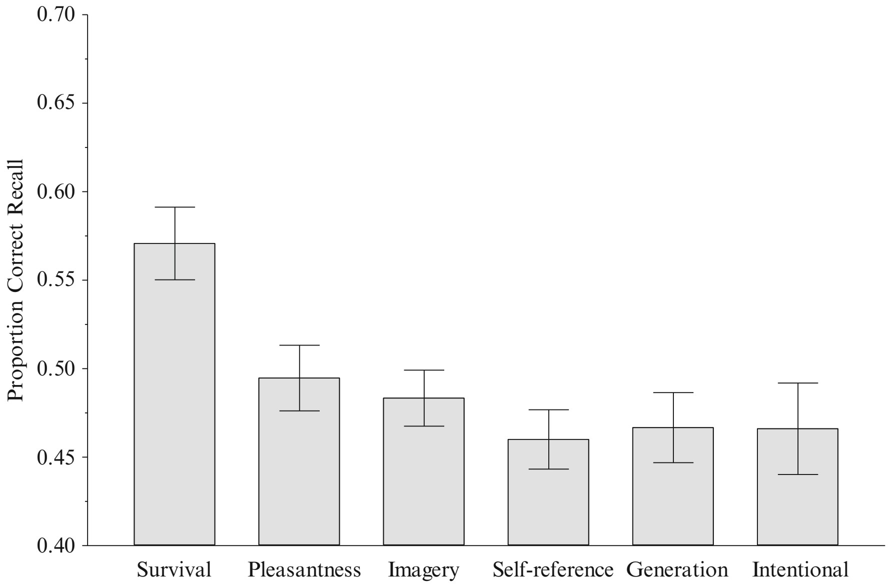

Fig. 10.1 Average proportion correct free recall for the various conditions in Nairne et al. (2008)

conditions, matching the stimuli is not a concern. Our design captures the context-dependent nature of survival relevance as well. One of the interesting findings from our research is that even stimuli that are rated as irrelevant to the survival scenario are often remembered well (although stimuli rated as relevant are typically remembered better). It is the spotlight of survival processing that matters.

Still, one might suspect that there is something about the survival scenario, rather than fitness-relevancy per se, that affords richer processing. For example, we might have chosen a scenario that is unusually complex, novel, arousing, or difficult. Few participants are familiar with grassland scenarios, so survival processing might require an especially deep or meaningful form of processing, at least compared to rating an item for pleasantness or moving to a foreign land. However, the survival scenario has now been compared to many different control scenarios, some specifically designed to equate for possible confounding factors. Kang, McDermott, and Cohen (2008) controlled for the novelty and excitement of the grasslands scenario by comparing it to a robbery control in which people rated the relevance of words to planning a bank robbery. Röer, Bell, and Buchner (2013) tried to equate for distinctiveness by using an "afterlife" control in which people imagined that they had died and were searching for new companions and interesting things to do in the afterlife. Bell, Röer, and Buchner (2013) tested whether the survival scenario might simply induce negative affect by comparing it against a "suicide" control scenario. Strong survival processing advantages were obtained in each of these cases, effectively ruling out accounts that appeal to the unusual or novel features of the survival scenario.

However, the best evidence against these kinds of alternative interpretations comes from studies using matched control scenarios. In these cases, people are asked to rate the relevance of items to *exactly the same activities*, but in a context that is either fitness-relevant or not. Nairne, Pandeirada, Gregory, and VanArsdall (2009) asked people to rate the relevance of words to a hunting scenario, one in which they were required to hunt big game, trap small animals, and fish, but either to survive or to win a hunting contest. Both scenarios required tracking and hunting for food, in exactly the same way, but only the survival version was designed to induce fitness-relevant processing. Significantly better recall performance was found in the survival-based hunting condition. In another experiment, people were asked to search for and find edible food, either to survive or to win a scavenger hunt; again, exactly the same activities were included in each scenario, but framing the scenario around survival produced a stronger mnemonic effect. Ceo (2008) asked people to search for and find apples to eat, either to survive or for a picnic while vacationing at a fancy resort. Again, exactly the same activities were involved in both the survival and the control scenario, but the survival framing produced the best recall.

Matched scenario designs have also been used to investigate spatial memory (Nairne, VanArsdall, Pandeirada, & Blunt, 2012). Remembering that food has been seen in a particular area, or that potential predators are likely to be found in a given territory, should increase the chances of subsequent survival. Consequently, we anticipated that survival processing would enhance memory for the location of items. Participants were shown pictures of food or animals located at various positions on a computer screen. The task was to rate the ease of collecting the food or capturing the animals relative to a central fixation point. The main manipulation was whether people were collecting the items for survival or to win a hunting or scavenging contest. Later, surprise retention tests showed that people remembered the locations of the items better when the collection or capturing task was described as relevant to survival.

Collectively, these data indicate that the survival processing advantage is probably not an artifact of the particular scenario or rating task involved. Instead, the evidence is consistent with a "front-end" adaptation that is activated selectively by survival situations. When confronted with a survival situation, people naturally engage in a rich and elaborative form of processing, one that yields excellent long-term retention. The adaptation acts generally, in the same way that other front-end adaptations work in the body. Consider the fight-or-flight response as a case in point. The fight-or-flight response is unlikely to be a learned phenomenon, although experience might shape the ultimate response. Most would consider it to be an evolved adaptation designed to prepare an organism to respond effectively when danger is present. It is triggered by the attribution of perceived danger, but what constitutes "danger" is context-specific. There might be natural triggers in the environment, such as a snake or a looming object, but the response system is clearly flexible enough to be triggered by a variety of situations. Survival processing may represent a similar kind of process—a front-end adaptation that, once triggered, relies on other evolved mnemonics to achieve an adaptive end.

The Mnemonic Value of Animacy

Animacy is another prime candidate for an evolved "crib sheet" or tuning in remembering. Animacy, defined roughly as the distinction between living and nonliving things, plays a central role in psychological science—for good reason. From an evolutionary perspective, of course, it is important to attend selectively to animate things because animate entities represent potential food, predators, mating partners, or competitors. In fact, some have argued that primates possess unusually large brains for body size primarily because of the computational demands of complex social systems (i.e., the social brain hypothesis; Dunbar, 2007). To the extent that language evolved, it evolved to solve problems arising from social interactions with animate agents (e.g., Pinker, 1994).

Developmentally, the animate–inanimate distinction appears to be a skeletal principle that organizes children's experiences from a very early age (Opfer & Gelman, 2011). Babies very quickly show differences in looking times between people and artifacts (e.g., Klein & Jennings, 1979) and early in the first year seem to understand that animate things, but not inanimate things, are capable of self-propelled movement (Markson & Spelke, 2006). By age 3 or 4, preschool children are remarkably accurate in distinguishing between living things, such as animals, and inanimate objects; they draw a richer set of inferences from animals than from artifacts as well (Heyman & Gelman, 2000). Not surprisingly, animacy plays an important role in language development and in the general structure of language overall (e.g., Silverstein, 1976).

There appear to be perceptual tunings for animacy as well, or at least to cues reliably associated with animacy. New, Cosmides, and Tooby (2007) found that people could more quickly and accuracy detect changes to visual scenes when the change involved animate (people and animals) rather than inanimate objects. The animate advantage remained even when the inanimate changes were large and quite discriminable on their own (e.g., the presence or absence of a large building). People also readily impart animacy to inanimate objects that move in animate ways (Heider & Simmel, 1944) and attribute animacy to inanimate objects moving in a random fashion as long as other cues are evocative of animacy (e.g., the wolfpack effect in which chevrons move randomly but are "pointed" at a central display; Gao, McCarthy, & Scholl, 2010).

We would expect then to find similar animacy biases in learning and remembering. Barrett and Broesch (2012) found a content bias for learning about dangerous animals in children that held for both city-dwelling children from Los Angeles and for Shuar children from the Amazon region of Ecuador. There are also animacy-specific semantic deficits in brain-damaged patients. Some patients lose the ability to name living things, such as animals, but not nonliving entities (Caramazza & Shelton, 1998). However, few, if any, studies have actually manipulated animacy experimentally. For example, one could select animate and inanimate items that have been carefully matched along mnemonically relevant dimensions and test whether the animate items are easier to remember. Alternatively, one could take novel items, such as nonwords, or inanimate items and encourage people to process those items from an animate perspective. We have used both of these strategies in our laboratory, as I discuss shortly.

Initially, however, we wanted to see whether animacy significantly predicts recall using regression techniques (Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013). Multiple regression is often used as a statistical tool for identifying variables that contribute to some criterion. Rubin and Friendly (1986) tried to predict free recall performance using normative data for a number of word properties, such as meaningfulness, frequency of occurrence, and concreteness. Animacy was not a factor considered in their analysis, so we coded the Rubin and Friendly words for animacy (living vs. nonliving) and reanalyzed the data using animacy as an additional predictor variable. We discovered that animacy was one of the strongest contributors to the explainable variance. Animacy correlated strongly with recall ($r=0.42$) and its incremental importance (the unique contribution of the variable to R^2) was nearly twice that of its nearest competitor, imagery. These data suggested to us that animacy is indeed a potent mnemonic variable.

We next manipulated animacy experimentally, seeking to establish a causal link between animacy status and retention. First up, we carefully matched sets of animate (e.g., turtle) and inanimate words (e.g., purse) along ten mnemonically relevant dimensions (e.g., imagery, emotionality, familiarity, meaningfulness, etc.). We then asked people to study and remember the words for a free-recall test. The animate and inanimate words were intermixed in a list and people were given 5 s to study each item. Figure 10.2 shows the results of the free recall test for each of three study and test trials. As the figure shows, there was a strong recall advantage for the animate items on each of the three study-test trials. Shortly after we published our initial study, our findings were replicated in a different lab, using a different word pool, and the animacy advantage was found to hold for pictures of animate entities and on a recognition memory test as well (Bonin, Gelin, & Bugaiska, 2014).

We have also investigated the mnemonic value of *animacy processing* (VanArsdall, Nairne, Pandeirada, & Blunt, 2013). Instead of directly comparing the recall of animate and inanimate words, we asked people to process novel stimuli (nonwords) as either living or nonliving things. In these experiments, people were shown pronounceable nonword "names" (e.g., FRAV) along with properties characteristic of either living (e.g., enjoys cooking) or nonliving (e.g., has a hollow center) things. For each nonword and its assigned property, the task was simply to classify the object as a living or nonliving thing. Every nonword was processed as either a living or a nonliving thing across participants, effectively eliminating any item selection concerns. Following the classification task, a memory test was given for the rated nonwords (either free recall or recognition). Once again, there was an animacy advantage—the nonwords classified as animate were recalled and recognized better than those classified as inanimate. Our data suggest that merely thinking about an object in an animate way may have mnemonic consequences over the long-term.

These animacy advantages certainly reinforce the notion that our cognitive systems are tuned to detect and remember animate things. Such a tuning makes evolutionary sense because animals and people are apt to be fitness-relevant—e.g., it is much more important to remember the sudden appearance of a predator or a potential

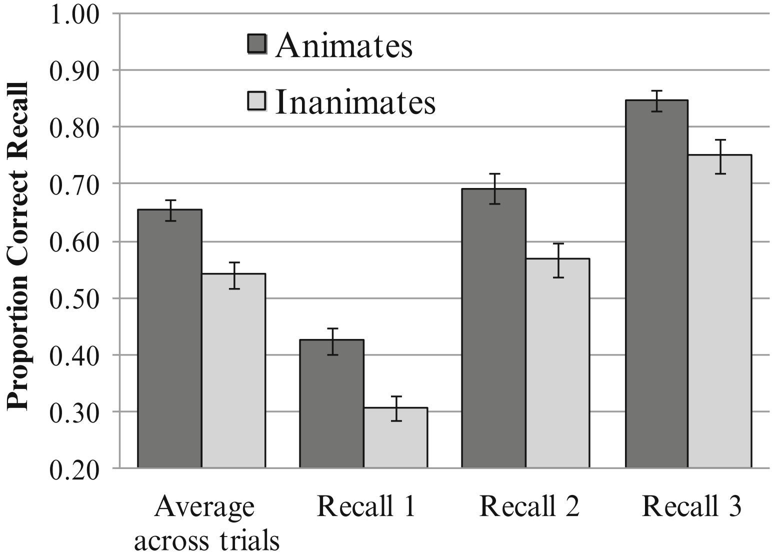

Fig. 10.2 Proportion correct recall averaged across the three recall trials, and for each recall trial, for animates and inanimates in Exp. 2 of Nairne, VanArsdall, Pandeirada, Cogdill, and LeBreton (2013). Error bars represent standard errors of the mean

mate than it is to remember, say, a random twig blowing across the ground. To the extent that the computational demands of complex social systems helped drive the evolution of cognitive systems, at least in part, we would anticipate increased processing of animate entities. As with survival processing, we need memory-based "crib sheets" that help us attend to and remember those things pertinent to improving the chances of survival and reproduction.

The Mnemonic Value of Potential Contamination

Our laboratory has also been interested in exploring the mnemonic value of contamination, which likely represents yet another content-based memory tuning. Considerable work has been conducted on the emotion of disgust, which promotes avoidance of pathogen-laden substances. Disgust is often classified as a "basic" emotion, and there is considerable cross-cultural consistency in the expression of disgust (Ekman & Friesen, 1974). There also appears to be a relatively straightforward relationship between cues that evoke disgusting reactions and cues that signal disease (Curtis, de Barra, & Aunger, 2011). People generally find body byproducts disgusting, such as feces, urine, vomit, or blood, and these things are recognized sources of bacteria and disease. For this reason, disgust is classified as an evolved disease-avoidance adaptation with considerable survival value (Oaten, Stevenson, & Caser, 2009).

Given their obvious relevance to fitness, then, we would expect disgusting objects to be remembered well. As emotional stimuli, particularly stimuli with negative valence, pictures or descriptions of disgusting objects are indeed remembered well (e.g., Croucher, Calder, Ramponi, Barnard, & Murphy, 2011). One finds enhanced source memory for disgusting things as well, meaning that we can remember whether an object or a person exhibited disgusting attributes. In a study by Bell and Buchner (2010), people were shown pictures of faces accompanied by descriptions of disgusting behavior (e.g., "this person eats dog meat"), neutral information (e.g., "this person is a gardener"), or pleasant behaviors (e.g., "this person bakes fresh cookies"). Later, the faces were shown again and people were asked to indicate whether each face had earlier been associated with disgusting, neutral, or pleasant behaviors. The best source memory was found for the faces associated with disgust.

There appears to be something special about disgust as well, over and above the fact that disgusting objects are arousing and are negatively valenced (Chapman, Johannes, Popenk, Moscovitch, & Anderson, 2013). Chapman and colleagues carefully matched fearful and disgusting photographs for valence and arousal and found a significant retention advantage for the disgusting objects (e.g., body products such as feces or vomit) compared to the fearful images (e.g., animal threats, disasters). The retention advantage held even when attentional differences were controlled between fear and disgust along with response biases. The authors suggested that disgust enhancement may draw on distinctive neural mechanisms that improve memory over and above the enhancements that are produced by general emotional arousal.

One reason why disgusting objects may indeed be "special" is their potential for contamination, which likely represented a common threat to one's fitness. Neutral objects that come in contact with an object of disgust can themselves become contaminated. There is substantial anecdotal and laboratory evidence showing that people are extremely sensitive to potential contamination. For example, as documented by Rozin and colleagues, people are reluctant to interact with objects that have simply come in contact with disgusting things (e.g., Rozin, Millman, & Nemeroff, 1986). People are unlikely to drink juice from a glass that had previously been "contaminated" with a dead and sterilized cockroach, even though everyone was informed that the juice was perfectly safe to drink. People are reluctant to wear clothes that have previously come in contact with a disliked person, such as Hitler or a serial killer.

Obviously, these proclivities make evolutionary sense because avoiding potentially contaminated things increases the chances of survival. But we were interested in the mnemonic consequences of contamination. We know people remember disgusting objects better than neutral objects, but does the memory enhancement extend to things that have simply come in contact with something that is disgusting? To investigate this issue, we asked a simple question: Will people remember items that have been touched by a sick person better than items touched by a healthy person? Anecdotally, this certainly seems true. Most of us are reluctant to handle things that have recently come in contact with a sick person which implies some sort of mnemonic salience.

In our experiment, people were shown pictures of everyday objects along with a descriptor signifying the health status of a person who had recently "touched" the object. For example, a picture of a ball was shown along with the statement "person with a constant cough" or the statement "person with a straight nose." After every third item, the three preceding items were shown again and people were required to classify whether each had been touched by an obviously sick person or by a person without any obvious symptoms (i.e., a healthy person). This immediate test was included simply to ensure that people paid attention to the descriptor. After a series of these presentations, everyone was asked to recall all of the items seen in the experiment. The final free recall test was unexpected.

Performance on the immediate test was excellent and near ceiling, as expected, and no differences were found between the sick and healthy conditions. Again, these tests were designed simply to ensure that people paid attention to the descriptors. Performance on the surprise free recall test, however, revealed a strong recall advantage for the items paired with a "sick" descriptor. Even though people were not expecting a final memory test, those items that were classified as having been touched by a sick person were remembered significantly better than the "healthy" control. We have extended the finding to source memory as well. Not only do people remember the "contaminated" object better overall, but if asked to identify who touched the object, a sick person or a healthy person, people are better at identifying that the object was touched by a sick person. Regardless of the proximate mechanisms that underlie these advantages—e.g., perhaps people have a stronger emotional reaction to the contaminated items—the net result is clearly adaptive. Remembering potentially contaminated items can help us to avoid those items in future interactions.

Conclusions and Implications for Educational Practice

The default position among most psychologists is that learning and memory processes are general and equipotential. It is accepted that memory and other cognitive systems are the product of an evolutionary process and confer evolutionary advantages, but the imprint of nature's criterion on system functioning is either ignored or assumed to be irrelevant. Instead, the guiding premise of most psychologists and educators is that the same basic cognitive mechanisms apply, in the same fashion, regardless of the materials involved or the particular task at hand. In the case of learning, for example, causal connections among stimuli are assumed to be governed by a few basic principles, such as contiguity or informativeness, and the specific content of the events involved is rarely, if ever, considered as a factor. Constraints are sometimes grudgingly acknowledged, such as flavor-illness associations, but often only as after-thoughts or in special sections of textbooks.

Throughout this chapter, I have advocated an alternative viewpoint, namely, that our learning and retention systems are biased or "tuned" to specific kinds of content or forms of processing. And, more important, those biases or tunings are the direct result of cognitive systems that evolved to solve adaptive problems—specifically, problems related to survival and reproduction. The simplistic view that our brains evolved solely to acquire and retain "information," or form connections among any two stimuli that happen to occur contiguously, cannot be correct because information, by itself, has no fitness consequences. One needs to discriminate among *kinds* of information—those that are relevant to fitness and those that are not (Geary, 2005). Otherwise, we would very quickly run into problems of computational explosion, or mnemonic clutter, as many evolutionary psychologists have discussed (e.g., Ermer et al., 2007).

The fact that we may have evolved brains that are "tuned" to learn about certain kinds of content, such as animate agents or potentially contaminated objects, does not mean that our learning and retention systems lack flexibility. On the contrary, we need the capacity to learn about a wide variety of events, as well as relationships among events, because fitness-relevance is often context-specific. It would be wrongheaded to think that our brains are simply filled with built-in content—such as a list of predators or food types—although particular predator characteristics may have shaped the evolution of some systems. Some have argued that the visual system evolved, at least in part, to solve the problem of detecting snakes in the grass (e.g., Isbell, 2006). Instead, what likely evolved were content-sensitive forms of processing; for example, as discussed earlier, when information is processed in a survival context, or one is searching for animate or agentic properties in a stimulus, mnemonic machinery operates particularly efficiently resulting in excellent long-term retention.

From an educational perspective, of course, this means that it should be easier to acquire and retain information that is processed from a fitness perspective. As Geary (2008) has noted, children are inherently motivated to learn about information that is "biologically primary" or evolutionarily salient. To some extent, then, we can encourage educators to frame their lesson plans in a manner that takes advantage of natural learning biases of the type discussed in this chapter; similar arguments have been made about teaching mathematical skills, that is, one should develop learning tasks that fit snugly with our naturally developing "number sense" (see Berch, 2005). One can imagine framing content around fitness-relevant situations, for example, or developing work problems that make use of agents, survival problems, or even general social contexts. Of course, whether evolved biases will help or hinder performance will depend on the problem context. As Geary (2008) has stressed, much of what needs to be learned in the classroom is evolutionarily novel and may conflict with our natural intuitions (e.g., Newtonian mechanics).

At this point, we cannot make broad claims about the applicability of our laboratory studies to the classroom, but we have shown that fitness-relevant processing can facilitate the learning of a wide variety of stimuli, including novel foreign language words. In one study using the procedure adopted for our contamination studies, people were shown Swahili words paired with either fitness-relevant or fitness-irrelevant descriptors. For example, the word "kaburi" might appear with the descriptor "could be thrown to distract a predator" or the word "gutu" with the descriptor "could be packed carefully in a box." For each of the words, people were required to decide whether it was relevant to a survival or a moving situation. At the end of the experiment, everyone then received a surprise recognition test for the words. Swahili words that had previously been paired with a survival descriptor were recognized significantly better than words paired with a fitness-irrelevant moving descriptor.

We have also shown that animacy can facilitate the learning of foreign language translations (VanArsdall et al., 2015). Once again people were shown Swahili words, but this time with assigned English "translations." The task was to learn to produce the appropriate English translation when given the Swahili word as a cue. The Swahili words were not paired with their actual translations; instead, for control purposes we chose translation targets that were either animate or inanimate but otherwise matched on a variety of important mnemonic variables (e.g., rembo-duck vs. sahani-stove). Each word pair appeared for 5 s and people were told to learn the pair such that they could produce the translation (duck) when provided the cue (rembo). The results are shown in Fig. 10.3, for each of three study-test trials. Across all three trials, a strong cued-recall advantage was found for the animate pairs.

The results of our experiments using Swahili words show that it is possible to extend our laboratory procedures to learning situations that might have some applications in the classroom. For example, it might be beneficial during foreign language

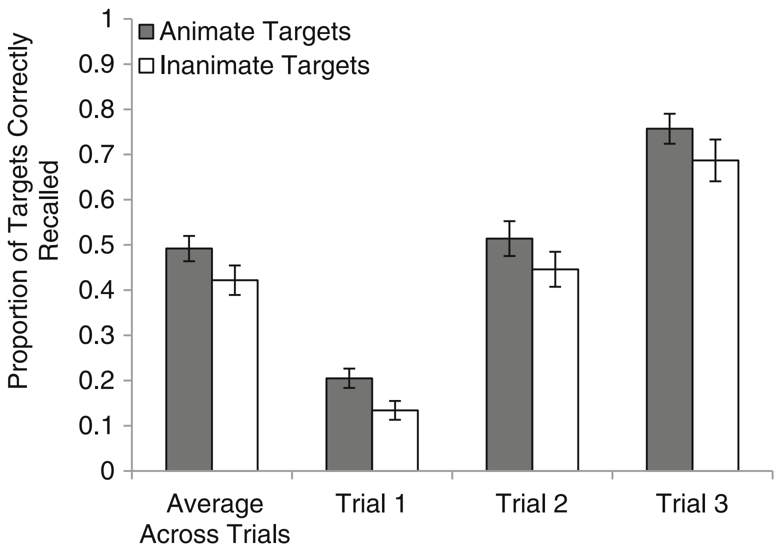

Fig. 10.3 Results from VanArsdall et al. (2015): Mean proportion of targets correctly recalled as a function of trial and word type. Data are shown averaged across the three cued recall trials and separately for each trial. Error bars represent standard errors of the mean

learning to start with vocabulary with references to animate agents or other fitness-relevant concepts. Prokop and Fancovicova (2014) recently showed that children find it easier initially to learn about plants with colors that signal ripeness (e.g., red vs. green) and particularly plants with relevance to survival (e.g., whether or not the plant was toxic). Even 6-month-old infants are apparently "prepared" to use social information to learn about the edibility of plants compared to learning about artifacts (Wertz & Wynn, 2014). Such natural tendencies can certainly be exploited to help the transition from simple learning contexts to more complex ones.

Besides recognizing and exploiting inherent content biases, adopting an evolutionary perspective in the classroom has another tangible benefit. It forces one to think functionally about the learning process. As discussed earlier, most psychologists and educators simply try to reverse engineer learning: People are asked to learn and remember material and then one looks for regularities in the empirical patterns. Although many effective training strategies have been discovered through reverse engineering—e.g., distribute rather than mass study periods, practice active retrieval of material rather than passive study (see Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013)—one rarely gets much insight into why our learning systems work this way. Again, our learning and memory systems almost certainly evolved to solve specific adaptive problems. To understand those systems completely, one needs to understand the selection pressure that shaped their development.

Similar benefits accrue from thinking functionally as an instructor. At the university level, students are often mystified by the coverage they find in their classes because teachers, like researchers, consistently favor the "what" over the "why." When learning is covered in introductory psychology courses, for example, students hear extended discussions about drooling dogs and key-pecking pigeons, but connections are rarely drawn between classical and instrumental conditioning and the kinds of learning problems people face on a daily basis. As William James once said, it is difficult to understand a house by focusing on its bricks and mortar—one needs to know what the house is for, what the house is designed to do, and it is only in this functional context that bricks and mortar make sense. The same reasoning applies to students in the classroom—before they can understand the mechanics of a psychological process, they need to know what the psychological process is *for* (see Nairne, 2014). Both in research and in the classroom, thinking functionally is a vital component of success.

References

Aslan, A., & Bäuml, K.-H. T. (2012). Adaptive memory: Young children show enhanced retention of fitness-related information. *Cognition, 122*, 118–122.

Barrett, H. C., & Broesch, J. (2012). Prepared social learning about animals in children. *Evolution and Human Behavior, 33*, 499–508.

Bell, R., & Buchner, A. (2010). Valence modulates source memory for faces. *Memory & Cognition, 38*, 29–41.

Bell, R., Röer, J. P., & Buchner, A. (2013). Adaptive memory: The survival-processing memory advantage is not due to negativity or mortality salience. *Memory & Cognition, 41*, 490–502.

Berch, D. B. (2005). Making sense of number sense: Implications for children with mathematical disabilities. *Journal of Learning Disabilities, 38*, 333–339.

Bonin, P., Gelin, M., & Bugaiska, A. (2014). Animates are better remembered than inanimates: Further evidence from word and picture stimuli. *Memory & Cognition, 42*, 370–382.

Brown, R., & Kulik, J. (1977). Flashbulb memories. *Cognition, 5*, 73–99.

Caramazza, A., & Shelton, J. R. (1998). Domain-specific knowledge systems in the brain the animate-inanimate distinction. *Journal of Cognitive Neuroscience, 10*(1), 1–34.

Ceo, D. (2008). *Memory for survival processing of hierarchical categories*. PhD Thesis, Purdue University.

Chapman, H. A., Johannes, K., Popenk, J. L., Moscovitch, M., & Anderson, A. K. (2013). Evidence for the differential salience of disgust and fear in episodic memory. *Journal of Experimental Psychology General, 142*, 1100–1112.

Croucher, C. J., Calder, A. J., Ramponi, C., Barnard, P. J., & Murphy, F. C. (2011). Disgust enhances the recollection of negative emotional images. *PLoS One, 6*, e26571. doi:10.1371/journal.pone.0026571.

Curtis, V., de Barra, M., & Aunger, R. (2011). Disgust as an adaptive system for disease avoidance behavior. *Philosophical Transactions of the Royal Society, 366*, 389–401.

Domjan, M., & Galef, B. G. (1983). Biological constraints on instrumental and classical conditioning: Retrospect and prospect. *Animal Learning & Behavior, 11*, 151–161.

Dunbar, R. (2007). Evolution of the social brain. In S. W. Gangestad & J. A. Simpson (Eds.), *The evolution of mind: Fundamental questions and controversies* (pp. 280–286). New York, NY: Guilford.

Dunlosky, J. D., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest, 14*, 4–58.

Ebbinghaus, H. (1964). *Memory: A contribution to experimental psychology*. Oxford, England: Dover (Original work published 1885).

Ekman, P., & Friesen, W. V. (1974). Detecting deception from the body or face. *Journal of Personality and Social Psychology, 29*, 288–289.

Erickson, K., & Coultas, J. C. (2014). Corpses, maggots, poodles, and rats: Emotional selection operating in three phases of cultural transmission of urban legends. *Journal of Cognition and Culture, 14*, 1–26.

Ermer, E., Cosmides, L., & Tooby, J. (2007). Functional specialization and the adaptationist program. In S. W. Gangestad & J. A. Simpson (Eds.), *The evolution of mind: Fundamental questions and controversies* (pp. 86–94). New York, NY: Guilford.

Gao, T., McCarthy, G., & Scholl, B. J. (2010). The wolfpack effect. Perception of animacy irresistibly influences interactive behavior. *Psychological Science, 21*(12), 1845–1853.

Garcia, J., & Koelling, R. A. (1966). Relation of cue to consequence in avoidance learning. *Psychonomic Science, 4*, 123–124.

Geary, D. C. (2002). Principles of evolutionary educational psychology. *Learning and Individual Differences, 12*, 317–345.

Geary, D. C. (2005). *The origins of mind: Evolution of brain, cognition, and general intelligence*. Washington, DC: American Psychological Association.

Geary, D. C. (2008). An evolutionarily informed education science. *Educational Psychologist, 43*, 179–195.

Gould, S. J., & Lewontin, R. C. (1979). The spandrels of San Marco and the Panglossian paradigm: A critique of the adaptationist programme. *Proceedings of the Royal Society of London, Series B, 205*, 581–598.

Heider, F., & Simmel, M. (1944). An experimental study of apparent behavior. *The American Journal of Psychology, 57*(2), 243–259.

Heyman, G. D., & Gelman, S. A. (2000). Preschool children's use of trait labels to make inductive inferences. *Journal of Experimental Child Psychology, 77*, 1–19.

Hirst, W., Phelps, E. A., Meksin, R., Vaidya, C. J., Johnson, M. K., Mitchell, K. J. …. Olsson, A. (2015). A ten-year follow-up of a study of memory for the attack of September 11, 2001: Flashbulb memories and memories for flashbulb events. *Journal of Experimental Psychology General, 144*(3), 604–23.

Isbell, L. A. (2006). Snakes as agents of evolutionary change in primate brains. *Journal of Human Evolution, 51*, 1–35.

Kamin, L. J. (1969). Predictability, surprise, attention, and conditioning. In B. A. Campbell & R. M. Church (Eds.), *Punishment and aversive behavior*. New York, NY: Appleton-Century-Crofts.

Kang, S., McDermott, K. B., & Cohen, S. (2008). The mnemonic advantage of processing fitness-relevant information. *Memory & Cognition, 36*, 1151–1156.

Kanwisher, N. (2010). Functional specificity in the human brain: A window into the functional architecture of the mind. *Proceedings of the National Academy of Sciences of the United States of America, 107*, 11163–11170.

Klein, S. B., Cosmides, L., Tooby, J., & Chance, S. (2002). Decisions and the evolution of memory: Multiple systems, multiple functions. *Psychological Review, 109*, 306–329.

Klein, R. P., & Jennings, K. D. (1979). Responses to social and inanimate stimuli in early infancy. *The Journal of Genetic Psychology, 135*(1), 3–9.

Markson, L., & Spelke, E. S. (2006). Infants' rapid learning about self-propelled objects. *Infancy, 9*(1), 45–71.

Müller, S., & Renkewitz, F. (2015). Replication of Study 2 by Nairne, J. S., Pandeirada, J. N. S., & Thompson, S. (Psychological Science, 2008). *Open Science Framework: Reproducibility Project*.

Nairne, J. S. (2005). The functionalist agenda in memory research. In A. F. Healy (Ed.), *Experimental cognitive psychology and its applications: Festschrift in honor of Lyle Bourne, Walter Kintsch, and Thomas Landauer*. Washington, DC: American Psychological Association.

Nairne, J. S. (2014). *Psychology*. Belmont, CA: Cengage.

Nairne, J. S. (2015). Adaptive memory: Novel findings acquired through forward engineering. In D. S. Lindsay, C. M. Kelley, A. P. Yonelinas, & H. L. Roediger III (Eds.), *Remembering: Attributions, processes, and control in human memory: Papers in honor of Larry L. Jacoby* (pp. 3–14). New York, NY: Psychology Press.

Nairne, J. S., & Pandeirada, J. N. S. (2008). Adaptive memory: Remembering with a stone-age brain. *Current Directions in Psychological Science, 17*, 239–243.

Nairne, J. S., Pandeirada, J. N. S., Gregory, K. J., & VanArsdall, J. E. (2009). Adaptive memory: Fitness-relevance and the hunter-gatherer mind. *Psychological Science, 20*, 740–746.

Nairne, J. S., Pandeirada, J. N. S., & Thompson, S. R. (2008). Adaptive memory: The comparative value of survival processing. *Psychological Science, 19*, 176–180.

Nairne, J. S., Thompson, S. R., & Pandeirada, J. N. S. (2007). Adaptive memory: Survival processing enhances retention. *Journal of Experimental Psychology Learning, Memory, and Cognition, 33*, 263–273.

Nairne, J. S., VanArsdall, J. E., Pandeirada, J. N. S., Cogdill, M., & LeBreton, J. M. (2013). Adaptive memory: The mnemonic value of animacy. *Psychological Science, 24*, 2099–2105.

Nairne, J. S., VanArsdall, J. E., Pandeirada, J. N. S., & Blunt, J. R. (2012). Adaptive memory: Enhanced location memory after survival processing. *Journal of Experimental Psychology Learning, Memory, and Cognition, 38*, 495–501.

New, J., Cosmides, L., & Tooby, J. (2007). Category-specific attention for animals reflects ancestral priorities, not expertise. *Proceedings of the National Academy of Sciences of the United States of America, 104*(42), 16598–16603.

Nouchi, R. (2012). The effect of aging on the memory enhancement of the survival judgment task. *Japanese Psychological Research, 54*, 210–217.

Oaten, M., Stevenson, R. J., & Caser, T. I. (2009). Disgust as a disease-avoidance mechanism. *Psychological Bulletin, 135*, 303–321.

Ohman, A., & Mineka, S. (2001). Fears, phobias, and preparedness: toward an evolved module of fear and fear learning. *Psychological Review, 108*, 483–522.

Opfer, J. E., & Gelman, S. A. (2011). Development of the animate-inanimate distinction. In U. Goswami (Ed.), *The Wiley-Blackwell handbook of childhood cognitive development* (2nd ed., pp. 213–238). Oxford, England: Wiley-Blackwell.

Paivio, A. (2007). *Mind and its evolution: A dual coding theoretical approach*. Mahwah, NJ: Erlbaum.

Pandeirada, J. N. S., Pinho, M. S., & Faria, A. L. (2014). The mark of adaptive memory in healthy and cognitively impaired older adults and elderly. *Japanese Psychological Research, 56*, 168–179.

Pinker, S. (1994). *The language instinct*. New York, NY: HarperCollins.

Prokop, P., & Fancovicova, J. (2014). Seeing coloured fruits: Utilisation of the theory of adaptive memory in teaching botany. *Journal of Biological Education, 48*, 127–132.

Rescorla, R. A. (1988). Pavlovian conditioning: It's not what you think it is. *American Psychologist, 43*, 151–160.

Rescorla, R. A., & Wagner, A. R. (1972). A theory of Pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement. In A. H. Black & W. F. Prokasy (Eds.), *Classical conditioning II*. New York, NY: Appleton-Century-Crofts.

Röer, J. P., Bell, R., & Buchner, A. (2013). Is the survival-processing advantage due to richness of encoding? *Journal of Experimental Psychology Learning, Memory, and Cognition, 39*, 1294–1302.

Rozin, P., Millman, L., & Nemeroff, C. (1986). Operation of the laws of sympathetic magic in disgust and other domains. *Journal of Personality and Social Psychology, 50*, 703–712.

Rubin, D. C. (1995). *Memory in oral traditions. The cognitive psychology of epic, ballads, and counting-out rhymes*. New York, NY: Oxford University Press.

Rubin, D. C., & Friendly, M. (1986). Predicting what words get recalled: Measures of free recall, availability, goodness, emotionality, and pronunciability for 925 nouns. *Memory & Cognition, 14*, 79–94.

Sakaki, M., Niki, K., & Mather, M. (2012). Beyond arousal and valence: The importance of the biological versus social relevance of emotional stimuli. *Cognitive, Affective, & Behavioral Neuroscience, 12*, 115–139.

Scholl, B. J., & Gao, T. (2013). Perceiving animacy and intentionality: Visual processing or higher-level judgment? In M. D. Rutherford & V. A. Kuhlmeier (Eds.), *Social perception: Detection and interpretation of animacy, agency, and intention* (pp. 197–230). Cambridge, MA: MIT Press.

Shepard, R. N. (1994). Perceptual-cognitive universals as reflections of the world. *Psychonomic Bulletin & Review, 1*, 2–28.

Silverstein, M. (1976). Hierarchy of features and ergativity. In R. Dixon (Ed.), *Grammatical categories in Australian languages*. Canberra, ACT, Australia: Australian Institute of Aboriginal Studies.

Stubbersfield, J. M., Tehrani, J. J., & Flynn, E. G. (2015). Serial killers, spiders and cybersex: Social and survival information bias in the transmission of urban legends. *British Journal of Psychology, 106*, 288–307.

Ungerleider, L. G., & Haxby, J. V. (1994). 'What' and 'where' in the human brain. *Current Opinion in Neurobiology, 4*, 157–165.

VanArsdall, J. E., Nairne, J. S., Pandeirada, J. N. S., & Blunt, J. R. (2013). Adaptive memory: Animacy processing produces mnemonic advantages. *Experimental Psychology, 60*, 172–178.

VanArsdall, J. E., Nairne, J. S., Pandeirada, J. N. S., & Cogdill, M. (2015). Adaptive memory: Animacy effects persist in paired-associate learning. *Memory, 23*, 657–663.

Wertz, A. E., & Wynn, K. (2014). Selective learning of plant edibility in 6- and 18-month-old infants. *Psychological Science, 25*, 874–882.

Wilson, S., Darling, S., & Sykes, J. (2011). Adaptive memory: Fitness relevant stimuli show a memory advantage in a game of pelmanism. *Psychonomic Bulletin & Review, 18*, 781–786.

Chapter 11
Adapting Evolution Education to a Warming Climate of Teaching and Learning

Gale M. Sinatra and Robert W. Danielson

There may be little agreement as to the actual level of evolution acceptance in the U.S. However, we have argued, and likely many would agree, that the level has remained low and relatively steady for decades (Sinatra & Danielson, 2014). Gallup poll numbers place evolution acceptance somewhere around 40 %, depending on how the question is phrased. In the U.S., less than 20 % accept the scientific explanation for human origins (Newport, 2014). Understanding and acceptance have been consistently poor arguably since Darwin's time. We posit that to shift these numbers, evolution educators must adapt to the new warmer climate in which they teach and in which students learn. By warmer climate, we are referring to the context of learning which is charged with emotions and motivations about science topics (Sinatra, Broughton, & Lombardi, 2014; Sinatra, Kienhues, & Hofer, 2014).

In this chapter, we draw on examples from our own research and that of others, in both evolution and climate science education, addressing the challenges of teaching and communicating about "hot" topics. By hot topics, we refer to those topics that the public believes to be controversial and about which individuals hold strong views. Since "controversy" is really in the eye of the beholder, a better description would be "socio-scientific" topics. Socio-scientific topics are those, such as evolution and climate change, which have both high personal and social relevance but are also embedded within a complex web of social and psychological issues such as identity, emotions, motivations, and beliefs (Sadler, 2009). The social-psychological context influences individuals' responses to these topics. Socio-scientific topics are "hot," not just because they are considered controversial, but also because they evoke "hot" or emotionally charged reactions in many individuals. However, socio-scientific topics can also promote interest and high engagement in learners as well

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as the opportunity to address many of the barriers that students must overcome to appreciate science (Sadler, 2009; Sinatra, Broughton, et al., 2014).

We begin by reviewing two generally accepted barriers to evolution understanding and acceptance: knowledge deficits and religious objections. We problematize the view that these are, either uniquely or jointly, the sole stumbling blocks for understanding and acceptance of evolution. We offer as an alternative a number of other barriers that research has shown are also important to consider. Specifically, we review folk or naïve views of biology, complexity and emergent systems, misconceptions, emotions, and identity. We review our own and others' research in these areas, and we conclude with instructional implications for teaching evolution within the "warmer climate" of today's classrooms, where emotions and motivations are key determinants of learning outcomes.

Barriers to Evolution Understanding and Acceptance

Evolution is both poorly understood and not well-accepted by the majority of US citizens. Before considering the barriers to understanding and acceptance, it is worth noting that while precise and commonly agreed-upon definitions of both constructs are elusive, many researchers do distinguish the two. Understanding refers to the depth of one's conceptual knowledge about evolution (Smith & Siegel, 2004). So for example, when we ask whether students understand the concepts of genetic drift, speciation, and random variation, we are asking what they know about these concepts. If they do understand them, we would expect that they could explain them to others, use them to think and reason about evolution, and apply their understanding to other problems (such as considering the effect of climate change on extinction events). If they do not understand these concepts, it may be because they lack knowledge of them or they hold misconceptions about them.

While understanding is a construct that is fairly easy to grasp, what is meant by acceptance is much less clear. Many have tried to sort out what it means to accept evolution (Smith & Siegel, 2004; Southerland, Sinatra, & Matthews, 2001). Some distinguish acceptance from belief (Smith, 2015), because scientists do not *believe* in evolution in that they do not take it on faith. Rather, their views are based on evidence and are subject to change if warranted by new evidence. Acceptance, then, refers to "the mental act or policy of deeming, positing, or postulating that the current theory of evolution is the best current available scientific explanation of the origin of new species from preexisting species," (Smith, 2015, p. 8). Or more simply put, acceptance refers to "perceptions of evolutionary theory's scientific validity" according to Rutledge & Warden (1999, p. 13). How to conceptualize these constructs warrants much more discussion (see further discussion of these issues in Sinatra & Nadelson, 2011; Southerland et al., 2001). For our purposes here, understanding refers to a degree of conceptual knowledge, and acceptance refers to a judgment about scientific validity. (For more on judgments about the plausibility of scientific theories, see Lombardi, Sinatra, & Nussbaum, 2013.)

The Knowledge-Deficit View

The theory of evolution is not a new scientific discovery. Recently, we celebrated the 150th year since the publication of Darwin's *Origin of Species* (Darwin, 1859). While the theory of evolution could certainly be called revolutionary, it should be treated in education analogously to the discovery of plate tectonics. That is, it should be taught in public school as our current scientific view of biological change, with few objections and no demands for teaching alternative theories. After all, we do not present the "fixist" view of continents as though it were still considered a viable alternative perspective (Frankel, 1987). The scientific debate about plate tectonics sharply divided the field of geology for nearly 50 years (Frankel, 1987). However, the matter is now considered settled (and has been since the 1960s). No eyebrows are raised, nor town-hall meetings held, when parents discover that plate tectonics will be part of their child's curriculum. Indeed, roughly 80 % of the public has a basic understanding of plate tectonics according to Miller (2004). So why is this not the case for biological evolution?

Many teachers and scientists express frustration at the persistently low levels of public understanding of evolution. They may think, "I don't understand why they don't get this. We went over variation and natural selection in class." They may reason that, "If I just *gave them more information*, they would accept evolution!" These comments represent the knowledge-deficit view. This view purports that evolution education should follow the simple recipe: "just add knowledge." However, if this perspective were correct, levels of evolution understanding and acceptance would show increases and decreases over time, aligned with the emphasis on teaching evolution in the schools. Yet the levels have remained relatively constant across time.

This stability in the acceptance rate is vexing for two reasons. First, the field of evolutionary biology has made tremendous strides in recent years. The number of new discoveries and the amount of evidence supporting evolution has continued to rise. Second, with the widespread use of the Internet, most of this information is just a click away on our computers. Yet despite this increase in information and access, the acceptance rate in the U.S. has remained stubbornly low and ranking below most European counties (Heddy & Nadelson, 2012; Miller, Scott, & Okamoto, 2006). As scientists determined to use evidence for decision-making, we must look skeptically at the knowledge-deficit view and admit that it does not explain the whole story.

So, why has this idea been resistant to change? The idea that humans are blank slates—empty vessels just waiting to be filled with knowledge—has a rich philosophical tradition that can be traced through Rousseau and Locke to Aristotle (Reynolds, Sinatra, & Jetton, 1996). Yet research clearly illustrates that humans are not simply knowledge-recording machines, where new information is inscribed and mistakes are easily erased and re-written. Advancements in research on pedagogy have also illustrated that the strategy of "just adding knowledge" is not particularly robust. Having students sit passively while professors pour information into them may work for some learners and certain topics, but this approach is about as effective as rote memorization (see also Toub et al. this volume). That is to say, it can work for memorizing basic facts such as state capitals, or the names of epochs, but there are better techniques to promote understanding of more complex phenomena.

A better instructional strategy is to have students connect with the content they are learning on a personal level—relating new knowledge to their prior knowledge. Recently, Heddy and Sinatra (2013) used an approach to teaching evolution designed to help students make personal connections to the content called, *Teaching for Transformative Experiences in Science* (TTES), originally developed by Pugh (2002). Heddy and Sinatra taught two groups of college students in a teacher education program six evolution concepts (adaptation, variation, inheritance, speciation, domestication, and extinction) using either the TTES model or a more traditional text and discussion instructional approach.

TTES is an instruction model designed to help students connect what they are learning to what they already know through the use of three key instructional elements: *active use*, *expansion of perception*, and *experiential value* (Pugh, 2002). Like the comparison group, student in the TTES group read and discuss text related to the six key conceptions. However, the TTES students are taught how to *actively use* the concepts they are learning about by applying them in their everyday experiences. For example, one student noted how after TTES instruction he had, "watched a show about the eastern cougar and thought about extinction" (p. 735). Next, TTES students are encouraged to consider how this broadens their view of the concept, promoting an *expansion of their perception*. One student, who upon realizing all life on earth is related, exclaimed, "I never thought I was related to a plant!" (p. 735). Finally, students are encouraged to find value in the concepts they are learning. Heddy and Sinatra (2013) shared this example of a student who they believe *valued the content*, commenting, "It (learning about evolution) was an excellent reminder to stop and reflect on what is going on around me. It makes my life more meaningful and answers questions about existence while creating new ones" (p. 735).

The results of this study showed that both the groups showed learning gains. However, the TTES instructional group who were taught to actively use, expand their perception of, and value the content showed greater learning gains than the traditional instructional group. The group who experienced the TTES model that emphasized connecting to the content on a personal level not only showed significantly higher gains than the comparison group, but they actually reported that they *enjoyed* the instruction. Since positive emotions are associated with positive learning outcomes (Pekrun & Stephens, 2012), this was a particularly important finding.

Heddy and Sinatra's (2013) study shows that knowledge about evolution can be gained, but not by a simple addition process. Rather, students must be encouraged to connect in meaningful ways to that knowledge. Knowledge is not simply added into a student's head, but rather the learner must actively use the information in a personally meaningful way. Concepts are more likely to be incorporated into students' knowledge base if students' change the way they see the world around them, experience a sense of value, and perhaps even a sense of awe and wonderment. This study demonstrates how by bringing a "warmer," more affective view of learning into the classroom, learning can be enhanced and enriched.

The Religious Objection View

Some argue that knowledge deficits are the key reason for poor evolution acceptance (Lawson & Weser, 1990). In other words, one cannot accept evolution as a valid scientific theory with an impoverished understanding of the theory, the argument goes. Alternatively, others argue that religious beliefs stand in the way of acquiring knowledge about evolution (Rissler, Duncan, & Caruso, 2014). If the "just add knowledge" fallacy applies to the way we think students learn, then the "religious objections" fallacy applies to the way we think about our role as educators. This thinking creates a Catch 22 of sorts—that is, if students cannot accept evolution without sufficient knowledge, and religious beliefs stand in the way of students gaining said knowledge, then where does that leave us? Further complicating the issue is the concern that we cannot address knowledge gaps because we cannot (or should not) change students' religious beliefs. We want to close the gaps in students' knowledge, but by attempting to close these gaps educators fear crossing the border from biology education into religious studies. Evolution educators may think that, "If we could just add some knowledge, these students could understand evolution. However, we cannot add any knowledge without encroaching on religious beliefs. And since changing religious beliefs is outside of our purview, we just can't do anything to move the needle on evolution acceptance."

The first point we want to make is that many world religions have authored statements indicating that they accept the theory of evolution as either compatible with, or at least not incompatible with, their respective teachings. According to PEW, these include: Buddhism, Catholicism, Judaism, and many denominations of Christianity (Episcopalians, Presbyterians, United Church of Christ, and United Methodist Church), Hinduism, and less conservative denominations of Islam (see http://ncse.com/media/voices/religion). In addition, there are individuals of faith and even scientists of faith who have no problem reconciling their two world views (see for example, Miller, 1999). This should serve as initial evidence that even though there is a strong relationship between religiosity and evolution acceptance (Nadelson & Hardy, 2015; Rissler et al., 2014), *religion in and of itself is not the main problem*, in that religious belief and acceptance and understanding of evolution do coexist for some individuals. Of course, not everyone agrees that such a resolution is theoretically possible (Coyne, 2015). However, even Coyne acknowledges that "evolution… is accepted by many Jews, Buddhists, Christians, and liberal Muslims" (Coyne, 2015, preface).

We suggest that a more important hurdle is to understand what students *think* it means to accept evolution (Brem, Ranney, & Schindel, 2003). Brem et al. (2003) showed that even those who accept evolution have strong negative feelings about it. Richard Dawkins has accumulated quite a bit of reactionary mail (see https://richarddawkins.net/2015/01/love-letters-to-richard-dawkins/) and their contents are rather revealing as to the mindset of those opposed to his ideas—very few letters attempt to dispute the science. Most are vitriolic in tone and express some combination of rage, disbelief, and profound sadness. This is important because it illustrates the strong emotions that students are struggling with when they attempt to process scientific ideas they perceive to be in conflict with their beliefs. The debate has moved from the realm of science, a place that many scientists are comfortable, into the realm of politics and personal beliefs, a place where many scientists may feel less comfortable. However, failure to engage with students where they are—a failure that is endemic in evolutionary education—leaves students confused about what it means to accept evolutionary theory. Educators have their own emotions and many are concerned about how best to teach evolution without upsetting students or their parents (Griffith & Brem, 2004; Nadelson & Sinatra, 2009). (It is noteworthy that acceptance rates among teachers are comparable to the general public, Losh & Nzekwe, 2011; Nadelson & Sinatra, 2009.) Instead of engaging in what Stanley Fish (2008) describes as "academicizing" these difficult subjects, we suggest that educators meet students where they are in their understanding. Acknowledging that for many individuals science and religion are compatible (Miller, 1999) can be a starting point. Demarking the differences between religion and science can also help (Sinatra & Nadelson, 2011). Ultimately, students will decide what it means for them to accept or reject scientific explanations such as evolutionary theory—but by illustrating that for at least some individuals (if not many) the choice is not one *between* science and religion, we may allow students to find "a place to stand" (Sinatra & Nadelson, 2011; Southerland et al., 2001).

We fully acknowledge that knowledge deficits and religious objections are concerns for promoting both evolution understanding and acceptance. However, there are other barriers that also have great import but receive less attention. This is unfortunate because they may be more tractable. By focusing on these other barriers, we may be able to push the needle a bit more than we have to date. These include folk knowledge, misconceptions, complex and emergent systems, academic emotions, and identity. We turn to these next.

Folk Biology

There is a growing body of research suggesting that understanding evolution requires us to think in ways that conflict with our "default" modes of thinking and reasoning about living things and perhaps even requires us to suppress this conflicting knowledge (Shtulman & Valcarcel, 2012). Known as cognitive biases (Evans, 2008), or folk knowledge (Geary, 2007, 2008), our evolutionary history endowed us with modes and methods of thinking and reasoning about the world that were adaptive in our past, but ironically make it difficult for us to comprehend our biological heritage.

Evans and others have written extensively about these inherent conceptual barriers to evolutionary thinking (Evans, 2008; Kelemen, 1999). These researchers have described how naïve or intuitive theories or cognitive biases conflict with the types of thinking required for understanding evolution (Shtulman & Valcarcel, 2012). Cognitive biases such as essentialism, teleology, and intentionality present specific difficulties for individuals' learning about biological evolution. Essentialism is the idea that living things have an "essence" that is immutable. Even young children are aware that some transformations are biologically irrelevant. For example, if you dress a cat in a dog costume, even very young children know the "essence" of the cat has not changed. Essentialism is an asset to the developing child who is learning to categorize different animals (Carey, 2009) and is functional in terms of hunting and horticulture in traditional settings (Atran, 1998). However, it is a barrier when learning about species change.

Teleology is the belief that behavior is goal-directed. This leads to another challenge for evolutionary thinking, because it underlies a scientific misconception, that of a needs-based view of evolution. Individuals learning about evolution may reason that birds have wings because they "need" them to fly or that fish have gills because they "need" them to breath under water. This presents a challenge for understanding that adaptations are biological responses to a changing environment, not responses based in meeting an individual organism's needs. The third bias is intentionality, or the idea that an intelligent agent is responsible for goal-directed actions (Evans, 2008). Coupled with teleological thinking, naïve learners of evolution might reason that fish need gills, ergo, someone must have provided them with gills.

Taken together, these three biases contradict basic scientific tenants of evolution, such as random favorable mutations being preserved resulting in adaptations to environmental conditions. Rather than being developmentally primed to acquire a scientific view of biological change, Evans argues that we are instead predisposed to view life on earth as the result of the goal-directed intentional actions of a designer who created species in the well-adapted forms we see today. In the words of Ernst Mayr, "evolution, in a way, contradicts common sense," (Mayr, 1982, p. 309).

These default modes of thought most likely evolved themselves to provide quick, heuristic solutions to "biological primary" problems encountered when interacting with other living organisms such as "should I eat this, befriend this, or will I be eaten by this?" These heuristics provide helpful shortcuts for managing and navigating through the natural world, but when they are employed to solve what Geary refers to as "biological secondary" problems, that is, learning evolutionarily novel concepts, they serve us less well.

Biologically, primary domains are organized around folk psychology (knowledge and biases related to the self and other people), folk biology (knowledge and biases related to other species), and folk physics (knowledge and biases related to the physical world) (Geary & Berch, this volume). Examples include facial recognition and language learning (Geary, 2008). These are tasks humans have acquired the ability to learn quite easily. Associated knowledge and biases are partially built-in and partially fleshed-out and adapted to local conditions through experience, which results in easy and rapid learning. Indeed, children do not have to be explicitly instructed to learn to recognize a face. The propensity to recognize a face is so strong that we tend to see faces even when they are not there (i.e., the ubiquitous "man in the moon"). Language is much the same way; any normal developing child with adequate cognitive and hearing abilities will acquire the language of the speaking adults around him or her with little effort and without much in the way of direct instruction. However, understanding evolution requires what Geary describes as "biologically secondary" modes of thought. Topics such as trigonometry and reading are not readily learned without direct instruction (Sweller, this volume). Indeed, many humans of normal intellectual abilities fail to acquire one or the other of these abilities even with explicit instruction and deliberate effort and study.

These default modes of thought provide strong resistance to acquiring a scientifically accurate conception about biological change. However, research has shown that even learners with strongly biased or misconceived ideas about evolution can benefit from instruction (Shtulman & Calabi, 2013). When students have the opportunity to receive direct instruction in the areas of their misconceptions, learning can occur. We turn to misconceptions next.

Misconceptions

Any biologist can attest that humans are very complex organisms. Likewise, any psychologist can attest that the process of human learning is also very complex. Yet this complexity is lost on many—although human capabilities like walking down the street or tracking and catching a football are seen as naturally easy processes, the best minds in the world are currently struggling to design machines that can do these tasks as effectively as an 8-year-old child. Similarly, once an individual learns how to read (a difficult process for many), reading seems an effortless, automatic task. While many computers would have a very difficult time reading a passage where 75 % of the words are misspelled, *in fcat, hunams cna raed comlpex setnecnes evne wehn the lettres are jumlbed*!

Although humans have evolved an amazing capacity for sense making, our ability to make sense of what we see around us often leads to *misconceptions*. These misconceptions can often be tied to folk beliefs. For example, the Earth appears flat to young children, objects of greater weight appear to fall faster, and it makes intuitive sense that during the summer the Earth should be closer to its heat source, the Sun. These notions may have served our ancestors well in the past, but they are not as useful for developing scientific understandings of the same phenomena. In many ways, science is *counter-intuitive*, and students must discard their previously held ideas in order to gain more sophisticated scientific understanding.

In prior research, we have found that telling students that Pluto had been reclassified as a dwarf planet draws not only confusion, but frustration, surprise, and even anger on the part of elementary school students (Broughton, Sinatra, & Nussbaum, 2011). The process of changing conceptual knowledge is known as accommodation or conceptual change and can be very cognitively and emotionally taxing (Dole & Sinatra, 1998; Sinatra, 2005).

Misconceptions arise as natural extensions from everyday inferences that often serve us well. It turns out that humans are very good at classifying objects, but the challenge comes when they must be re-classified. Sometimes misconceptions can be restructured through direct instruction (such as learning the spherical shape of the Earth) (Vosniadou & Brewer, 1992). Some misconceptions persist despite direct instruction (many adults continue to hold the erroneous belief that seasonal change is due to the Earth's position relative to the sun) (Cordova, Sinatra, Broughton, Taasoobshirazi, & Lombardi, 2014).

Misconceptions can be very intuitively appealing—the sun is hot, the Earth's rotation is elliptical, so when the Earth is closer to the sun the Earth should be warmer. This idea is incorrect, but it seems right. Telling students the correct information is often not sufficient if they hold a misconception. They may reject the correct concept outright, or if not, they may modify the information to fit with their misconception (Chinn & Brewer, 1993). Instead, instructional approaches that directly confront the misconception, such as refutation texts, have been shown to be more effective than simply providing the correct information (Sinatra & Broughton, 2011).

A refutation text presents the misconception and then directly refutes it. This is an important distinction because readers generally cannot hold all this information in mind at the same time (Sweller, this volume). For example, "fossil and DNA evidence suggest that humans and apes share a common ancestor" implies that humans did not evolve from modern day apes. In contrast, the refutation text would state the misconception: "Some people think that humans evolved from modern day apes," and then directly refute it by stating, "However, this is not correct." This would be directly followed with an explanation of the scientific concept such as "Fossil and DNA evidence suggest that humans and apes share a common ancestor." Evidence suggests that this approach helps students hold both the naïve idea and the scientific idea in mind at the same time, allowing them to notice the contradiction (Kendeou & van den Broek, 2007).

There are a myriad of misconceptions about evolution that are well-identified and researched (Alters & Nelson, 2002; Sinatra, Brem, & Evans, 2008; West, El Mouden, & Gardner, 2011). We suggest that educators actively refute these misconceptions. Teaching the correct conception well is not necessarily sufficient. Even when students can answer questions correctly about hominid common ancestry, they may still harbor the misconception about human's relation to modern apes if it is not directly refuted.

Using refutation texts has been shown to be effective both with non-controversial topics (like photosynthesis or seasonal change) as well as "controversial" topics like evolution or climate change. In our own research, we have used them effectively to overcome misconceptions on many topics including Pluto's reclassification (Broughton et al., 2011), seasonal change (Cordova et al., 2014), genetically modified foods, (Heddy, Sinatra, & Danielson 2014), climate change (Danielson, Sinatra, Jaeger, & Wiley, 2015), and evolution (Heddy & Sinatra, 2013). However, in addition to refutation texts, there are a host of other effective techniques for confronting misconceptions such as discussion, argumentation, experimentation, and the use of simulations, which also give students the opportunity to confront their misconceptions (Duit, Treagust, & Widodo, 2008).

Complexity/Emergent Systems

Understanding evolution requires individuals to grapple with a complex and emergent system. The challenges students have understanding complex and emergent systems have been well-documented (Chi, 2005; Hmelo-Silver & Azevedo, 2006; Penner, 2000). Such systems have properties that are not easy to understand without instruction because they are counterintuitive. As Hmelo-Silver and Azevedo (2006) explain, complex systems tend to have a hierarchical structure with interacting levels. Thinking and reasoning about complexity is taxing on cognitive resources such as working memory, and to make matters worse, these systems are not often addressed in regular instruction.

Emergence is a property of complex systems that presents its own unique challenges. In emergent systems, predicting outcomes is not a straightforward process of summing up the effects of each component part. Rather, higher-level properties can emerge as the result of components interacting at lower levels of the system (Penner, 2000). Chi (2005) explained how the nature of student misconceptions about emergent systems makes them robust and difficult to overcome. This may be a domain general phenomenon in so far as evolution, climate change, and other complex systems all share emergent properties that are likely to present conceptual challenges for learners (Lombardi, Seyranian, & Sinatra, 2014). Chi argues that while students readily understand direct causal schemas and narratives from their day-to-day experience, they struggle with indirect causal models that underlie emergent systems (Chi, Roscoe, Slotta, Roy, & Chase, 2012). Features of direct causal systems and narratives include a triggering event, a protagonist with goals, a series of actions, and causal connections between actors and outcomes. Students encounter difficulties when they try to apply the features of the direct causal or narrative explanation to a complex and emergent system where these characteristics do not apply.

Fortunately, instruction designed to address these conceptual challenges can make a difference. Hmelo-Silver and Azevedo (2006) argue that computer-based learning environments hold promise for teaching students about complex and emergent systems. These provide not only the opportunity to experience these systems, but embedded support within the learning environment can scaffold learning by helping students understand the unique properties of these systems. Chi (2005) recommends that directly teaching students the underlying causal structure of emergent systems, and how they differ from direct causal systems, can help them overcome their misconceptions about emergent processes. Perhaps instruction in the differences between direct and emergent systems should be a key component of evolution instruction.

Academic Topic Emotions

Science is considered by some to be a rational enterprise devoid of affect and emotions. This notion is misguided, as feeling and thinking human beings conduct science. Science learning is also rife with both positive and negative emotions (Sinatra, Broughton, et al., 2014). Emotions impact every aspect of science learning including thinking, reasoning, and evaluating scientific evidence. Definitions of emotion vary (Linnenbrink, 2002); however, emotions are often characterized as quick, automatic, often unconscious affective responses to a specific referent (Rosenberg, 1998). Pekrun (2006) describes academic emotions as "multi-component, coordinated processes of psychological subsystems including affective, cognitive, motivational, expressive, and peripheral physiological processes" (p. 316). In previous work, we have described emotions as "mediating the science learning experience, through their impact on cognitive processing, motivation, engagement, and learning outcomes," (Sinatra, Broughton, et al., 2014).

Topic emotions are a specific type of academic emotions (such as anxiety, anger, or enjoyment), which are experienced by students when learning about a particular topic within a specific domain. Topic emotions are aroused by the topic itself, such as those that may be experienced by students when learning about human evolution in a biology class (Pekrun & Stephens, 2012; Sinatra, Broughton, et al., 2014). Epistemic emotions, or emotions about knowledge, are a subclass of topic emotions such as curiosity, interest, frustration, boredom, and confusion, which can also be triggered by learning about a specific topic (Muis et al., 2015; Pekrun & Linnenbrink-Garcia, 2012).

In our work, we have empirically demonstrated that epistemic emotions emerge when learning about controversial topics such as curiosity about climate change (Muis et al., 2015), confusion about genetically modified foods (Heddy, Sinatra, & Danielson, 2014), and surprise and frustration about Pluto's demotion to dwarf planetary status (Broughton et al., 2011). Educators may be leery of acknowledging that these emotions are in play in their classroom. However, epistemic emotions can be learning catalysts. D'Mello, Lehman, Pekrun, and Graesser (2014) have described the role of confusion during learning about complex topics. They argue that confusion is likely to result when learners recognize a mismatch between their prior knowledge and the to-be-learned information, which creates dissonance. However, this type of situation is potentially ripe for learning because if the learner puts forth the effort necessary to resolve the discrepancy successfully, the end result is positive for learning.

When information is complex and conflicting, as students might encounter when learning about evolution, students' beliefs about the nature of knowledge as well as their epistemic emotions may be triggered and can play a key role in how they engage with the content. Muis et al. (2015) demonstrated that when presented with conflicting information about climate change, those students who believed that justifying knowledge claims requires critical evaluation reported higher levels of curiosity and enjoyment, lower levels of boredom, and employed more successful learning strategies. Furthermore, students who reported a belief that knowledge is uncertain also reported lower levels of anxiety when learning about the conflicting accounts of climate change. Muis et al. conclude that, "scaffolding or supports for the kinds of cognitive incongruity that individuals may experience when presented conflicting information may be necessary to foster positive change" (p. 182). In other words, educators should expect students to have affective reactions when learning about complex or conflicting accounts of biological change and that when these are acknowledged and supported during instruction, they can be beneficial to learning.

Motivation

Many of the challenges we have noted influence students' motivation regarding how they engage with information about evolution. In general, motivations characterize why people tend to approach or avoid certain topics or situations (Meyer & Turner, 2002). The word "motivation" derives from the Latin verb "to move," and unfortunately, many students are motivated to move away from evolution education. It is important to note that these students may not *lack* motivation—however, they may be motivated to disengage. Understanding students' motivations can help educators intervene, and hopefully, change this trajectory.

Educators too can be burdened with negative emotions that hinder communication and contribute to avoidance of enacting curriculum to meet state standards for evolution instruction. Many evolution educators are motivated to avoid confrontations with students and their parents, and they wish to avoid triggering negative emotions and experiences for their students. It has been documented that even thinking about teaching evolution can cause clinical levels of stress (Griffith & Brem, 2004). We suspect that this is one reason that the *knowledge deficit view* and *religious objection view* are so pervasive. Educators might be motivated to stick to the information in the textbook, hoping it will sink in and avoid drifting into a conversation about beliefs. This is also why, when facing strong criticism or resistance, some educators may simply omit or water down their teaching on biological evolution. We hope that understanding the emotions and motivations student are likely to bring to the classroom will help educators be prepared to cope with these situations when they emerge.

Generally speaking, humans want to approach experiences that are interesting or promote positive feelings and avoid experiences that are boring or promote negative feelings (Pekrun, 2006). We know from previous research that many students have strong negative emotions and conceptions about evolution, and this can lead to avoiding the topic or to disengagement. Making evolution education less threatening and more personally relevant (i.e., the evolution of drug resistance) is one way to increase engagement and enjoyment (Hawley & Short, 2015; Heddy & Sinatra, 2013). Providing students with a safe environment in which they can question the content and feel comfortable talking about their beliefs is important for creating the right context.

Motivations can also impact how individuals think and reason. *Motivated reasoning* describes how individuals' motivations, that is, their goals for processing information, can bias their judgments (Kunda, 1990). Individuals motivated to come to a desired conclusion (such as climate change is a hoax or humans are a special creation or vaccines cause autism) process information differently than those who are "accuracy driven" or motivated to get to the best answer, rather than a particular answer. For example, they will be more critical of information that supports the counter perspective than they are of information that supports their own point of view.

It has been well-documented that individual differences in motivations, such as the need to avoid uncertainty or ambiguity, relate to information processing, decision making, and even political affiliation (Jost, Glaser, Kruglanski, & Sulloway, 2003). Those individuals who are motivated to avoid uncertainty or are uncomfortable with uncertainty have been shown to be less accepting of evolution, and conversely, those individuals who are more open-minded and more comfortable with uncertainty are more accepting of evolution (Sinatra, Southerland, McConaughy, & Demastes, 2003). Confronting motivated reasoning is a tough challenge in part because individuals are often unaware that their motivations are impacting their thinking. Helping students consider their own motivations for accepting or rejecting scientific perspectives can put some educators in uncomfortable situations, but reflecting on our motives is the only way to bring them into our conscious attention (Hawley & Short, 2015). Individuals may also be committed to an idea because abandoning it would have personal or social consequences. Thus, individuals' motivations to accept or reject evolution may have consequences for their identity, which we turn to next.

Identity

A liberal colleague recently told me a story. He was visiting his mother-in-law who lived in a politically conservative neighborhood. During a political discussion among a group of her friends, one elderly woman leaned over to him and whispered, "I don't agree with them, but don't tell them. I don't want to get kicked out of the group." This may have just been a witty quip, or it could have been a genuine concern. The tendency to form ingroups and outgroups is inherent in the human species and shared ideas are one defining feature of an ingroup. An ingroup is a group with whom an individual shares characteristics, such as beliefs, that have strong emotional resonance for the individual's social identity (Sinatra & Seyranian, 2016). In other words, if an individual identifies with a group, group membership and adoption of the group's beliefs becomes part of how they identify. Perhaps conservatives are skeptical of climate change in part because they know that members of their ingroup tend to share that skepticism. A conservative who accepts the scientific perspective that humans are contributing to global warming may feel reluctant to share that perspective with other ingroup members for fear of being ostracized from the group. Similarly, some students may think that by accepting evolution they are rejecting or will be rejected by members of their family, religious community, or social group. Indeed, evidence suggests that parents' beliefs are a strong predictor of students' eventual perspectives on evolution (Evans, 2000).

Group membership can even influence how individuals perceive a message. Sinatra and Seyranian (2016) explain how messages from ingroup members can be more persuasive than those from outgroup members. In other words, if a student's pastor is telling her that evolution is a myth or evil, and her classroom teacher is telling her that scientists claim it is the best explanation of biological relatedness on Earth, the pastor may be more persuasive if he is perceived to be a member of the student's ingroup and teachers (or scientists) are perceived as members of an outgroup. Indeed, outgroup members (scientists if you are not a scientist) are not necessarily trusted and this lack of trust relates to evolution acceptance (Nadelson & Hardy, 2015). This may be why the ingroup members who are scientists may be the most impactful in promoting understanding and acceptance of scientific issues (Hayhoe & Farley, 2009; Miller, 1999).

Learning raises identity issues for students (Kaplan & Flum, 2009) and learning about evolution perhaps more so than other domains. In a research study the first author conducted on understanding evolution, one student wrote on her paper, "If I accept evolution, than who will I be?" I have had other students say that they cannot discuss evolution with their family members. Questioning one's identity should not have to be the price a student pays to understand evolution, but for some of these questions do arise and it can be life-altering to have to confront them head on.

If educators can recognize these feelings in students, they may be able to turn the motivation to disengage with evolution into a motivation to learn more about evolution. First, many students incorrectly believe that their faith is against evolution. For example, a devout Roman Catholic student may believe that evolution and their religious beliefs are in direct confrontation. It may be helpful to this student to learn that Pope Francis declared that evolution and Catholicism are not in conflict. This may open the door for this student to learn more about evolution. Second, scientists may also be persons of faith and there are those who do not perceive this as a conflict (Miller, 1999). Indeed, a number of scientists have declared that as their understanding of science and evolution increased, the depth of their faith and the wonder they see in the world has increased as well. Third, it is important to let students know that religion and science are seen by many to be asking and answering different questions (Sinatra & Nadelson, 2011), and while science can tell you what you are made of (carbon atoms), questions about one's identity might be explored in other ways.

Implications for Evolution Education

We have raised a number of issues that impact both the teaching and learning of evolution. Issues such as knowledge deficits and misconceptions, religious objections, cognitive biases, motivation, emotions, and identity all play key roles in evolution understanding and acceptance. The list is daunting and it is by no means complete (for more challenges, see Rosengren, Evans, Brem, & Sinatra, 2012). And yet, we are hopeful because when instruction is designed to meet at least some of these challenges, evidence suggests that it will be more effective. In this section, we list our recommendations for instruction based on the research we have reviewed.

1. *Determine What Students Know and Believe Prior to Instruction*

   Prior knowledge, misconceptions, and strongly held emotions and beliefs are much more likely to interfere with learning when instruction proceeds without these being on the table. Instructors should assess students' knowledge and survey students' degree of acceptance of evolution prior to instruction. Many tests and measures of knowledge and acceptance are available in the literature (see for example, Anderson, Fisher, & Norman, 2002; Nadelson & Southerland, 2012; Rutledge & Warden, 1999; Settlage & Jensen, 1996) or instructors can construct their own. Instructors cannot address misconceptions they do not know their students' hold. Once they do, they can confront them directly. Instructors may be reluctant to find out about their students' emotions and beliefs prior to instruction, but having them come up later in the course of instruction can undermine the classroom climate and students' learning.
2. *Let Students Know that Religion and Science Are not Necessarily in Conflict*

   There will always be individuals who resist science and see it as in conflict with their own religion or worldview. But, it helps those students from faiths not in conflict with science to hear this as they may not be aware. Some of the strongest objectors to evolution may be ill-informed not only about biology, but about the religious doctrine of their own faith. Of course, evolution educators cannot teach world religions, but they can acknowledge that there are faiths that are not in conflict and they can invite students to explore their own faith's positions. It is also important to let students know that there are scientists who are also persons of faith (Hayhoe & Farley, 2009; Miller, 1999). Examples help students to see that there are individuals who have reconciled science and religion productively in their own lives. This may open the door for them to re-envision that accepting evolution and even becoming a scientist are possibilities for their future identity (Barton et al., 2012).
3. *Make the Content Personally Relevant, Interesting, and Interactive*

   Students learn most content better when instruction is personally relevant. But for a topic such as evolution, it is even more critical that students see the relevance to their daily lives. Issues such as antibiotic use, animal to human organ transplants, and genetically modified organisms can be relevant and intriguing to students. Having students conduct their own inquiry into these or other timely issues of interest to them is much more likely to be engaging than lectures and textbook assignments. There are many excellent resources for evolution lessons that are compelling and interactive (for example, see the Understanding Evolution website or the journal *Evolution: Education and Outreach*). Evolution simulations are available for students as young as elementary grade levels (see the Concord Consortium website).
4. *Teach Evolution as a Complex and Emergent System*

   Too often, the urge is to simplify science for students as we try to stick to "just the basics." However, for complex and emergent systems such as evolution, "dumbing it down" is probably not a successful strategy. Understanding how multiple lines of evidence from the fossil record, as well as the DNA of living organisms, all converge to tell a coherent story about the interconnectedness of life on Earth is compelling. Supporting students' understanding of how complexity can emerge from the component processes of evolution may be more convincing than glossing over complexities.

5. *Acknowledge Their Motivations, Emotions, and Identity Issues*

   Students' motivations, emotions, and issues of identity may be avoided or ignored by educators, particularly by those with the best intentions of maintaining a comfortable learning environment. But as we have argued, whether acknowledged or ignored, affective processes are the elephant in the middle of the classroom. That is, whether they are out in the open or below the surface, emotions and motivations are as important in learning as prior knowledge. Recognition of and sensitivity to students' affective states allows the student the opportunity to bring his or her lived experiences into the learning context in a productive way. It also gives educators the opportunity to help students navigate and manage their feelings. The fear educators may have is that this could backfire on them and create discomfort for learners. Our guess is that the discomfort is already there, they may just not be aware of it. We encourage educators to make the classroom a safe place for students to share their concerns and objections. Students may or may not change those views, but, if left unacknowledged, they likely will harbor negative feelings and reject the content. In other words, there may be much less to lose by opening up the door to difficult conversations than there is by keeping it shut. Excellent resources exist for engaging in difficult conversations (Young, 2003). Employing a mediator (a counselor or instructor from another discipline) trained in facilitation strategies might be a good strategy for anyone inexperienced in handing strong emotions.

Conclusions

Levels of evolution understanding and acceptance have remained relatively flat in the U.S. for decades. We acknowledge that individuals simply do not know enough about evolution and we admit that their own worldviews or religious faith may serve as a barrier to learning more about it. Beyond these concerns, we contend that classrooms are a "warm" environment, filled with motivations and emotions that are both doors and keys to learning. Specifically, we encourage educators to consider the research on folk or naïve views of biology, complexity and emergent systems, misconceptions, emotions, and identity as potential levers of change. Out of this research, we make five instructional recommendations, (1) assess students' knowledge and beliefs before instruction; (2) acknowledge that many individuals and scientists have personally resolved conflicts between their religious beliefs and science; (3) help students make active and personal connections to the content; (4) teach evolution as a complex, emergent system; and, (5) acknowledge the "hot" constructs that are in the classroom. We argue that by preparing ourselves as evolution educators to teach within such warmer climates, we have a better chance to nudge the needle towards scientific perspectives on evolution.

References

Alters, B. J., & Nelson, C. E. (2002). Perspective: Teaching evolution in higher education. *Evolution, 56*(10), 1891–1901.

Anderson, D. L., Fisher, K. M., & Norman, G. J. (2002). Development and evaluation of the conceptual inventory of natural selection. *Journal of Research in Science Teaching, 39*(10), 952–978.

Atran, S. (1998). Folk biology and the anthropology of science: Cognitive universals and cultural particulars. *Behavioral and Brain Sciences, 21*(04), 547–569.

Barton, A. C., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2012). Crafting a future in science tracing middle school girls' identity work over time and space. *American Educational Research Journal, 50*(1), 37–75. doi:10.3102/0002831212458142.

Brem, S. K., Ranney, M., & Schindel, J. (2003). Perceived consequences of evolution: College students perceive negative personal and social impact of evolutionary theory. *Science & Education, 87*(2), 181–206.

Broughton, S. H., Sinatra, G. M., & Nussbaum, E. M. (2011). "Pluto has been a planet my whole life!" Emotions, attitudes, and conceptual change in elementary students' learning about Pluto's reclassification. *Research in Science Education, 42*, 1–22. doi:10.1007/s11165-011-9274-x.

Carey, S. (2009). *The origin of concepts*. New York, NY: Oxford University Press.

Chi, M. T. H. (2005). Commonsense conceptions of emergent processes: Why some misconceptions are robust. *The Journal of the Learning Sciences, 14*(2), 161–199.

Chi, M. T. H., Roscoe, R. D., Slotta, J. D., Roy, M., & Chase, C. C. (2012). Misconceived causal explanations for emergent processes. *Cognitive Science, 36*(1), 1–61.

Chinn, C. A., & Brewer, W. F. (1993). The role of anomalous data in knowledge acquisition: A theoretical framework and implications for science instruction. *Review of Educational Research, 63*, 1–49.

Cordova, J., Sinatra, G. M., Broughton, S. H., Taasoobshirazi, G., & Lombardi, D. (2014). Self-efficacy, confidence in prior knowledge, and conceptual change. *Contemporary Educational Psychology, 39*, 164–174. doi:10.1016/j.cedpsych.2014.03.006.

Coyne, J. A. (2015). *Faith vs. fact: Why science and religion are incompatible*. New York, NY: Viking.

D'Mello, S., Lehman, B., Pekrun, R., & Graesser, A. (2014). Confusion can be beneficial for learning. *Learning and Instruction, 29*, 153–170. doi:10.1016/j.learninstruc.2012.05.003.

Danielson, R. W., Sinatra, G. M., Jaeger, A., & Wiley, J. (2015). *Augmenting the refutation-text effect with analogies and graphics*. Paper presented at the Society for Text and Discourse, Minneapolis, MN.

Darwin, C. (1859). *On the origin of species by means of natural selection*. London, England: John Murray.

Dole, J. A., & Sinatra, G. M. (1998). Reconceptualizing change in the cognitive construction of knowledge. *Educational Psychologist, 33*(2/3), 109–128. doi:10.1080/00461520.1998.9653294.

Duit, R., Treagust, D. F., & Widodo, A. (2008). Teaching science for conceptual change: Theory and practice. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (pp. 629–646). Dordrecht, The Netherlands: Springer.

Evans, E. (2000). The emergence of beliefs about the origins of species in school-age children. *Merrill-Palmer Quarterly, 46*, 221–254.

Evans, E. (2008). Conceptual change and evolutionary biology: A developmental analysis. In S. Vosniadou (Ed.), *International handbook of research on conceptual change*. New York, NY: Routledge.

Fish, S. (2008). *Save the world on your own time*. New York, NY: Oxford University Press.
Frankel, H. (1987). The continental drift debate. *Resolution of Scientific Controversies: Case Studies in the Resolution and Closure of Disputes in Science and Technology*. Cambridge, MA: Cambridge University Press.
Geary, D. C. (2007). Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology. In J. Carlson & J. Levin (Eds.), *Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology* (pp. 1–99). Charlotte, NC: Information Age Publishing.
Geary, D. C. (2008). An evolutionarily informed education science. *Educational Psychologist, 43*(4), 179–195.
Griffith, J., & Brem, S. K. (2004). Teaching evolutionary biology: Pressures, stress, and coping. *Journal of Research in Science Teaching, 41*(8), 791–809.
Hawley, P. H., & Short, S. D. (2015). The effects of evolution education: Examining attitudes towards and knowledge of evolution in college courses. *Evolutionary Psychology, 13*(1), 67–88.
Hayhoe, K., & Farley, A. (2009). *A climate for change: Global warming facts for faith-based decisions*. New York, NY: Hachette Book Group.
Heddy, B. C., & Nadelson, L. S. (2012). A global perspective of the variables associated with acceptance of evolution. *Evolution Education and Outreach, 5*(3), 412–418.
Heddy, B. C., & Sinatra, G. M. (2013). Transforming misconceptions: Using transformative experience to promote positive affect and conceptual change in students learning about biological evolution. *Science Education, 97*, 725–744. doi:10.1002/sce.21072.
Heddy, B. C., Sinatra, G. M., & Danielson, R. W. (2014). *Modifying attitudes, emotions, and conceptual knowledge about genetically modified foods*. Paper presented at the American Educational Research Association, Philadelphia, PA.
Hmelo-Silver, C. E., & Azevedo, R. (2006). Understanding complex systems: Some core challenges. *The Journal of Learning Sciences, 15*(1), 53–61.
Jost, J. T., Glaser, J., Kruglanski, A. W., & Sulloway, F. J. (2003). Political conservatism as motivated social cognition. *Psychological Bulletin, 129*, 339–375.
Kaplan, A., & Flum, H. (2009). Motivation and identity: The relations of action and development in educational contexts—An introduction to the special issue. *Educational Psychologist, 44*(2), 73–77.
Kelemen, D. (1999). Why are rocks pointy? Children's preference for teleological explanations of the natural world. *Developmental Psychology, 35*, 1440–1452.
Kendeou, P., & van den Broek, P. (2007). The effects of prior knowledge and text structure on comprehension processes during reading of scientific texts. *Memory & Cognition, 35*, 1567–1577.
Kunda, Z. (1990). The case for motivated reasoning. *Psychological Bulletin, 108*(3), 480–498.
Lawson, A. E., & Weser, J. (1990). The rejection of nonscientific beliefs about life: Effects of instruction and reasoning skills. *Journal of Research in Science Teaching, 27*(6), 589–606.
Linnenbrink, E. (2002). Emotion research in education: Theoretical and methodological perspectives on the integration of affect, motivation, and cognition. *Educational Psychology Review, 18*(4), 307–314.
Lombardi, D., Seyranian, V., & Sinatra, G. M. (2014). Source effects and plausibility judgments when reading about climate change. *Discourse Processes, 51*(1–2), 75–92. doi:10.1080/0163853X.2013.855049.
Lombardi, D., Sinatra, G. M., & Nussbaum, E. M. (2013). Plausibility reappraisals and shifts in middle school students' climate change conceptions. *Learning and Instruction, 27*, 50–62. doi:10.1016/j.learninstruc.2013.03.001.
Losh, S. C., & Nzekwe, B. (2011). Creatures in the classroom: Preservice teacher beliefs about fantastic beasts, magic, extraterrestrials, evolution and creationism. *Science & Education, 20*(5–6), 473–489.
Mayr, E. (1982). *The growth of biological thought: Diversity, evolution, and inheritance.* Harvard University Press.

Meyer, D. K., & Turner, J. C. (2002). Discovering emotion in classroom motivation research. *Educational Psychologist, 37*(2), 107–114. doi:10.1207/S15326985EP3702_5.

Miller, K. R. (1999). *Finding Darwin's God*. New York, NY: Harper Collins.

Miller, J. D. (2004). Public understanding of, and attitudes toward, scientific research: What we know and what we need to know. *Public Understanding of Science, 13*(3), 273–294.

Miller, J. D., Scott, E. C., & Okamoto, S. (2006). Public acceptance of evolution. *Science Magazine, 313*, 765–766. doi:10.1126/science.1126746.

Muis, K. R., Pekrun, R., Azevedo, R., Sinatra, G. M., Trevers, G., Meier, E., & Heddy, B. C. (2015). The curious case of climate change: Epistemic emotions mediate relations between epistemic beliefs, learning strategies and learning outcomes. *Learning and Instruction, 39*, 168–183. doi:10.1016/j.learninstruc.2015.06.003.

Nadelson, L. S., & Hardy, K. K. (2015). Trust in science and scientists and the acceptance of evolution. *Evolution Education and Outreach, 8*(1), 9.

Nadelson, L. S., & Sinatra, G. M. (2009). Educational professionals' knowledge and acceptance of evolution. *Evolutionary Psychology, 7*(4), 490–516. doi:10.1016/s0010-0277(99)00010-4.

Nadelson, L. S., & Southerland, S. (2012). A more fine-grained measure of students' acceptance of evolution: Development of the Inventory of Student Evolution Acceptance—I-SEA. *International Journal of Science Education, 34*(11), 1637–1666.

Newport, F. (2014). In U.S., 42% believe creationist view of human origins: Americans' views related to religiousness, age, and education. Retrieved from http://www.gallup.com/poll/170822/believe-creationist-view-human-origins.aspx?utm_source=position1&utm_medium=related&utm_campaign=tiles.

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review, 18*, 315–341. doi:10.1007/s10648-006-9029-9.

Pekrun, R., & Linnenbrink-Garcia, L. (2012). Academic emotions and student engagement. In S. L. Christensen, A. L. Reschley, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 259–282). New York, NY: Springer.

Pekrun, R., & Stephens, E. J. (2012). Academic emotions. In K. R. Harris, S. Graham, T. Urdan, S. Graham, J. M. Royer, & M. Zeidner (Eds.), *APA handbooks in psychology* (pp. 3–31). Washington, DC: American Psychological Association.

Penner, D. E. (2000). Explaining systems: Investigating middle school students' understanding of emergent phenomena. *Journal of Research in Science Teaching, 37*(8), 784–806.

Pugh, K. J. (2002). Teaching for idea-based, transformative experiences in science: An investigation of the effectiveness of two instructional elements. *Teachers College Record, 104*, 1101–1137.

Reynolds, R. E., Sinatra, G. M., & Jetton, T. L. (1996). Views of knowledge acquisition and representation: A continuum from experience centered to mind centered. *Educational Psychologist, 31*(2), 93–104.

Rissler, L. J., Duncan, S. I., & Caruso, N. M. (2014). The relative importance of religion and education on university students' views of evolution in the Deep South and state science standards across the United States. *Evolution Education and Outreach, 7*(1), 24.

Rosenberg, E. L. (1998). Levels of analysis and the organization of affect. *Review of General Psychology, 2*, 247–270.

Rosengren, K. S., Evans, E. M., Brem, S. K., & Sinatra, G. M. (Eds.). (2012). *Evolution challenges: Integrating research and practice in teaching and learning about evolution*. New York, NY: Oxford University Press.

Rutledge, M. L., & Warden, M. A. (1999). The development and validation of the measure of acceptance of the theory of evolution instrument. *School Science and Mathematics, 99*(1), 13–18.

Sadler, T. D. (2009). Situated learning in science education: Socio-scientific issues as contexts for practice. *Studies in Science Education, 45*, 1–42.

Settlage, J., & Jensen, M. (1996). Investigating the inconsistencies in college student responses to natural selection test questions. *Electronic Journal of Science Education [On-line]*. Retrieved from http://unr.edu/homepage/jcannon/euse/settlage.html.

Shtulman, A., & Calabi, P. (2013). Tuition vs. intuition: Effects of instruction on naïve theories of evolution. *Merrill-Palmer Quarterly, 59*(2), 141–167.
Shtulman, A., & Valcarcel, J. (2012). Scientific knowledge suppresses but does not supplant earlier intuitions. *Cognition, 124*, 209–215.
Sinatra, G. M. (2005). The "warming trend" in conceptual change research: The legacy of Paul R. Pintrich. *Educational Psychologist, 40*(2), 107–115.
Sinatra, G. M., Brem, S. K., & Evans, E. M. (2008). Changing minds? Implications of conceptual change for teaching and learning about biological evolution. *Evolution Education and Outreach, 1*, 189–195.
Sinatra, G. M., & Broughton, S. H. (2011). Bridging reading comprehension and conceptual change in science: The promise of refutation text. *Reading Research Quarterly, 46*(4), 374–393.
Sinatra, G. M., Broughton, S. H., & Lombardi, D. (2014). Emotions in science education. In R. Pekrun & L. Linnenbrink-Garcia (Eds.), *International handbook of emotions in education* (pp. 415–436). New York, NY: Routledge.
Sinatra, G. M., & Danielson, R. W. (2014). Adapting to a warmer climate of scientific communication. *Bioscience, 64*(4), 275–276. doi:10.1093/biosci/biu023.
Sinatra, G. M., Kienhues, D., & Hofer, B. K. (2014). Addressing challenges to public understanding of science: Epistemic cognition, motivated reasoning, and conceptual change. *Educational Psychologist, 49*(2), 123–138. doi:10.1080/00461520.2014.916216.
Sinatra, G. M., & Nadelson, L. S. (2011). Science and religion: Opposite ends of core epistemological continua. In R. Taylor & M. Ferrari (Eds.), *Epistemology and science education: Understanding the evolution vs. intelligent design controversy* (pp. 173–193). New York, NY: Routledge.
Sinatra, G. M., & Seyranian, V. (2016). Warm change about hot topics: The role of motivation and emotion in attitude and conceptual change. In L. Corno & E. M. Anderman (Eds.), *Handbook of educational psychology* (pp. 245–256). New York, NY: Routledge.
Sinatra, G. M., Southerland, S. A., McConaughy, F., & Demastes, J. (2003). Intentions and beliefs in students' understanding and acceptance of biological evolution. *Journal of Research in Science Teaching, 40*(5), 510–528.
Smith, M. U. (2015). *The GAENE—Generalized Acceptance of EvolutioN Evaluation: Development of a new measure of evolution acceptance* (Unpublished Manuscript).
Smith, M. U., & Siegel, H. (2004). Knowing, believing, and understanding: What goals for science education? *Science & Education, 13*, 553–582.
Southerland, S. A., Sinatra, G. M., & Matthews, M. (2001). Belief, knowledge, and science education. *Educational Psychology Review, 13*, 325–351.
Vosniadou, S., & Brewer, W. F. (1992). Mental models of the earth: A study of conceptual change in childhood. *Cognitive Psychology, 24*, 535–585.
West, S. A., El Mouden, C., & Gardner, A. (2011). Sixteen common misconceptions about the evolution of cooperation in humans. *Evolution and Human Behavior, 32*(4), 231–262.
Young, G. (2003). Dealing with difficult classroom dialogue. In P. Bronstein & K. Quina (Eds.), *Teaching gender and multicultural awareness: Resources for the psychology classroom* (pp. 347–360). Washington, DC: American Psychological Associate.

Chapter 12
Cognitive Load Theory, Evolutionary Educational Psychology, and Instructional Design

John Sweller

Cognitive load theory (Sweller, Ayres, & Kalyuga, 2011) is an instructional approach based on our knowledge of human cognitive architecture, including the limits of working memory, the organization of information in long-term memory, and the interactions between these memory systems. That architecture is used to generate novel instructional procedures intended to facilitate learning in educational settings. Once an instructional procedure is developed based on this theory, its effectiveness is tested by comparing learning outcomes to more traditional procedures using randomized controlled trials. When those learning outcomes favor the new instructional procedure, a new cognitive load effect has been identified for further study and a potential new instructional procedure is available for use in the classroom.

Those aspects of human cognitive architecture relevant to instruction and used by cognitive load theory depend on evolutionary educational psychology in two respects. First, biological evolution can be used to determine categories of knowledge that are important to instructional considerations. Second, the selection pressures that drive evolution by natural selection are analogous to those that operate during human learning. I will begin by considering human cognitive architecture from an evolutionary educational psychology perspective, and then link these to instructional design.

Evolutionary Educational Psychology and Human Cognition

Early versions of cognitive load theory did not use evolutionary educational psychology when discussing human cognitive architecture, but instead placed the primary emphasis on relations between working and long-term memory.

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While those relations still are critical to the theory, the subsequent emergence of a viable evolutionary educational psychology placed the relations between working and long-term memory into a context that provided substantially more explanatory power and generated a wider range of hypotheses. By using evolutionary educational psychology, the categories of knowledge to which cognitive load theory did and did not apply became clearer, as did the way in which information was processed, stored, and used during and subsequent to instruction.

Categories of Knowledge

Knowledge probably can be categorized in an infinite number of ways, but for present purposes, the only categories that matter are ones that have instructional implications. Categorization schemes in which the same instructional procedures are equally effective across the identified categories have minimal or no instructional implications. For example, if the same instructional techniques are important in teaching concepts and teaching procedures, the distinction between concepts and procedures becomes irrelevant from an instructional perspective, even if it is important from other perspectives. One scheme based on evolutionary educational psychology was devised by David Geary and has profound significance for instructional procedures (Geary, 2012, this volume). He divided knowledge into biologically primary and secondary knowledge, two categories that require vastly different experiences for their development and so different instructional procedures.

Biologically primary knowledge. We have evolved to acquire biologically primary knowledge over countless generations. It tends to be knowledge that is critical to our survival and is organized around the domains of folk psychology such as social abilities, folk biology such as knowledge of other species, and folk physics such as the ability to navigate from place to place (Geary, 2005). Recognizing faces, learning to listen to and speak a first language, basic social skills associated with relationships are all features of folk psychology, for instance. We also have evolved general problem-solving skills and the ability to plan ahead and strategize.

Biologically, primary knowledge has several important characteristics. First, it tends to be modular with, for example, the ability to recognize faces likely to have evolved independently and in a different epoch than language skills. Thus, the manner in which we acquire one skill may differ markedly from the manner in which we acquire a different, unrelated skill. Second, because we have evolved to acquire biologically primary knowledge, it tends to be acquired easily, automatically, and unconsciously through natural activities, such as play and social discourse. To acquire biologically primary skills, we merely need membership of a functioning (or in some cases, even a dysfunctional) society. As a consequence, biologically primary skills do not need to be explicitly taught, or indeed, taught at all. All normally functioning individuals will acquire those skills.

Third, it is likely that most of the generic skills considered important in education are biologically primary (Tricot & Sweller, 2014). For example, because of their importance in many real-world contexts, we may have evolved general problem solving and planning skills. Means-ends analysis provides an example of a general problem-solving skill (Newell & Simon, 1972). We solve many novel problems by noting our current and goal problem states, finding problem-solving operators to reduce differences between the two states, and then repeating the process until the goal has been attained. This means-ends strategy is a generic skill that is commonly used, but without any evidence that it is teachable. It constitutes a complex, primary skill that all normal humans acquire without instruction. It follows that such generic skills do not need, indeed cannot, be taught because they are automatically acquired. Including instruction of such skills in curricula is likely to be futile.

Biologically secondary knowledge. In contrast to biologically primary knowledge that we all must acquire in order to function appropriately in any society, biologically secondary knowledge is culturally specific. While the knowledge itself is entirely domain-specific, we have evolved to acquire any secondary knowledge generically. In other words, the ability to acquire secondary knowledge is biologically primary (Geary, 2005). We do not need to be taught how to obtain biologically secondary knowledge because we have evolved to do so. As a result, teaching learners how to develop knowledge as opposed to teaching them the actual knowledge may be a pointless exercise. The manner in which we acquire biologically secondary knowledge is largely identical irrespective of the nature of that knowledge: We have evolved to acquire a wide variety of types of biologically secondary knowledge in a similar manner.

Examples of biologically secondary knowledge can be found in every curriculum area found in any educational establishment. We invented schools in order to teach biologically secondary knowledge because, unlike primary knowledge, it is unlikely to be acquired without the functions and procedures found in educational establishments.

There are two characteristics of biologically secondary knowledge that are critical to instructional issues. First, it is domain-specific (Tricot & Sweller, 2014). To learn to solve mathematics problems, we do not need to be taught generic, cognitive problem-solving skills, such as means–ends analysis. These skills are already part of our evolved repertoire, although some domain-specific problem-solving procedures such as the use of formal logic and experimental design must be explicitly taught in the areas to which they are applied (but see Gray, this volume; Toub et al., this volume). For example, the experimental designs suitable for biology or psychology bear little resemblance to those used in physics. Learning those procedures is a biologically secondary task that must be taught explicitly. Similarly, we do need to be taught the procedures required to solve particular, narrow classes of problems. For example, we need to learn how to solve problems of the type, $a/b = c$, solve for a. The knowledge gained is domain-specific in that knowing how to solve this category of problem will not be of assistance in solving unrelated mathematics problems or unrelated, non-mathematical problems.

The second important characteristic of biologically secondary knowledge is that, unlike biologically primary knowledge, it can be difficult to learn, requires conscious effort, and is learned much more easily with explicit instruction rather than minimal guidance (Kirschner, Sweller, & Clark, 2006). When acquiring biologically primary knowledge, learners can be left to their own devices because they have evolved to acquire such knowledge. It is inadvisable to provide minimal guidance when dealing with biologically secondary knowledge. Without guidance, the information may be misunderstood or not acquired at all, a risk that is minimal when dealing with biologically primary knowledge.

Natural Information Processing systems

From the above analysis, the major function of instruction is to assist learners to acquire biologically secondary knowledge. The cognitive architecture associated with the acquisition and use of biologically secondary knowledge is closely analogous to the process of biological evolution itself. The suggestion that evolution by natural selection and human cognition is analogous has a very long and illustrious history (Campbell, 1960; Darwin, 1871/2003; Popper, 1979; Siegler, 1996). Both human cognitive architecture and evolution by natural selection are examples of natural information processing systems (Sweller & Sweller, 2006). They can be described using five basic principles.

Information store principle. Natural information processing systems require a very large store of information in order to function in a natural environment. In the case of biological evolution, that store is represented by a genome. While there is no agreed upon measure of the size of a genome, any measure considered results in thousands of units of information for the smallest genomes and much more for larger genomes (Portin, 2002; Stotz & Griffiths, 2004).

For human cognitive architecture, long-term memory provides the functional equivalent of a genome. Competent performance in any substantive, biologically secondary area requires many years of deliberate practice to improve performance (Ericsson, Krampe, & Tesch-Romer, 1993). That practice results in the storage of large amounts of domain-specific information. The initial evidence for the huge amounts of information stored in long-term memory came from De Groot's (1965) classic work on chess. He found that chess masters did not engage in more problem-solving search than weekend players. The only difference between the two groups was in memory of chessboard configurations. Chess masters, who have shown a configuration taken from a real game for 5 s, were able to accurately replace over 80 % of the pieces. Weekend players only were able to replace less than 30 % of the pieces. Chase and Simon (1973) replicated these results and in addition found no difference between masters and weekend players' presented random board configurations as opposed to real game configurations. For random configurations, accuracy was similar to that of weekend players' presented configurations taken from real games. Thus, only chess masters presented real game configurations performed at a high level. Similar results have been obtained in a variety of areas relevant to education, including learning algebra and computer programming (e.g., Egan & Schwartz, 1979; Jeffries, Turner, Polson, & Atwood, 1981; Sweller & Cooper, 1985).

The work on expertise and particularly De Groot's (1965) work changed our view of human cognition and, indeed, our view of ourselves. Arguably, it is the most important finding of cognitive psychology. Until this work, we saw the defining characteristic of human cognition to be our ability to "think," but a definitive definition has remained elusive. The new role of long-term memory in human cognition, while not providing a definition, set us on the road. Playing chess at master or grand master level surely required thought and it turned out that long-term memory was critical to that thought to an extent that previously had not been imagined.

With respect to learnable factors as opposed to inherited factors, a key difference between someone who is good at an intellectual activity in a specific secondary domain and someone who is not seems to be largely dependent on the information held in long-term memory. In this context, we know, for example, that working memory capacity is dramatically affected by the contents of long-term memory (see the organizing and linking principle below) and that IQ tests need to be re-standardized every few years and show a continuously rising trend (Flynn, 1987). We also know that one additional year of schooling increases IQ by more than one additional year of age (Cahan & Cohen, 1989). A parsimonious explanation of changes in working memory capacity and IQ can be provided by assuming that both are strongly affected by the contents of long-term memory. Indeed, at present, there is no clear evidence of any other factor being relevant.

Whether dealing with a genome or long-term memory, the information held in the information store is central to natural information processing systems. Natural environments tend to be complex. To deal with that complexity, a large store of information is essential.

Borrowing and reorganizing principle. How is the large amount of information held in a natural information store acquired? The manner in which an individual genome obtains its information is well-known. During either sexual or asexual reproduction, information is borrowed from ancestors. In the case of sexual reproduction, that information is necessarily reorganized as an essential part of the process.

An analogous process is used by human cognition. We imitate what others do (Bandura, 1986), we listen to what they say, and we read what they write. We are one of a very small number of species that have evolved to provide and receive information via deliberate teaching from other members of the species (Thornton & Raihani, 2008). Our ability to obtain information from other people is biologically primary, even when used to acquire a biologically secondary skill such as reading. The skill is secondary, but the general ability to obtain the information required for that secondary skill is primary. We have to teach people to read, but we do not have to teach them to obtain information by reading because once one is taught how to read, the skill can tap into our biologically primary natural language and social-information systems. People know that they can obtain information from other people by reading because that knowledge is biologically primary and does not need to be taught.

The information we obtain from others is reorganized in the same manner as information is reorganized during sexual reproduction. Knowledge obtained from other people is automatically combined with knowledge already held in long-term memory to provide new knowledge that may be unique and useful. For this reason, the information obtained from other people is rarely recorded precisely. It is constructed when combined with previously held knowledge.

From an instructional perspective, it follows that instruction should provide learners with information. Cognitive load theory places its major emphasis on techniques designed to facilitate the acquisition of domain-specific, biologically secondary knowledge using explicit instruction.

Randomness as genesis principle. While we have evolved to obtain most of our knowledge from other people, that knowledge needs to have been created in the first place. Evolution by natural selection also needs to create novel information. It does so by random mutation that is the initial source of all biological variation.

In the case of human cognition, random generate and test during problem solving creates novel concepts and procedures (Sweller, 2009). When presented with a problem, we will attempt to solve it automatically using information held in long-term memory. The bias to use known solution procedures is biologically primary and so unteachable. A known solution always will be used if it is available. If a problem is novel with no known solution stored in long-term memory, it may be possible to generalize from a known solution to a similar problem. Again, if we have access to a problem from which we can generalize, we will do so automatically. Generalizing also is unteachable because it is a biologically primary skill. Of course, if the problem is novel, by definition we cannot know whether a solution to a known problem really does generalize to the new one. We only can find out whether an old solution works on a new problem by trying it out. In a form of generate and test, we generate the solution and see if it works. If it works, we may store the new problem and its solution in long-term memory for use on subsequent occasions.

Frequently, when faced with a novel problem, no solution or even partial solution can be obtained from long-term memory. Either from the start or during problem solving, we may find that there are several possible moves that can be made, but we have no knowledge-based information that will indicate which move we should try. At that point, we will have no choice but to randomly choose a move and test it for effectiveness using a random generate and test procedure. Again, if the move or sequence of moves is effective, we may store it in long-term memory for later use, but jettison it if it proves to be ineffective. In this way, new knowledge is created.

It may be argued that no problem-solving move is ever entirely random and that all such moves have some knowledge attached to them. In a sense, that argument must be correct. If we have no knowledge, we probably not only would be unable to solve the problem, we probably could not even assimilate the meaning of the problem to begin solving it. Nevertheless, the fact that some knowledge always is required does not contradict the randomness as genesis principle. In the same way as random mutation does not occur in a vacuum but only is applied to a current genome, so random generate and test during problem solving always will be applied to a current knowledge base. The fact that there must be organized information already stored prior to the randomness as genesis principle being applied does not eliminate the random component. In the case of problem solving, there inevitably will be some circumstances in which no knowledge is available to discriminate between alternative problem-solving moves. Under those circumstances, random generate and test is unavoidable. When it occurs, new knowledge is created just as new genetic variations are created by random mutation.

Narrow limits of change principle. The randomness as genesis principle has structural consequences. If new information is to be generated randomly, it needs to be restricted in some way. The need for such a restriction can be seen most clearly in the case of human cognition. Assume that during problem solving, three elements of information need to be combined. If no information is available indicating how they should be combined, then there are $3! = 6$ possible permutations of the three elements. Assume instead that there are ten elements that need to be combined. There are $10! = 3,628,800$ possible permutations. Using a random generate and test procedure, it will take much longer to determine which permutations are beneficial for ten than three elements. Based on ten elements, a useful permutation that needs to be stored may never be found. For this reason, to ensure that useful, previously stored information is not damaged by a sudden large change, both evolution by natural selection and human cognition require mechanisms that prevent large, rapid changes to the store.

Evolution by natural selection solves this problem by limiting the number of mutations that are likely to occur. The epigenetic system is used to vary the number of mutations that might occur at any given genome location. For example, the level of stress in an environment may alter the number of mutations. Similarly, some sections of a genome may have mutations rates thousands of time higher or lower than other sections. Mutation rates can be very high if diversity is required such as venom used to disable prey (Jablonka & Lamb, 2005). In other words, environmental requirements can result in changes in generation rates of mutations. Nevertheless, large numbers of mutations can jeopardize the integrity of a genome and so mechanisms such as DNA repair are required to constrain mutation rates.

The number of mutations that are retained tends to be low in order to ensure that the organized information stored in a genome is not lost by large, random changes that are likely to be fatal. Genetic change due to random mutation is slow. In effect, very small changes are made and tested for effectiveness. Most of those changes are not adaptive and jettisoned over evolutionary time through differential survival and reproduction. Occasionally, a change is adaptive and retained. The result is a series of very small changes over long periods of time that can slowly improve the adaptation of a genome to an environment without destroying the genome.

In the case of human cognition, working memory plays an analogous role to these genetic changes. New information can be obtained during problem solving, but it is obtained very slowly with the characteristics of working memory constituting the limiting factor. When dealing with novel information, working memory capacity is limited to holding about seven items (Miller, 1956) and processing no more than about four or less items (Cowan, 2001) where processing involves combining, comparing, or relating items in some manner. Not only is the capacity of working memory severely limited when dealing with novel information, the duration that novel information will be retained in working memory is constrained to no more than about 20 s without rehearsal (Peterson & Peterson, 1959). As a consequence of these limitations of working memory when dealing with new information, changes to the long-term memory store are slow in the same way that changes to a genome are slow.

Environmental organizing and linking principle. While the environment influences changes to the information store, the ultimate purpose of this store is to enable adaptive functioning in a given environment. That purpose is realized through the environmental organizing and linking principle. In the case of biological evolution, the epigenetic system can transform genetic functions. For example, while a person's skin cells and liver cells have identical genotypes, they have vastly different phenotypes. Those differences cannot be caused by genetic factors because, for a given individual, the genetic information in the nucleus of a skin cell is identical to the genetic information in the nucleus of a liver cell. The epigenetic system determines the phenotypic differences by turning genes on or off. Rather than determining where mutations occur and the speed of mutations under the narrow limits of change principle, the epigenetic system can determine the different structures and functions of two types of cells by activating or de-activating particular genes using the environmental organizing and linking principle. It can take large amounts of information from the genome to determine specific structures and functions. Under a different environment, it can use different parts of the available genomic information (different sets of base pairs) to determine different structures and functions.

Similarly, while working memory determines which changes are made to long-term memory, it also determines which information held in long-term memory is used to determine action in a given environment. As is the case for the epigenetic system, working memory can take unlimited amounts of information from the information store, in this case long-term memory, to determine actions appropriate to a given environment. The capacity and duration limits that are necessary when working memory deals with novel information are no longer necessary when it deals with organized information stored in long-term memory (Ericsson & Kintsch, 1995). Working memory has no known capacity or duration limits when dealing with stored information from long-term memory.

Two separate functions of working memory and the epigenetic system. The narrow limits of change and the environmental organizing and linking principles indicate two largely unrelated functions of each of working memory and the epigenetic system. Historically, working memory has been treated as a single system (Atkinson & Shiffrin, 1968), with working memory having the same properties when dealing with novel information from the external environment or familiar information stored in long-term memory. In fact, that unified view of working memory, while attractive in some respects, could not be maintained and for that reason, in the current treatment, working memory has very different properties depending on whether it obtains its information from the environment (the narrow limits of change principle) or from long-term memory (the environmental organizing and linking principle). The distinction is so important that Ericsson and Kintsch (1995) suggested an entirely new structure, long-term working memory to deal with information that is stored in long-term memory and then processed in working memory.

(From a functional perspective, it makes no difference whether we describe two separate structures or a single structure with two separate functions.)

The same issue is relevant to the epigenetic system. It usually is treated as a single system that sometimes affects the number and location of mutations and at other times affects expression or inhibition of information stored in the genome. These two functions are regarded as separate and unrelated in the current treatment, closely analogous to the two functions of working memory. Epigenetically generated changes in the location and rate of mutations are considered under the narrow limits of change principle, while epigenetic factors switching genes on or off are considered under the environmental organizing and linking principle.

Cognitive Load Theory and Instructional Design

This cognitive architecture can be used to devise instructional procedures. In the case of human cognition, the environmental organizing and linking principle allows us to engage in activities that otherwise would be impossible. Those activities depend on us having accumulated large amounts of information in long-term memory via a very limited working memory. Cognitive load theory uses this cognitive architecture to devise instructional procedures. Those procedures generated from the above cognitive architecture have several common characteristics. The two most important are an emphasis on explicit instruction rather than minimal guidance and on the primacy of teaching domain-specific knowledge rather than generic skills. These two recommendations derived from our knowledge of human cognitive architecture will be discussed next.

The Importance of Explicit Instruction

Many instructional theories recommend that students should not be presented direct, explicit information, but rather should be encouraged to find information themselves (Gray, this volume). Inquiry learning, constructivist learning, and problem-based learning provide examples. Ultimately, all derive from discovery learning (Bruner, 1961) and cannot be distinguished from discovery learning or from each other. There is little evidence for the effectiveness of minimal guidance and considerable evidence for the importance of explicit instruction (Kirschner et al., 2006; Klahr & Nigam, 2004; Mayer, 2004; but see Toub et al., this volume).

The cognitive architecture described above explains why explicit instruction is important. Humans obtain the vast bulk of the biologically secondary information held in long-term memory via the borrowing and organizing principle. We have evolved to present and obtain such information from others as a biologically primary skill, as noted. Obtaining information from a teacher or instructor is entirely natural for humans but largely, though not entirely, absent in other animals (see Berch, this volume). Humans have evolved to learn from others and in ways advocated by proponents of discovery learning. This works well for fleshing out primary knowledge, but not for secondary learning (Geary, 1995, this volume). Given that we have evolved to acquire information from others, recommendations that we should not present explicit information to learners can be seen as little short of bizarre from a cognitive science perspective. These theories arise from people's primary folk psychology, without an understanding that secondary learning is very different from primary learning and what works for the latter does not work well for the former. We have evolved both to teach and to obtain information from teachers.

We also are able to obtain information by discovery learning procedures using the randomness as genesis principle. That machinery is essential when information is required, but there are no other people available to provide that information. While we can and must be able to obtain information in this manner and, indeed, the randomness as genesis principle provides the origin of all biologically secondary information, it is a very slow, difficult, and inefficient process for obtaining information. We are far better at obtaining information using the borrowing and organizing principle. Given a choice between having learners discover information and presenting them with the same information, we should present the information.

The Primacy of Domain-Specific Knowledge

Geary's (1995) distinction between biologically primary and secondary information has implications for the type of information we should be presenting to learners and the skills we should be teaching. Over many years, there has been an increasing emphasis in educational research on teaching generic, cognitive skills (Tricot & Sweller, 2014). These are skills that transcend a particular domain, for example, a general problem-solving skill that improves problem-solving performance irrespective of the domain or metacognitive skills that can improve learning in any area. In one sense, that emphasis is understandable. Generic, cognitive skills are likely to be critical to any cognitive functioning, and indeed, are likely to be far more important than domain-specific skills. Facilitating problem-solving skills that transcend a specific area is likely to be much more important than facilitating problem-solving skill in a narrow, specific domain.

While the importance of generic, cognitive skills explains the emphasis placed on them, there has been a marked lack of success in identifying teachable, learnable, generic cognitive skills. A teachable generic cognitive skill is one that results in improved performance on far transfer tasks that differ from the trained tasks but should, in theory, be improved by the training. An emphasis on far transfer is critical in order to ensure that any performance improvement can be attributed to the acquisition of a generic skill rather than domain-specific knowledge. For example, teaching a generic, cognitive skill and using algebra to provide examples and then testing the extent to which acquisition of the skill improved performance on algebra leaves open the possibility that any improvement may be due entirely to increased knowledge of algebra rather than increased knowledge of the generic, cognitive skill. If algebra is used to teach the generic skill, any test of the efficacy of learning the skill should use an area unrelated to algebraic skill. Despite many studies over many years, there is minimal evidence available that teaching a generic, cognitive skill improves transfer performance (Ritchie, Bates, & Deary, 2015; Tricot & Sweller, 2014).

We are left with the question as to why there continues to be such a strong emphasis in the field on teaching generic, cognitive skills given that research into teaching those skills failed? In some sense, the answer to this question is straightforward. People could see how easy it was for learners to learn to talk, walk, recognize faces etc., but so difficult to learn subject matter in schools. It followed, they suggested, that the difference in difficulty was due to faulty instructional procedures. If only we used the learning procedures common outside of schools, school learning would be just as easy, natural, and enjoyable as learning outside of school. Explicit teaching is not used to teach people how to listen and talk. If we eliminate explicit teaching of, for example, reading and writing, it will be learned as easily and naturally as listening and talking.

Of course, Geary's (1995) distinction between biologically primary and secondary knowledge explains why some information is acquired easily while other information is difficult to acquire. Because of the importance of generic, cognitive skills, most humans must possess them in order to survive. A skill that is essential to survival is a skill that we are very likely to have evolved to obtain easily and automatically without being taught. Such a skill is a biologically primary skill. If so, the failure to find teachable, learnable, generic, cognitive skills is not because such skills are unimportant, but rather because such skills are so important that most learners will have acquired them without instruction. In contrast, domain-specific skills are largely biologically secondary. They have been created over the past few millennia and do not have the built-in skeletal knowledge that makes primary learning easy and automatic. They are not acquired automatically and should be taught explicitly. We invented schools and other educational institutions precisely because the domain-specific, biologically secondary skills taught were not easily learned without deliberate, explicit instruction.

Some Instructional Effects Generated by Cognitive Load Theory

Cognitive load theory has generated a large number of cognitive load effects. Each effect is based on randomized, controlled experiments comparing a new instructional procedure with more conventional procedures. A cognitive load effect is demonstrated when the new procedure results in superior test performance to the older procedure. All of the hypotheses tested were generated using the above cognitive architecture and assume that effective instruction is explicit and concerned with the acquisition of domain-specific knowledge.

Each cognitive load effect is assumed to be caused by differential levels of element interactivity (Sweller, 2010), a concept that is concerned with the number of interacting elements that must be processed in working memory. As an example, assume learners are faced with a difficult task such as learning the symbols of the periodic table or some of the nouns of a foreign language. While these tasks are difficult, they do not impose a heavy cognitive load. Each element can be learned independently of every other element and so element interactivity is low resulting in a low working memory load. The task may be difficult, but the intrinsic cognitive load of the task is low. In contrast, other tasks may involve far fewer elements that need to be processed simultaneously in working memory, resulting in high element interactivity and a high intrinsic cognitive load. Balancing a chemical equation provides an example as does solving a problem such as $(a+b)/c=d$, solve for a. To solve this problem, all of the elements must be considered simultaneously because a change in one element is likely to have consequences for every other element. Element interactivity and the intrinsic cognitive load imposed by this task will be high. That intrinsic cognitive load only can be altered by altering the task or by acquiring knowledge stored in long-term memory. With knowledge, the equation, $(a+b)/c=d$, will be treated as a single element rather than multiple elements and so reduce intrinsic cognitive load.

Element interactivity also can be varied by instructional procedures (Sweller, 2010). Some instructional procedures require learners to process many elements simultaneously, while other procedures can substantially reduce the number of elements that need to be processed. Variations in element interactivity due to instructional procedures are referred to as variations in extraneous cognitive load. Most of the effects generated by cognitive load theory depend on a reduction in extraneous load on working memory resources.

The effects only will be very briefly summarized here. More detailed summaries may be found in Sweller et al. (2011). It must be emphasized that each of the effects described below assumes that knowledge acquired in educational institutions is domain-specific, biologically secondary information best acquired by explicit instruction. In that sense, cognitive load theory differs from most of the extant theories in the field of cognitive processes and instructional design.

The worked example effect. Learners presented with worked examples to study will perform better on subsequent problems than learners who have to solve the same problems, due to a reduction in extraneous cognitive load. Worked examples reduce working memory load compared to discovery-based problem solving and make use of the borrowing and organizing principle rather than the randomness as genesis principle. Worked examples provide explicit instruction and domain-specific knowledge.

The problem completion effect. Rather than providing a complete solution, completion problems provide a partial solution that learners must complete. Completion problems can be just as effective as worked examples and are effective for the same reasons.

The split-attention effect. Assume instructional material such as a worked example consisting of two or more sources of information that split attention and so must be mentally integrated before they can be understood. A diagram and text that are unintelligible in isolation and so must be mentally integrated provide an example.

The act of mental integration requires working memory resources that consequently are unavailable for learning, resulting in the imposition of an extraneous cognitive load. By physically integrating those sources of information, more working memory resources are available for learning, reducing extraneous cognitive load.

The modality effect. Rather than physically integrating the two sources of information as in the split-attention effect, if one source of information can be provided in spoken rather than written form, learning is facilitated. Using both visual and auditory processors rather than just the visual processor can functionally expand working memory.

The redundancy effect. Frequently, two or more sources of information can be understood in isolation. For example, text may simply repeat the information in a diagram or one source of information may in reality be uninformative and so unnecessary. Such redundant sources of information should be eliminated to reduce extraneous cognitive load, rather than integrated or converted into spoken form. The logic of the relations between the multiple sources of information is critical to determining whether information should be integrated (or presented in auditory form) or eliminated.

The expertise reversal effect. As indicated above, the storage of information in long-term memory has dramatic effects on working memory by bringing the environmental organizing and linking principle into play rather than the borrowing and reorganizing, the randomness as genesis or narrow limits of change principles. In turn, those changes necessitate changes in instructional procedures. The worked example effect provides one of many examples. As indicated above, it occurs when providing novices with worked examples facilitates learning compared to having learners solve the equivalent problems on their own. With increasing expertise in a given area of problem solving, that difference reduces and eventually reverses resulting in the expertise reversal effect. While studying a worked example may be important for a novice, it may be a redundant activity for more knowledgeable learners.

The guidance fading effect. Based on the expertise reversal effect, the explicit guidance provided by worked examples should be gradually removed as expertise increases and the environmental organizing and linking principle takes over from the other principles associated with acquiring novel information. The guidance fading effect provides evidence for this hypothesis. Only novices require explicit guidance.

The transient information effect. The introduction of modern educational technology allows a more ready use of procedures such as animations and spoken information. Sometimes, those procedures transform easily accessible, permanent information into less easily accessible, transient information. For example, transforming complex written information into spoken information can vastly increase cognitive load. Difficult to understand written information can be processed and easily re-processed on multiple occasions in a manner that is difficult or impossible with spoken information that disappears to be replaced by new information. The duration limits of working memory may render complex spoken information unintelligible. Such information is better presented in written form. Rather than facilitating learning, such technological "advances" can interfere with secondary learning.

The imagination effect. Asking learners to imagine or mentally rehearse previously learned information might assist in transferring that information to long-term memory.

The element interactivity effect. Reducing element interactivity due to extraneous cognitive load may be unnecessary if element interactivity due to intrinsic cognitive load is low. Cognitive load effects due to extraneous load should not be expected if intrinsic load is low because the number of elements that must be considered simultaneously may be within working memory limits.

The isolated elements effect. If the number of elements that must be processed is very high, it may be impossible to process them simultaneously. In that case, the information needs to be broken up into isolated elements even if that means it cannot be fully understood immediately. Understanding can come later when interacting information is reconstituted from its memorized, isolated elements.

The goal-free effect. This effect was the first cognitive load theory effect studied. Asking learners solving a mathematics problem to calculate values for as many variables as possible rather than asking them to find a value for a specific goal reduces working memory load. For example, instead of asking geometry students to “Find a value for Angle X,” we can ask them to “Find the value of as many angles as you can.” Attending to a specific goal may require learners to consider simultaneously the several moves needed to reach the goal. A goal-free approach limits consideration to each individual move rather than combinations of moves required to reach a goal.

Collective working memory effect. For difficult problems where knowledge is spread among two or more people, having them learn collaboratively rather than individually can facilitate learning. In effect, the group has a collective rather than an individual working memory. It should be noted that the effect disappears where all members of the group share similar knowledge.

Discussion

The architecture used by cognitive load theory with its evolutionary roots can result in instructional design recommendations that depart from many common assumptions. Nevertheless, evolutionary educational psychology provides a well-structured, highly organized base from which to consider instructional issues. All of the instructional recommendations of cognitive load theory derive from our knowledge of human cognitive architecture that was used to generate the cognitive load effects. In turn, all of those effects have been tested using multiple, replicated, randomized, controlled experiments. Those experiments provide the data that generate instructional recommendations and to the extent that those recommendations are successful provide evidence for the theory. The instructional effects discussed above can be readily understood and followed from Geary’s (1995) distinction between biologically primary and secondary skills.

References

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation* (Vol. 2, pp. 89–195). Oxford, England: Academic.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewoods Cliffs, NJ: Prentice Hall.

Bruner, J. (1961). The art of discovery. *Harvard Educational Review, 31*, 21–32.

Cahan, S., & Cohen, N. (1989). Age versus schooling effects on intelligence development. *Child Development, 60*, 1239–1249.

Campbell, D. (1960). Blind variation and selective retention in creative thought as in other knowledge processes. *Psychological Review, 67*, 380–400.

Chase, W. G., & Simon, H. A. (1973). Perception in chess. *Cognitive Psychology, 4*, 55–81.

Cowan, N. (2001). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences, 24*, 87–114.

Darwin, C. (2003). *The descent of man*. London, England: Gibson Square (Original work published 1871).

De Groot, A. (1965). *Thought and choice in chess*. The Hague, Netherlands: Mouton (Original work published 1946).

Egan, D. E., & Schwartz, B. J. (1979). Chunking in recall of symbolic drawings. *Memory & Cognition, 7*, 149–158.

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review, 102*, 211–245.

Ericsson, K. A., Krampe, R., & Tesch-Romer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100*, 363–406.

Flynn, J. (1987). Massive IQ gains in 14 nations: What IQ tests really measure. *Psychological Bulletin, 101*, 171–191. doi:10.1037/0033-2909.101.2.171.

Geary, D. (1995). Reflections of evolution and culture in children's cognition: Implications for mathematical development and instruction. *American Psychologist, 50*, 24–37.

Geary, D. (2005). *The origin of mind: Evolution of brain, cognition, and general intelligence*. Washington, DC: American Psychological Association.

Geary, D. (2012). Evolutionary educational psychology. In K. Harris, S. Graham, & T. Urdan (Eds.), *APA educational psychology handbook* (Vol. 1, pp. 597–621). Washington, DC: American Psychological Association.

Jablonka, E., & Lamb, M. J. (2005). *Evolution in four dimensions: genetic, epigenetic, behavioral, and symbolic variation in the history of life*. Cambridge, MA: MIT Press.

Jeffries, R., Turner, A., Polson, P., & Atwood, M. (1981). Processes involved in designing software. In J. R. Anderson (Ed.), *Cognitive skills and their acquisition* (pp. 255–283). Hillsdale, NJ: Erlbaum.

Kirschner, P., Sweller, J., & Clark, R. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential and inquiry-based teaching. *Educational Psychologist, 41*, 75–86.

Klahr, D., & Nigam, M. (2004). The equivalence of learning paths in early science instruction: Effects of direct instruction and discovery learning. *Psychological Science, 15*, 661–667.

Mayer, R. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist, 59*, 14–19.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*, 81–97.

Newell, A., & Simon, H. A. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice Hall.

Peterson, L., & Peterson, M. J. (1959). Short-term retention of individual verbal items. *Journal of Experimental Psychology, 58*, 193–198.

Popper, K. (1979). *Objective knowledge: An evolutionary approach*. Oxford, England: Clarendon.

Portin, P. (2002). Historical development of the concept of the gene. *Journal of Medicine and Philosophy, 27*, 257–286.
Ritchie, S., Bates, T., & Deary, I. (2015). Is education associated with improvements in general cognitive ability or in specific skills? *Developmental Psychology, 51*(5), 573–82.
Siegler, R. (1996). *Emerging minds: The process of change in children's thinking*. New York, NY: Oxford University Press.
Stotz, K., & Griffiths, P. (2004). Genes: Philosophical analyses put to the test. *History and Philosophy of the Life Sciences, 26*, 5–28.
Sweller, J. (2009). Cognitive bases of human creativity. *Educational Psychology Review, 21*, 11–19.
Sweller, J. (2010). Element interactivity and intrinsic, extraneous and germane cognitive load. *Educational Psychology Review, 22*, 123–138.
Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory*. New York, NY: Springer.
Sweller, J., & Cooper, G. (1985). The use of worked examples as a substitute for problem solving in learning algebra. *Cognition and Instruction, 2*, 59–89.
Sweller, J., & Sweller, S. (2006). Natural information processing systems. *Evolutionary Psychology, 4*, 434–458.
Thornton, A., & Raihani, N. (2008). The evolution of teaching. *Animal Behaviour, 75*, 1823–1836.
Tricot, A., & Sweller, J. (2014). Domain-specific knowledge and why teaching generic skills does not work. *Educational Psychology Review, 26*, 265–283. doi:10.1007/s10648-013-9243-1.

Chapter 13
Beyond Academic Performance: The Effects of an Evolution-Informed School Environment on Student Performance and Well-being

Richard A. Kauffman Jr. and David Sloan Wilson

While education has the narrow goal of teaching subject matter, schools also share the broader aim of facilitating "healthy" human and cultural development, promoting a strong sense of well-being, and encouraging prosocial behavioral strategies, for example. "Schools are a central interface between education and culture. They are the contexts in which children learn the evolutionarily novel abilities and knowledge needed to function as adults in modern societies" (Geary, 2008, p. 179). A comprehensive mission for schools is to facilitate the students' development of lifelong learning habits and to educate them to be knowledgeable, responsible, socially skilled, healthy, caring, and contributing citizens (Dewey, 1900, 1916; Keating, 1996).

In traditional societies, many of these traits are spontaneously learned through routine interactions (Gray, 2013, this volume; Lancy, this volume). Yet, as the complexities of modern life increase, it becomes more difficult to transmit all the resources and achievements of a complex society without formal, "intentional," education (Geary & Berch, this volume). Schools have become the cultural constructs that are assigned the task of facilitating the healthy development of its learners, to teach skills that will benefit the individual over the long term and society as a whole.

As human cultural change accelerates over time, society and technology recurringly transform people's ideas about what competencies students should be developing. Education policy makers respond by attempting to redefine what all students should learn. The rapid accumulation of knowledge across all academic disciplines has caused many recent educational policies to focus on identifying "what students need to know," reserving standardized subject-based concentration exams as the central measure of educational achievement. As students across America fail to

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achieve proficient exam scores, the narrow goals of education get even narrower; the broad are sacrificed altogether (Kohn, 2000).

Without appropriate assessment, the broad goals of education become overlooked; behavioral and socio-emotional competencies are left to develop with little to no support. By developing assessment techniques that allow educators to understand non-academic influences and the social support available to each student, schools can better provide effective instruction and educational support to help students better manage their lives. This is especially true for at-risk students, who often forego long-term goals (e.g., high exam scores, high school graduation, college admission) for more short-term rewards (e.g., approval among their peers, financial gain, the alleviation of stress) (Ellis et al., 2012; Montague, Enders, Cavendish, & Castro, 2011).

With appropriate monitoring, schools may be able to better identify situations where students display poor academic achievement for reasons separate from matters of intelligence—for example, when problems at home prevent the student from regularly attending school or when the student experiences routine stressors in the classroom that cause her to disengage from classroom activities. Furthermore, as the narrow goals of education largely depend upon the broad goals, by measuring non-academic differences between academically successful and non-successful students, policy makers can better identify which elements of developmental support are most influential to academic success.

With this chapter, we continue a report on the Regents Academy (RA), a program for at-risk high school students in Binghamton, New York, designed with the broad goals of education in mind. We have briefly described the design of the RA and its impact on academic performance elsewhere (e.g., Wilson, Kauffman, & Purdy, 2011). Here we describe in more detail how the program was designed from an evolutionary perspective and its broad impact on behavioral, psychological, and social development, providing encouraging support for the idea that it's possible to improve the narrow and broad goals of education simultaneously.

The Regents Academy

The RA was implemented in 2010 as a program for 9th and 10th grade Binghamton High School (BHS) students who failed at least three of five courses during their previous year of school and would be very likely to drop out if nothing were done. The program was self-contained, with its own principal and teaching staff, and the cost per student was slightly greater than for the regular high school. The program operated during the normal school day and year and similar programs are feasible for most public school districts. Working with the academy principal and its dedicated staff of teachers, we designed a social environment that, according to theory, would be maximally conducive to cooperation and learning. The program was assessed in a randomized control design, where we identified 117 qualifying

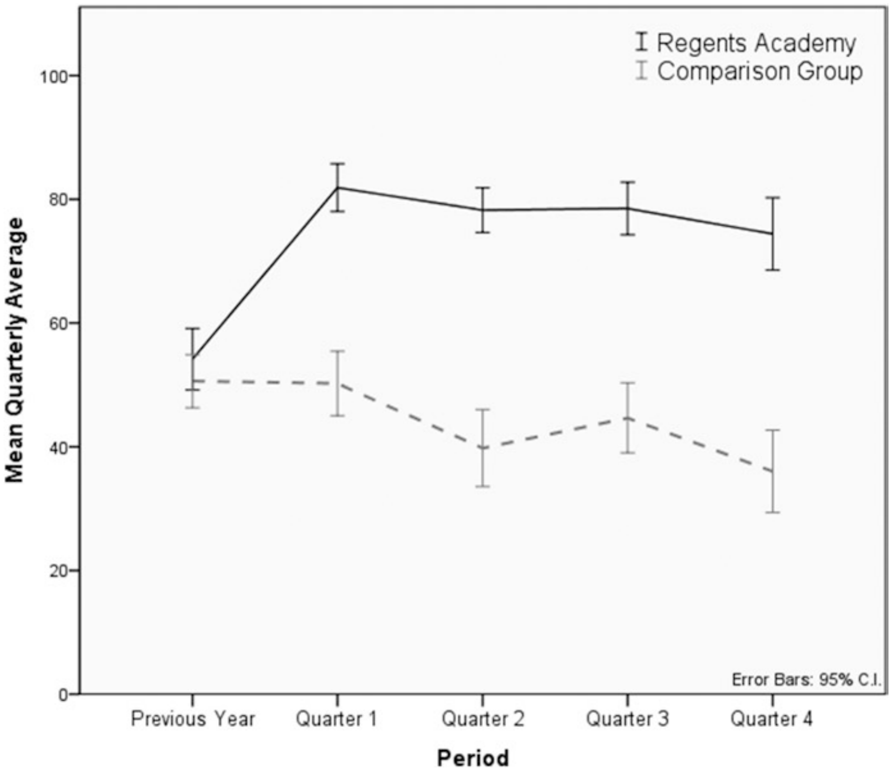

Fig. 13.1 Grades for previous year and for each quarter of the academic year. Grades during the previous year (before enrolling at Regents Academy) were not significantly different between the RA students and their comparison group ($t(95) = -7.16$, $p = .476$). Compared to the previous year, RA students improved their grades during the first quarter ($t(41) = -12.791$, $p < .001$), while the comparison group showed no change from the previous year ($t(47) = -.095$, $p = .925$)

students and randomly selected 56 to enter the RA. The remaining 61 students were tracked as they experienced the normal routine at BHS. We also compared both groups to the performance of the average BHS student.

The RA students responded to their new social environment quickly. After only one quarter of the school year, RA students showed dramatic improvements in their grades, relative to the comparison group. This pattern of success remained steady for the rest of the year (Fig. 13.1). While this achievement is laudable in itself, the state-mandated Regents Exams allow a more-rigorous comparison between the RA students, their comparison group, and BHS as a whole.

Not only did the RA students greatly outperform their comparison group on these standardized tests at the end of the year, but they also performed on par with the average Binghamton High School student (Fig. 13.2). The dropout rate declined

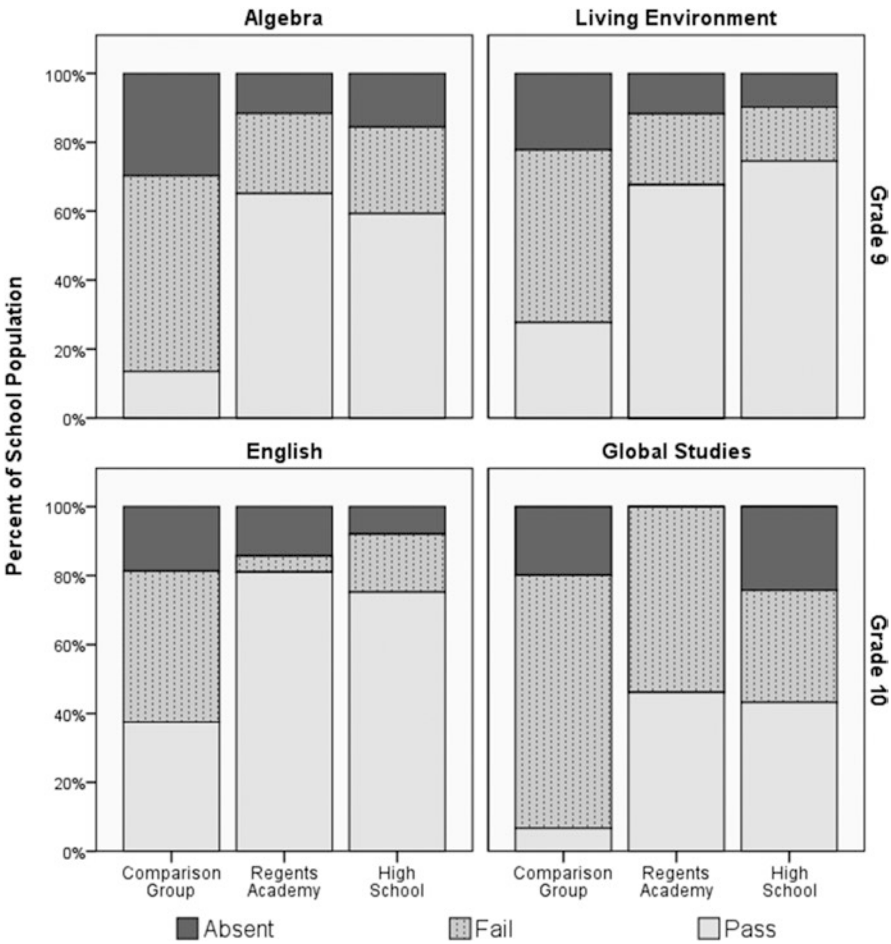

Fig. 13.2 Performance on state-mandated exams in four subjects: Algebra, Living Environment, English, and Global Studies. In all panels, Comparison Group (CG) is presented as the *left bar*; Regents Academy (RA) is the *middle bar*; High School students are on the *right*. RA students surpassed the passing rate of the comparison group on all subjects There were no significant differences between the passing rates of RA students and the Binghamton High School students (BHS) as a whole. Also, thanks to the heroic efforts of Mark Fish (RA Global Studies teacher), students from the RA were more likely to attend the Global Studies exam than students from both the comparison group ($\chi^2(1, 41) = 5.61$, $p = .043$) and BHS ($\chi^2(1, 565) = 8.226$, $p = .001$). Attendance rates for the other exams did not differ

to 3.5 % for the RA students versus 16 % for the comparison group. Male, female, Black, White, and Hispanic students benefited equally. These results have been published in the Public Library of Science's open-access journal, *PLOS ONE* (Wilson et al., 2011).

How the Regents Academy Was Informed by Evolutionary Theory

The Design Principles

The principles guiding the RA stand on the firm interdisciplinary framework of evolutionary theory. Beginning with the fact that schools are social groups whose members must cooperate with each other to achieve certain objectives, the RA encourages a learning environment with design features that enable any human group to function as a cooperative unit (Wilson, Ostrom, & Cox, 2013). These design features draw from the work of Elinor Ostrom (Ostrom, 1990, 2010), who earned the Nobel Prize in economics in 2009 for demonstrating that *when certain conditions are met, groups of people are capable of sustainably managing their common resources* (Hess & Ostrom, 2007).

Drawing from empirical cases and guided by the emerging field of game theory, Ostrom (1990, 2010) identified eight design principles that enable common-pool resource groups to effectively manage their resources (Cox, Arnold, & Tomás, 2010). Briefly, these principles are: (1) clearly defined boundaries, with a strong group identity and sense of purpose; (2) proportional equivalence between costs and benefits; (3) collective choice arrangements; (4) monitoring; (5) graduated sanctions; (6) conflict resolution mechanisms that are quick and seen as fair by all group members; (7) local autonomy and the minimal recognition of rights to organize; and (8) for groups that are part of larger social systems, there must be appropriate coordination among relevant groups.

Because of their theoretical generality, the design principles have since been applied to a wider range of application than common-pool resource groups and are now considered relevant to nearly any situation where people must cooperate and coordinate to achieve shared goals (Wilson et al., 2013). Because the general capacity to cooperate does not specify how to achieve any particular shared objective, many groups also require auxiliary design principles in order to best achieve their specific objectives. Two auxiliary design principles for education settings that were also part of the RA design were: (9) learning requires an atmosphere of safety and trust, and (10) the need for long-term learning goals to also be rewarding over the short term (Wilson et al., 2011).

Program Design

The RA was located on a single-floor in a Binghamton City School District (BCSD) alternative school building. Although the building was shared with other school programs (i.e., an alternative middle and high school program for at-risk students, run through the regional Board of Cooperative Educational Services (BOCES) program), we deliberately designed the program so that our students would not

Fig. 13.3 (**a**, **b**) Regents Academy Logo and Motto Scroll. (**a**) Regents Academy logo, designed by a committee of representative students and staff at RA when the school decided they would like to have t-shirts made. This logo became the official image of the RA and was used for letterhead and other formal representation; the t-shirt was redesigned each year. (b) The motto was developed by the staff at the RA and was printed on motivational banners in the hallway and classrooms; was used in t-shirt designs; was used as discussion topics for various group activities. Students were often encouraged to reflect on the motto at team meetings, assemblies, disciplinary hearings, etc.

have opportunities to socialize or participate in classes/programs with students from the other services provided at the school. This was as an important component of the RA design, as the first of Ostrom's design principles (DP#1) is for a group to foster its own identity. Another step taken towards reinforcing DP#1 was to have the staff and students work together at the beginning of the school year to develop a logo and school motto (Fig. 13.3a, b) that were then printed on, for example, t-shirts, drawstring bags, posters, and letterhead. Students shared the physical education and cafeteria facilities and staff with the other students in the building, but each group used them at separate times.

A typical day at the RA was similar to what one would experience at the regular high school. Students rotated between rooms for 45-min classes (doubled for science lab). All students were enrolled in classes for their basic “core” subjects—Science, Math, English, and History, as well as a Language Literacy class (and some students also took a Math Literacy class, depending on need). Students had an enriched study hall—“Learning Lab” (described below)—during class periods opposite their science labs. All students at the RA ate breakfast and lunch together at two large tables in the cafeteria. Teachers rotated "lunch duty" and would take turns eating lunch with the students in the cafeteria. The principal also attended lunch with students in the cafeteria daily. This kind of socializing between the principal, teachers, and students contributed to the implementation of multiple design principles: a strong group identity (DP#1), monitoring (DP#4), and fast & fair conflict resolution (DP#6)[1].

The Rooms

Aside from its standard, under-resourced classrooms, the RA also housed a Resource Room, the "Community Room," "Learning Lab," and a Main Office (with a partitioned Principal's Office in the Main Office).

"The Lounge" (Resource Room). The Resource Room served as the classroom of the Special Education teacher (five of the students at the RA were formally classified as special education students) and it was also the "office" of the first author of this paper. The Resource Room was never referred to by this name; it eventually adopted the name: "The Lounge." While it remained a room where students could go when they needed to be removed from class for special circumstances, i.e., testing or to finish working on an assignment with extended time (and this rite was not only reserved for the classified students), the main function of "The Lounge" was to serve as a place where students could go when they had free time (when they finished in-class assignments before the end of the period, or during lunch, or before school, or during "Learning Lab," etc.) to play games, or to draw, or to socialize, or to engage in extra-curricular learning activities, etc. The first author would regularly introduce challenges[2] (e.g., games and brain teasers, "The Sudoku Puzzle Challenge"; Tetris Tournaments; "Who can teach me about _______?"; "Anyone can Juggle!"; "Can you learn to knit a hat?") to stimulate engagement during non-instructional times.

Community Room. The "Community Room" was a large room (originally, the building's auditorium) where school meetings and other whole-school activities were held. For example, during the first two days of school, students remained in the Community Room participating in team-building exercises and group meetings about what to expect while at the RA. Semester-meetings were also held in the

[1] This example illustrates the flexibility of the *generalized* design principles with any one *particular* implementation: A single implementation may be used to target multiple design principles; and also any one principle may be targeted by multiple simultaneous or staggered interventions (so long as the interventions are complementary in design). See Embry and Biglan (2008) and Embry (2004) for an introduction to effective implementation strategies.

[2] The RA utilized a token economy engagement system, where students would receive tickets that they could exchange for items from the "Kudos Cabinet." Kudos Tickets were often offered as a prize for completing a challenge and effectively served as a "teaser" to get some students, even the ones with the "roughest of edges," interested in participating.

Community Room, where the group reviewed the school's academic performance, attendance, and other matters at hand. Awards and special recognitions were announced (DP#2). Students were also provided the opportunity to formally discuss any grievances with the program during these meetings (DP#6). The Community Room was also where students gathered for "Fun Friday." Fun Friday, described in the previous RA report as "Fun Club," was a weekly time set aside for students to engage in activities of their choosing, e.g., juggling, music, art, games.

Learning Lab. The Learning Lab was a double-sized classroom, with a set of desks in one half of the room and a computer lab on the other side, separated by bookshelves full of donated books, school/craft supplies, puzzles, and games. Students were scheduled to be in the Learning Lab on days opposite their science labs, serving as a study hall. Learning Lab classes began with students catching up on missed assignments (teachers would submit a daily report of assignments that students needed to complete). When finished with their "make-up work," students could choose to either work on homework assignments or have "free time" on the computers for the remainder of the period. Students were also permitted to visit "The Lounge" or Community Room when they completed their make-up assignments. The Learning Lab also functioned as the computer lab and teachers could reserve the computers for their class sessions; on these days, all Learning Lab students were assigned to the Community Room after completing their overdue assignments.

"The Office." The "Main Office" of the RA was a large, inviting room with multiple tables and seats (including oversized, padded chairs). One of the tables had jigsaw puzzles and other various "brain teaser" activities; coloring books, blank paper, and markers, crayons and colored pencils; various games (i.e., chess, checkers, "Connect Four"); all available for students to use during "down times" and, in many cases, when appropriate, while awaiting disciplinary action. (These were not introduced for disciplinary purposes during the first few months of the program.)

The Administrative Office Assistant's (OA) desk was positioned near the entrance of the room, and the "Principal's Office" was located beyond a partition on the opposite side. The principal did not wish to be separated from the students through a closed-door and, in fact, she was rarely seated at her desk during school hours (unless she was holding a meeting with a student and/or a student's parents).

As opposed to a typical high school, where students only enter the Main Office for disciplinary issues, most of the students at the RA would float in and out of the office throughout the school day—before and after school hours, between classes, and even while using a hall pass. Occasionally, students would find their way into the office when they were supposed to be in class and the OA would send them back to their classes with a stern-but-loving reprimand. The OA developed a very strong, personal rapport with each student and was one of the key ingredients that enabled the RA social environment to thrive with an atmosphere of trust, respect, discipline, and love. She played a role in disciplinary procedures, whether it was administering a "time out" or talking with students to find out why they were having an "off day." Students would confide in her about any personal issues they were facing and she was able to inform the rest of the staff about the conflicts that each student was dealing with, both inside and outside of school. The OA represented a very unique feature of the program and the RA could not have succeeded without the right person in this position.

The school principal was another key ingredient to cultivating the social climate of the RA. While students recognized her as the disciplinarian, she was also very well-respected and students knew that she cared deeply about each of them. Early in the school year, the principal met with each student to discuss why they were there and to establish a plan for personal growth. Disciplinary action plans were not based on previously determined dogma, but, instead, were developed independently for each student—based on personal behavioral patterns and the expectation of growth (DPs#4–6). The principal was present in the hall during the switching of classes, where she was seen not as "overseer" but rather as someone socializing with the students (and occasionally hurrying the idle student toward class). The principal and the first author met daily to discuss the performance of the staff & students and to develop plans for further program implementations based on the evolving needs of the students (DP#4, and, in part, DPs#3&7).

Teachers and Staff

The RA staff consisted of five teachers (Science–Biology (Grade 9) and Environmental Science (Grade 10); Math–Algebra (9), Geometry (10), and Math Literacy (9 & 10); History–Global Studies (9 & 10); English–English Language Arts (9 & 10); and Literacy–Language Literacy and Reading (9 & 10)), a full-time teacher's aide (who floated between classes depending on daily needs), a Special Education teacher, an Administrative Office Assistant, and the school principal. Each staff member had been previously employed in a BCSD school prior to becoming involved with the RA. Being housed in a building with other school programs, RA students shared a Physical Education teacher with other students in the building and we had very little influence with that teacher's conduct.

Prior to the start of the school year, the researchers met with the RA staff multiple times to familiarize them with the basic design principles for the RA, and to involve them in the planning of the school. The first meetings were primarily led by the researchers and were used to establish: (1) that a social climate reflecting cooperation, trust, and respect was the primary goal for creating a "safe and secure" learning environment for the RA; (2) that long-term learning outcomes require short-term rewards/reinforcement; and (3) that many of the hardships students face outside of school influence their performance within the school building, that the best plans for success must work with students' needs rather than against them. Subsequent meetings focused on teachers' needs, scheduling, and developing strategies for how to work with a 100 % at-risk student population—something that most of the teachers had not experienced.

After these initial meetings prior to the start of the school year, the school staff met with the researchers on a weekly basis to review the program and to design new program implementations based on the evolving needs of the school. An emphasis was placed on teachers' having ownership of the school program and they were encouraged to lead the discussion of the weekly meetings. It is important to note this flexibility in program design was an essential component of the RA design that is often not reflected in traditional school settings (DPs#7&8).

Attitudes and Mindsets

Though coming from diverse backgrounds and teaching experiences, every staff member at the RA shared a common feature: they each elected to participate in the program. This was an important ingredient for the success of the school because, as described previously with the OA and principal, cultivating the target social climate at the RA required the teachers' attitudes to reflect the appropriate message; to convey a mindset that says: "I want to be here for you" and, most importantly, the idea that "we're in this together."

Research demonstrates that attitudes conveying success are a major indicator for achievement in education (Raudenbush, 1984; Sorhagen, 2013). This "Pygmalion Effect" (Rosenthal, 2002; Rosenthal & Jacobson, 1968), whereby the student performs better when there is a greater expectation placed upon them, was an explicit component of the RA design and a message that was repeatedly conveyed to the teachers during training sessions.

As developing the learning environment of the RA was the primary focus for this first year of operation, teacher training did not include strategies for developing lesson plans or enhancing curriculum-instruction-assessment practices beyond those factors that influenced the social climate. As a result, teachers did not alter their teaching strategies from how they had been previously developed and implemented at the regular high school.

Experimenter Participation

Another key feature of the RA that greatly differed from other typical school programs was the regular participation of the researchers. As mentioned above, the first author of this chapter played a unique, central role in the daily operation of the school—as an advisor to the principal and teachers and also as a "comrade" to the students. Because the students were naïve to the research component of the RA, there was no apparent connection with the researcher and an evaluation of the students; he was not a teacher at the school and the students did not perceive any connection to his presence with them being "graded" or evaluated; recognized by the students as a "volunteer school aide." This dynamic allowed the students to hold a very different relationship with the researcher when compared to the teachers, being perceived as a person who was present in their lives simply because he cared about them and their success.

The students would often arrive at school early for the researcher's "unofficial" morning program, to play games in "The Lounge" or for extra juggling lessons or to simply socialize with the other students. The researcher would often challenge the students to learn about subjects that had no connection to their classes, to spread the message that "learning is fun," and to model effective strategies for lifelong learning. And because the students were not being graded, they were generally willing to try out new things without the fear of being judged for failure.

Because students perceived the researcher as someone to learn from, he was a regular tutor for the students; either helping out during classroom instruction or helping students catch up on work and teaching content they may have missed due to an absence. Also, because he had previously worked as a high school science teacher, he was a regular substitute teacher when one of the main teachers was absent. This enabled continuity in instruction and also reduced the likely disruptions that are typical when an "outsider" is brought in as a day-to-day substitute teacher.

The other noticeable benefit provided by his role was that students were comfortable discussing their concerns and feelings about the school program with the researcher, generally being more candid with him than with their teachers. The researcher was then able to address these concerns at staff meetings, where the teachers could develop strategies for increasing student engagement based on the students' perceptions (DP#3, in part). The best example of this was mentioned in Wilson et al. (2011) when the Fun Friday program was developed in response to students indicating their desire to use time in school for learning about subjects of their own interests.

When this concern was raised during a staff meeting, the teachers agreed that they could forfeit one half-day of instruction every week. But, rather than simply announcing this to the students, it was implemented in the following manner: (1) the researcher convinced the students to raise these concerns to the teachers during the next group meeting, and to ask if they could have a "day off" each week; (2) the teachers then "negotiated" with the students, explaining that there were curricular goals that needed to be met and that they had to teach the content necessary for their state exams. The teachers then proposed giving up one half-day each week, to which the students agreed; (3) the teachers and students then negotiated the terms: students wanted this to be on Friday afternoons (and so did the teachers), and the students agreed that they would sign up for Fun Friday activities ahead of time, when the teachers expressed their concern of students just "wasting time." This approach not only demonstrates the flexibility of the RA design, but also exemplifies DP#3: consensus decision making, where students perceive that they have control over some aspects of their school day.

By facilitating this "cross-talk" between teachers and students and by filling the role of a "neutral" caregiver, the researcher being a part of the regular staff was a unique feature of the RA. Though this component was not directly assessed, it is likely to have played an important role in the success of the school program. One final benefit to identify about the researcher's role is that it yielded no extra cost to the school, as the researcher was employed by an outside institution.

Table 13.1 Demographic information for survey participants of total population and as separated by experimental group

Demographic variable		RA $n=25$	CG $n=9$	HS $n=390$
Gender	Female	11(44 %)	6(67 %)	206(56 %)
	Male	14(56 %)	3(33 %)	165(44 %)
Ethnicity	Caucasian	12(48 %)	3(33 %)	234(63 %)
	Black	10(40 %)	4(44 %)	85(23 %)
	Hispanic	3(12 %)	2(22 %)	33(9 %)
	Asian	0(0 %)	0(0 %)	19(5 %)
Free or reduced lunch		23(92 %)	7(78 %)	180(49 %)
Age		15.12 ± 0.78	14.78 ± 0.67	14.95 ± 0.75
Absence rate (%)		6.81 ± 8.57	9.50 ± 7.37	4.24 ± 4.90

Note: *Age* and *Absence Rate* represented with mean and standard deviation. Hispanic population determined by measure of English as Second Language (*ESL*) students

The Students: Population, Recruitment, and Class Size

As noted, students who qualified for the RA must have failed at least three of five courses during their previous year to qualify for the program, so they represent the most at-risk students within the community of Binghamton. Of the 117 students who qualified, 56 were randomly chosen to enter the program. The demographic composition of the RA population is provided in Table 13.1.

Once the RA students were selected, letters of invitation were sent to the parents/guardians of each student. This letter described the opportunity for the students to attend a school program that was designed to promote academic achievement and to better facilitate the needs of these selected students. Though parents/guardians were given the opportunity to opt-out of participation in the program, no one turned down the offer—maintaining a true randomized sample within the study population. Students and parents/guardians from the comparison group were not previously informed that the RA was being developed and that they were among the list of students who qualified for admission; therefore, they received no indication that they had not been selected to participate in the program.

The 56 students in the RA population were made up of 29 freshman and 27 sophomores. Each of these groups was divided into two separate teams in each grade level, resulting in four teams of approximately 14 students each. Thus, the class size at the RA was no more than 14 students (with regular absence rates, the average daily class size was actually closer to 8–10 students at any given time). Aside from being members of a specific class (9A, 9B, 10A, and 10B), students were also divided into mixed-age "tribes." Each tribe contained a mix of 9th and 10th grade students and was assigned a supervising staff member whose room served as the "home base." Students began and ended the school day in their "home base." Students also participated in a variety of team-building activities with their tribes throughout the school year, including various between-tribe challenges, e.g., attendance competitions.

Small School, Small Class

This "small school, small class" design was intentionally planned for the RA, as many reports demonstrate that small class sizes are a significant variable in school success for at-risk students (Allen & Steinberg, 2005; Finn & Voelkl, 1993; Howley, Strange, & Bickel, 2000; Lee & Smith, 1997). While large schools have the capacity to offer more specialized programs, at-risk students are less-likely to participate in these special programs (Finn & Zimmer, 2012). Disadvantaged students in large schools are more likely to "fall through the cracks" or feel cut off from the school culture. With such a small population, every staff member at the RA was able to develop a personal relationship with each student, and students were better able to form strong relationships with their peers.

Furthermore, the small school size of the RA also improved communication among its staff members. The small group size of the teachers enabled "teaming" to naturally occur within the staff population. Teaming refers to pairing a group of teachers (typically between four and six) with a group of 60–80 students, allowing teachers to discuss the students they have in common and to establish stronger teacher–student relationships based on an improved understanding of the students and their specific learning needs (Flowers, Mertens, & Mulhull, 1999; Hunt et al., 2003).

Compared to the regular high school, which has roughly twenty-five students per class and nearly five hundred students per grade, the RA provided its students an atmosphere where they could develop consistent, supportive, understanding relationships with teachers and adults and increased opportunities to form strong relationships with their peers. Given these factors, combined with the natural inclination for involving all staff members in a teaming structure, the small school size of the RA was designed to have an expected positive effect on learning, emotional growth, and social development.

Overview

We have described the unique design of the RA in detail, including seemingly arbitrary features such as the composition of the staff and the physical layout of the rooms, for the following reason: The success of the RA cannot be credited to any single design feature. The RA represents a package of unique design features that were particularly shaped to each other and to the local circumstances. A duplicate program would be nearly impossible to replicate elsewhere. The RA was successful not because of its specific features but rather because each of the specific features was organized and implemented through a single evidence-based framework.

It is this adherence to an organizing framework of general design principles that enables any learning environment to incorporate these principles into their own local practices. Any program of this sort will begin with a physical layout, a staff, and a budget that are highly contingent and beyond the control of the investigators. The challenge is to work with the material at hand with certain functional design principles in mind.

A detailed description is required to show how we worked with the material at hand to create a safe and secure social environment in which long-term learning outcomes were made rewarding over the short term. This required the creation of physical spaces where the students could mingle with each other and the adult staff; where they could play games and develop skills that were not seemingly oriented toward academic achievement; where they could take part in the decision-making process; where their behavior could be monitored in a way that was compassionate and mindful of their difficult lives; and so on. No two programs will be alike in their implementation of these design principles, a point that Elinor Ostrom stressed for the common-pool resource groups that she studied (Ostrom, 1990). Even the RA changed over the course of the school year as implementations that appeared to be working poorly were replaced by new attempts. It is impractical to rigorously assess each and every implementation, but the full package can be rigorously compared with "Treatment As Usual (TAU)"—in our case the normal high school routine available to the students, in a randomized controlled trial. This is common practice in applied social science research (e.g., Biglan, 2015; Wilson, Hayes, Biglan, & Embry, 2014), with more refined comparisons following upon whole-program comparisons.

Measuring the Broad Goals of Education at the Regents Academy

We used a modified version of the Developmental Assets Profile (DAP; Scales, Benson, Roehlkepartain, Sesma, & van Dulmen, 2006) to measure the internal (psychological, behavioral) and external (social, environmental) assets of students in the RA, their comparison group, and the students from the regular high school in the RA school district. The DAP, developed by Search Institute (http://www.search-institute.org/; also see Scales et al., 2006), identifies a set of skills, experiences, relationships and behaviors that enable young people to develop into successful and contributing adults. Data collected from Search Institute surveys of more than four million children and youth from all backgrounds and situations have consistently demonstrated that the more developmental assets young people acquire, the better their chances of succeeding in school and becoming happy, healthy, and contributing members of their communities and society (Benson & Scales, 2009, 2011; Benson, Scales, & Syvertsen, 2011; Scales et al., 2006, 2008, 2013).

Methods

In collaboration with the Binghamton City School District (BCSD), a modified version of the DAP was administered in March 2011 to 9th–12th grade students during gym class, in a procedure that was approved by both the school district and the

University's Human Subjects Research Review Committee. This study followed two similar administrations in May 2006 and January 2009 (O'Brien, Gallup, & Wilson, 2012; Wilson, O'Brien, & Sesma, 2009).

Study Participants

Students from the local public school district responded to an in-school survey in late March 2011 ($N = 1007$). Participants were students in the Regents Academy (RA; $n = 25$), a comparison group (CG; $n = 9$; created through a randomized controlled design, as described in Wilson et al., 2011), and Binghamton High School (HS; $n = 660$). Because the RA is a program for 9th and 10th grade students, the analysis excludes any students from HS who were not of freshman or sophomore level at the time of survey administration ($n = 390$). The 424 participants had an average *age* of 14.97 years; 54.5 % were *female*; 23.3 % *Black*, 4.5 % *Asian,* and 12.5 % identified as speaking English as a second language (*ESL*), which serves as a proxy for an estimate of the Hispanic population at this school. Student lunch status—free and reduced lunch vs. no assistance—is used as a measure of socioeconomic status (*SES*), with 52.6 % of the students on free or reduced lunch (low SES). Descriptive statistics for demographic variables are reported in Table 13.1.

The authors acknowledge the concern of low sample size in the CG and RA populations as a potential limitation to this study. Although the survey was administered over 2 days, participation was dependent upon school attendance. As both of these groups—CG and RA—are identified as at-risk students, low attendance rates are characteristic in this population and, although the RA did many things, it did not influence school attendance (as reported in Wilson et al., 2011).

While this low sample size could potentially introduce a selection bias, we do not feel this limitation ultimately impacts the findings of this study. Furthermore, if there is a selection bias in the CG, it is likely that the odds would be against our favor as the most intentionally skipped class at BHS (especially in the at-risk population) is gym class and, because the survey was administered during gym class, the students who did show up to take the survey are those who should report higher assets than any who skipped. Because of methodological differences between RA and BHS, students at RA were not able to skip survey administration if they entered school on these days and this selection bias would not exist in the RA population.

Measures

Demographic Variables. BCSD provided demographic information for each student: gender, birth date, age, ethnicity, lunch status (full paying, reduced price, or free lunch—where students qualify for free lunch if they live in a household with gross income below \$300/week (\$15,600/year) and reduced lunch if the gross income is below \$20,000/year plus \$7000/year per sibling in the house); at which time they replaced identifying information with arbitrary ID numbers, per Human Subjects Research Review Committee requirements. Gender was coded as a dichotomous variable ("1" = Female); birth date was used to calculate age at the time of administration; ethnicity was recoded as two different dichotomous variables (*Black*, and *Asian*; Whites, and the one Indian student were grouped together as a reference category); English as a second language (*ESL*) was coded as dichotomous variable ("1" = non-native English speakers; in this population, *ESL* is often used as a proxy to identifying Hispanic students, as Hispanic students are classified as Caucasian in BCSD); and lunch status was converted into two dichotomous variables ("1" = reduced lunch, "0" = others; and "1" = free lunch, "0" = others; those who pay for lunch act as the reference category). The two lunch status indicators were later combined into a single item to represent a proxy measure of socioeconomic status (*SES*; "1" = free *or* reduced lunch, "0" = others).

Survey Measures. Scales were developed to measure three internal/psychological assets—*well-being*, *learning*, *prosociality*, and one's perception of six external/social assets—perceived *physical disorder* of home neighborhood, social capital (*collective efficacy*) of home neighborhood, *family*, *school*, *extracurricular activities*, and *religion* (which also serves an internal/psychological role). All items are reported in Table 13.2.

We used scales created for the 2006 and 2009 administrations of the DAP, as described in Wilson et al. (2009), to measure well-being, learning, prosociality, and four forms of social support: family, school, extra-curricular activities, and social capital (*collective efficacy*) of neighborhood (as was expanded for the 2009 administration, drawn from Sampson, Raudenbush, & Earls, 1997). The scale for Social Capital of home neighborhood was comprised of two, three-item subscales: *social cohesion*—the strength of relationships an individual has with his neighbor (e.g., "People in my neighborhood are willing to help each other."), and *social control*—the enforcement of established rules/norms by a neighborhood upon its members (e.g., "If children were skipping school and hanging out in my neighborhood, adults would tell them to go to school."). *Social cohesion* and *social control* are combined into a single measure, *collective efficacy*, for this analysis.

This administration has substituted the original measure of religious assets with a more current scale derived from the Duke University Religious Index (DUREL; Koenig, Meador, & Parkerson, 1997). A measure of the perceived physical disorder in one's neighborhood was also added, derived from Ross and Mirowsky's (1999) measure for perceived neighborhood decay. A higher score on this scale represents a lower impression of neighborhood upkeep.

Participants indicated their level of agreement with each item on a five-point Likert scale. We calculated scale scores by summing the responses to all scale items and standardizing so that the lowest (all 1's) and highest (all 5's) possible scores were assigned values of 0 and 100, respectively.

All scale reliabilities are reported in Table 13.2. As in previous years, scales had acceptable to strong reliabilities (α's = .722–.858), except in the case of extracurricular activities (EA; α = .407). The low reliability of EA is, in part, an artifact of

Table 13.2 Scale items and associated Cronbach's alpha scores

Scale title and items	Reliability scores
Internal assets	
Well-being	**α = .775**
I feel in control of my life and future	
I feel good about myself	
I feel good about my future	
I am developing a sense of purpose in my life	
Learning	**α = .813**
I care about school	
I do my homework	
I enjoy learning	
I enjoy reading or being read to	
I am actively engaged in learning new things	
Prosociality	**α = .813**
I am trying to help solve social problems	
I think it is important to help other people	
I resolve conflicts without anyone getting hurt	
I tell the truth even when it is not easy	
I am helping to make my community a better place	
I am developing respect for other people	
I am serving others in my community	
I am sensitive to the needs and feelings of others	
External assets	
Family	**α = .830**
I am included in family tasks and decisions	
I have parent(s)/guardian(s) who are good at talking with me about things	
I am spending quality time at home with my parent(s)/guardian(s)	
I have a family that knows where I am and what I am doing	
I feel safe and secure at home	
I have parent(s)/guardian(s) who urge me to do well in school	
I have a family that gives me love and support	
I have parent(s)/guardian(s) who try to help me succeed	
School	**α = .788**
I feel safe at school	
I have a school that gives students clear rules	
I have a school that cares about kids and encourages them	
I have teachers who urge me to develop and achieve	
I have a school that enforces rules fairly	

(continued)

Table 13.2 (continued)

Scale title and items	Reliability scores
Religion	**α = .858**
I am a spiritual person	
I am a religious person	
I participate in private religious activities, like prayer or meditation	
My religious beliefs influence my approach to life	
About how often do you attend religious services or other religious groups or activities?[a,b]	
Extracurricular activities	**α = .407**
I am involved in a sport, club, or other group	
I am involved in creative activities such as music, theater, or art	
Neighborhood: ***Collective efficacy***	**α = .818**
Social cohesion	**α = .802**
I have good neighbors who help me succeed	
I have neighbors who help watch out for me	
People in my neighborhood are willing to help each other[c]	
Social control	**α = .722**
If a fight broke out in my neighborhood, it would be broken up[c]	
If children were disrespecting an adult in my neighborhood, other adults would stop them[c]	
If children were skipping school and hanging out in my neighborhood, adults would tell them to go to school[c]	
Neighborhood: ***Physical disorder***	**α = .748**
There is a lot of graffiti in my neighborhood	
There are a lot of abandoned buildings in my neighborhood	
People in my neighborhood take good care of their houses and apartments[b]	
My neighborhood is clean[b]	

Note: Chronbach's alpha describes the extent to which a scale's items intercorrelate.
[a]With options: 1 = More than once a week, 2 = About once a week, 3 = 1–3 times a month, 4 = Several times a year, 5 = Not at all
[b]Item reverse coded

having a two-item scale, each item being quite dissimilar from the other in routine practice—with one item measuring involvement in sports and clubs and the other in the arts. Given the theoretical similarity between the roles of these two activities in providing social support, we elected to maintain this as a scale during analysis.

Analyses

To compare differences between study populations, school attended (RA, CG, or HS) was transformed into a trichotomous variable ("0" = RA, "1" = CG, and "2" = HS). Demographic comparisons across study populations were performed with chi-square tests. *Age* and school attendance (*% Absent*) were compared between study populations with a univariate analysis of variance test (ANOVA). Pearson's correlation was used to measure the degree of relatedness between survey measures. A multivariate analysis of covariance (MANCOVA) was conducted to identify differences in developmental assets (DVs) across school populations between the different learning environments (IV). Gender, age, ethnicity, SES, and attendance rate were entered as covariates, as each was significantly correlated with multiple DAP scales. An analysis of covariance (ANCOVA) was conducted on analysis of covariance (ANCOVA) was conducted on each DV as a follow-up test to MANCOVA in order to examine significant associations.

Planned comparisons employing orthogonal contrasts were conducted in order to further investigate differences between study groups on each of the DVs. The first contrast compares students from the RA with those in the CG to test the primary hypothesis of this study: that the learning environment provided at the RA would positively influence the developmental assets of its students and they would therefore report higher DAP scores than their matched sample. The second contrast compares scores between RA and HS students in order to investigate how students at the RA compared with the rest of the HS population on DAP scores.

An alpha level of 0.05 was used for all statistical tests. All missing data were excluded listwise from the analysis; running the analysis with imputed data did not affect the results. All analyses were performed with SPSS 20.0.0.

Results

Demographic Analyses Across Experimental Groups

Chi-square tests revealed there was no difference in gender ratios between the populations of the RA, CG, and HS ($\chi^2_{df=2} = 1.671$, $p = .434$). As one would expect, the demographic composition of the students at the RA and in their CG illustrates a more at-risk population than the average HS student. Specifically, the RA and CG had a higher concentration of Black students than did the HS (RA = 40.0 %, CG = 44.4 %, HS = 21.8 %; $\chi^2_{df=2} = 6.637$, $p = .036$) and were more poor, as both the RA and CG had larger proportions of students on the free-lunch program than did the HS (RA = 92.0 %, CG = 77.8 %, HS = 49.5 %; $\chi^2_{df=2} = 19.369$, $p < .001$). There was no significant difference between RA and CG populations in the concentration of Black students ($\chi^2_{df=1} = 1.360$, $p = .244$) or students of low SES ($\chi^2_{df=1} = 1.289$, $p = .256$). While there were no Asian students in the RA or CG, this was not significantly different from the low frequency of Asian students in the HS sample population (19:390; $\chi^2_{df=2} = 1.734$, $p = .420$). Due to the absence of Asian students in the RA and CG, Asian students in the HS are removed from further analyses ($n_{HS} = 371$). There was no difference in the concentration of ESL speakers between schools ($\chi^2_{df=2} = .797$, $p = .671$).

Univariate ANOVAs were conducted to determine differences between age and attendance rates between study populations. There was no significant difference in age between school groups ($F(2, 402) = .852$, $p = .427$). Since the assumption of homogeneity was not met for attendance rates, we used Welch's adjusted F ratio and found no significant difference between schools for attendance rate (*Welch's* $F(2, 16.428) = 3.188$, $p = .068$).

Correlations

To confirm the use of demographic variables as covariates in the MANCOVA analysis, a series of bivariate correlations were performed between: (1) demographic predictors, (2) demographic predictors and survey scales, and (3) all survey scales. Results are presented in Table 13.3.

Few correlations were found between demographic variables. Of these, absence rate was most commonly correlated with other demographic characteristics; females ($r = .104$, $p = .038$), older students ($r = .214$, $p < .001$), and students from low economic backgrounds ($r = .172$, $p = .001$) all attended school less frequently than their counterparts. Socioeconomic status was also correlated with ethnicity, where Black students ($r = .305$, $p < .001$) and ESL students ($r = .193$, $p < .001$) tended to be from lower economic backgrounds.

Each demographic variable revealed moderate to highly significant correlations with at least one developmental asset, with many being significantly related to at least three of the nine scales. Female students reported significantly higher scores on attitudes toward learning ($r(400) = .232$, $p < .001$), higher levels of prosociality ($r(400) = .190$, $p < .001$), more involvement in extracurricular activities ($r(400) = .129$, $p = .010$), and greater support from their home neighborhood ($r(400) = .107$, $p = .033$). Younger students reported having a higher sense of well-being ($r(400) = -.116$, $p = .020$) and more involvement in extracurricular activities ($r(400) = -.160$, $p = .001$), while older students reported higher rates of physical disorder in their home neighborhoods ($r(400) = .132$, $p = .008$). Black students also reported higher levels of well-being ($r(400) = .116$, $p = .020$). ESL students reported receiving more assets from school ($r(400) = .122$, $p = .015$) and more support from their religious affiliations ($r(400) = .113$, $p = .023$). Students with lower SES reported lower levels of prosociality ($r(400) = -.125$, $p = .012$), less participation in extracurricular activities ($r(400) = -.192$, $p < .001$), and also that they live in worse neighborhoods—with higher levels of neighborhood physical disorder ($r(400) = .207$, $p < .001$) and lower levels of social support from their home neighborhoods ($r(400) = -.227$, $p < .001$). Students with higher rates of absence report similar patterns to those with lower SES, reporting lower levels of prosociality ($r(400) = -.119$, $p = .017$), less involvement in extracurricular activities ($r(400) = -.131$, $p = .008$), and lower levels of neighborhood collective efficacy ($r(400) = -.147$, $p = .003$).

Table 13.3 Correlation matrix for demographic variables and DAP scales

Correlatives	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. *Female*[a]	.051	.055	.072	−.038	.104*	.023	.232**	.190**	.056	.076	.023	.129**	.107*	−.089
2. *Black*[a]	–	−.084	.305**	−.038	.005	.116*	.096	−.038	.023	.076	.059	−.029	−.076	.059
3. *ESL*[a]		–	.193**	.075	.025	.040	−.004	.018	.044	.122*	.113*	−.030	−.010	−.062
4. *SES*[a]			–	.085	.172**	−.033	−.072	−.125*	−.036	.011	−.086	−.192**	−.227**	.207**
5. *Age*				–	.214**	−.116*	−.054	−.082	−.077	−.049	.019	−.160**	−.054	.132**
6. *% Absent*					–	−.054	.020	−.119*	.011	−.071	.014	−.131**	−.147**	.085
7. *Well-being*						–	.440**	.470**	.565**	.472**	.188**	.291**	.305**	−.369**
8. *Learning*							–	.592**	.394**	.419**	.251**	.473**	.300**	−.173**
9. *Prosociality*								–	.434**	.544**	.336**	.445**	.537**	−.323**
10. *Family*									–	.432**	.186**	.212**	.354**	−.381**
11. *School*										–	.175**	.254**	.396**	−.335**
12. *Religion*											–	.142**	.335**	−.082
13. *Extracurricular activities*												–	.288**	−.211**
14. *Collective efficacy*													–	−.462**
15. *Physical disorder*														–

$N = 402$
$*p < .05$, $**p < .001$
[a]Dichotomous variable with “1” equal to the variable’s name

In order to test the MANCOVA assumption that the dependent variables would be correlated with each other in the moderate range (Meyers, Gamst, & Guarino, 2006), a series of Pearson correlations were performed between all of the DVs. All measures featured highly significant correlations (df = 400), except the case of *religion* × *physical disorder* ($r = -.082$, $p = .100$), suggesting the appropriateness of a MANCOVA.

Comparison of Developmental Assets Between School Populations

Multivariate analysis of covariance (MANCOVA) was conducted to determine the effect of the different learning environments (IV) on developmental asset scores (DVs). Means and standard deviations of developmental asset scores in students across the three study populations (RA, CG and HS) are displayed in Fig. 13.4. Adjustments were made for six covariates: gender, age, ethnicity (*Black* and *ESL*), SES and attendance rate; as each of these variables was significantly correlated with multiple DAP scales. Using Wilks' criterion, the combined DVs were identified as significantly related to all covariates except *Age*. Results of this test are reported in Table 13.4. *Experimental Group* indicates significant effect on the combined DV (Wilks' $\Lambda = .853$, $F(18, 770) = 3.527$, $p < .001$, multivariate $\eta^2 = .076$), suggesting that there is a difference in developmental asset scores between the three school populations.

While sample sizes differed between groups, Levene's Test of Equality of Error Variances indicated equal variances among groups for all scales ($F(2, 399) = .002$–1.455, $p = .998$–$.235$). Additionally, the Box's M value of 49.89 was associated with a p value of .573, which was non-significant. Thus, the covariance matrices between the groups were assumed to be equal for the purposes of the MANCOVA.

Next, an analysis of covariance (ANCOVA) was conducted on each DV as a follow-up test to the omnibus MANCOVA in order to identify significant effects between the different learning environments on each of the asset scores individually. Experimental group (RA, CG, or HS) was entered as a trichotomous variable ("0" = RA, "1" = CG*,* and "2" = HS; with students in RA as the reference category). The six covariates (gender, age, ethnicity (*Black* and *ESL*), SES and attendance rate) and all other DVs were entered as controls for each test.

After adjustment for covariates (adjusted means reported in Table 13.5), significant effects of schooling were identified for six of the nine developmental assets: Well-being, Learning, Prosociality, Family, School, and Extracurricular Activities. Religion, Physical Disorder, and Collective Efficacy of Home Neighborhood were not significant. Results are reported in Table 13.5. Effects of covariates on each DV are reported in Appendix at the end of this chapter.

Though the ANCOVA indicates significant differences in assets scores between the three study populations, this test cannot determine for which school group(s) the differences are significant. Planned comparisons employing orthogonal contrasts were conducted in order to investigate these differences. Since the main

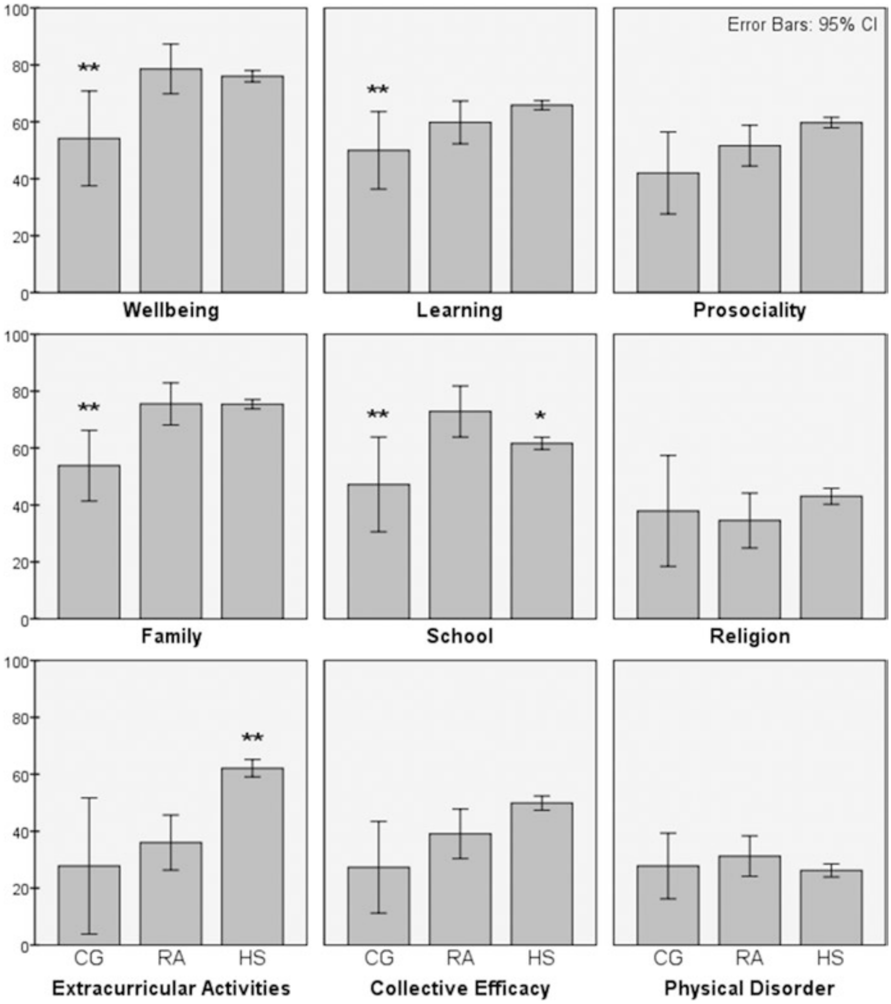

Fig. 13.4 Scores (and confidence intervals) of DAP scales. In all panels, Comparison Group (CG) is presented as the *left bar*; Regents Academy (RA) is the *middle bar*; High School students are on the *right*. * indicates $p = .011$ and ** indicates $p < .001$, when compared to RA

hypothesis of this study is that the learning environment provided at the RA would positively influence the developmental assets of its students and they would therefore report higher DAP scores than their matched sample, the first contrast compares students from the RA with those in the CG. Our previous study (Wilson et al., 2011) indicated that students at the RA not only performed better than their comparison group on academic measures, but that students at the RA performed on par with the average student at BHS; therefore, a second contrast between RA and HS was conducted to investigate how students at the RA compared with the rest of the HS population on DAP scores. Results of planned comparisons are presented in Table 13.6.

Table 13.4 Results of omnibus multivariate analysis of covariance

Effect	Wilks' Λ	F	p	Partial Eta squared
Female[a,b]	.913	4.062[c]	.000	.087
Black[a,b]	.937	2.875[c]	.003	.063
ESL[a,b]	.946	2.430[c]	.011	.054
SES[a,b]	.922	3.631[c]	.000	.078
Age[a]	.964	1.592[c]	.116	.036
Absent[a]	.954	2.071[c]	.031	.046
Experimental Group (RA, CG, or HS)[d,e]	.853	3.527[c]	.000	.076

[a]df = 402
[b]Dichotomous variable with "1" equal to the variable's name.
[c]Exact statistic
[d]df = 804
[e]Coded as trichotomous nominal variable with "0" = Regents Academy, "1" = Comparison Group, and "2" = High School

Comparing Students at the Regents Academy and Control Group. Planned comparisons of the adjusted means revealed that there were significant differences in scores between the RA and CG. Students at the RA reported significantly higher scores in Well-being ($t(393) = -3.420$, $p = .001$), Learning ($t(393) = -2.096$, $p = .037$), Family ($t(393) = -3.693$, $p < .001$), and School ($t(393) = -3.289$, $p = .001$). These results suggest that students in the RA reported higher self-esteem and held a higher perception of self-worth than their counterparts in the CG, had better attitudes toward learning, had increased family involvement, and felt a greater connection to their school.

Comparing Regents Academy Students with the Average High School Student. Comparisons of DAP scores between RA and HS revealed only two significant differences. Students at the RA were less involved in Extracurricular Activities than the regular HS students ($t(393) = 3.493$, $p = .001$). Finally, and most importantly, students at the RA reported higher assets gained through their school than did the HS population ($t(393) = -2.569$, $p = .011$). These results suggest that, though RA students were less involved with activities at school outside of the regular school day, the RA students liked school better than the average HS student and that the learning environment of the Regents Academy provided its students with higher levels of support than the average student received at the regular high school.

Furthermore, the absence of significant differences between RA and HS on all other DAP scores reflects that the students at the RA did not suffer from decreased assets over the typical HS student, whereas the results of post-hoc pairwise comparisons revealed that the CG scored significantly lower than HS on every scale except for Religion, Physical Disorder, and Collective Efficacy of home neighborhood. Results of comparisons between CG and HS are reported in Appendix at the end of this chapter.

Table 13.5 Estimated marginal means (and standard deviations) of DAP scores by school attended, and results of test of between-subjects effects of experimental group on dependent variables

Dependent variable	Group	Estimated marginal mean (SD)	Type III sum of squares	*F*	*p*	Partial Eta squared
Well-being	RA	78.33 (4.09)	5065.71	6.64	.001	.033
	CG	52.12 (6.63)				
	HS	76.04 (1.02)				
Learning	RA	60.61 (3.25)	3148.39	6.53	.002	.032
	CG	47.77 (5.27)				
	HS	65.76 (0.81)				
Prosociality	RA	54.06 (3.74)	2768.06	4.35	.014	.022
	CG	43.02 (6.05)				
	HS	59.47 (0.93)				
Family	RA	75.38 (3.40)	4741.93	9.02	.000	.044
	CG	51.77 (5.50)				
	HS	75.41 (0.85)				
School	RA	73.11 (4.36)	5191.08	6.00	.003	.030
	CG	46.13 (7.06)				
	HS	61.52 (1.09)				
Religion	RA	34.47 (5.64)	1919.85	1.33	.266	.007
	CG	35.52 (9.12)				
	HS	43.01 (1.40)				
Extracurricular activities	RA	40.01 (6.02)	17970.93	10.90	.000	.053
	CG	28.99 (9.74)				
	HS	61.77 (1.50)				
Collective efficacy	RA	44.15 (4.93)	3308.14	2.99	.051	.015
	CG	31.07 (7.98)				
	HS	49.48 (1.23)				
Physical disorder	RA	26.34 (4.46)	1.33	.00	.999	.000
	CG	26.72 (7.23)				
	HS	26.57 (1.11)				

Notes: Degrees of Freedom for all variables = 2. Covariates appearing in the model are evaluated at the following values: Female = .55, Age = 14.96, Black = .24, ESL = .09, SES = .52, % Absent = 4.52.

Prosociality. The planned comparisons conducted here did not reveal any significant differences between the RA and the CG or HS in measures of *prosociality*. Because the ANCOVA identified a main-effect between *prosociality* and school group, a post-hoc analysis was conducted to further investigate this relationship. Using a Bonferroni post-hoc test ($p < .05$), the significant difference in *prosociality* scores was found to be between the HS and CG populations ($p = .015$). As illustrated in Fig. 13.4, RA ($M = 51.63 \pm 17.36$) scores fell between CG ($M = 42.02 \pm 18.76$) and HS ($M = 59.74 \pm 18.30$) and were not significantly different from either of these groups.

Table 13.6 Matrix of results for planned comparisons between RA & CG, and RA & HS

Contrasts			Dependent variable								
			Well-being	*Learning*	*Prosociality*	*Family*	*School*	*Religion*	*Extracurricular activities*	*Collective efficacy*	*Physical disorder*
RA vs. CG	Contrast estimate		−26.21	−12.84	−11.04	−23.61	−26.98	1.05	−11.02	−13.08	.38
	Std. error		7.70	6.12	7.04	6.40	8.21	10.61	11.33	9.28	8.40
	t-value		−3.40	−2.10	−1.57	−3.69	−3.29	.10	−.97	−1.41	.04
	p		.001	.037	.118	.000	.001	.921	.331	.159	.964
	95 % confidence interval	Lower bound	−41.35	−24.88	−24.87	−36.19	−43.11	−19.80	−33.29	−31.32	−16.14
		Upper bound	−11.06	−.80	2.80	−11.04	−10.85	21.90	11.25	5.16	16.89
RA vs. HS	Contrast estimate		−2.29	5.15	5.42	.02	−11.59	8.54	21.76	5.32	.22
	Std. error		4.24	3.37	3.87	3.52	4.51	5.83	6.23	5.10	4.62
	t-value		−.54	1.53	1.40	.01	−2.57	1.46	3.49	1.04	.05
	p		.590	.127	.162	.995	.011	.144	.001	.297	.961
	95 % confidence interval	Lower bound	−10.61	−1.47	−2.19	−6.89	−20.46	−2.93	9.51	−4.70	−8.86
		Upper bound	6.04	11.76	13.02	6.94	−2.72	20.00	34.00	15.35	9.31

Note: For each contrast, RA is the reference category

Discussion of Study Outcomes

In this study, we used a modified version of the Developmental Assets Profile (DAP; Scales et al., 2006) to measure the internal (psychological, behavioral) and external (social, environmental) assets of high school students from the Binghamton City School District. These measures were used to complement more narrow metrics of academic success at a school for at-risk students (the Regents Academy; RA), specifically designed to impact the broad goals of education alongside the narrow measures of academic proficiency. The developmental assets of students at the RA were compared with those of a matched sample comparison group (CG) in a randomized control design (as described in Wilson et al., 2011), and with the full high school (HS) population.

Results revealed there were expected differences in assets scores between the RA and CG populations. Students of the RA reported significantly higher scores in *well-being*, *learning*, *family*, and *school* asset measures. These results suggest that at-risk adolescents respond to a positive social environment in a school designed to encourage cooperation and student engagement, and that the design of the RA learning environment increases broad developmental assets in addition to narrow academic performance.

In comparing RA students to the full high school (HS) population, there were only two significant differences found between RA and HS: RA students reported less involvement in *extracurricular activities* and higher scores in their connection to *school*. In this case, the absence of significant differences in asset measures between the RA and HS students is of remarkable importance, as these results imply that, at only seven months into the program, the at-risk students from the RA now matched the profile of a "typical" high school student.

An interpretation of these results from an evolutionary perspective is discussed below.

Comparisons of Asset Measures Between Experimental Groups

School and Learning. Students in the RA reported higher assets gained through *school* than both their CG and the HS students. These results imply that RA students liked their school more than the typical high school student, suggesting that all students can benefit from the design principles that inform the RA, not just at-risk students.

It should be expected that students who report learning as a higher asset would place more value in school. While *learning* was significantly correlated with *school*, and while RA students reported significantly higher attitudes towards learning than their CG, the analyses performed controlled for *learning* among the covariates, suggesting that the higher scores of the RA students in attitudes toward school (between RA & CG, and RA & HS) were not the result of feeling more positive towards learning but that school provided a separate and more important role in their social frame.

Well-being. Students from the RA scored significantly higher on measures of *well-being* than the CG and on a par with the HS population. The single-measure design of this study makes it unclear as to which components of the RA contributed to the increased sense of well-being in its students. It is likely that their improvement in academic performance, which began as early as the first quarter (Fig. 13.1), contributed to this effect. Students also experienced a high degree of encouragement from the staff of the RA, which may have had an intermediary effect.

Family. Much research has demonstrated that low family involvement is a significant predictor in risky adolescent behavior and low academic performance, so a key target for the design of the RA was to increase parental involvement. Examples of implementation strategies included calling home in order to praise a student and their family for student performance and developing "family fun night" programs to increase family relationships and parent engagement with the school. As predicted by the design of the program, students at the RA reported higher *family* assets than those in the CG. With the current measures, it is not possible to determine whether it was these specific parent-targeted interventions at the RA which influenced improvements in family assets directly or whether there was an indirect effect, such as the parents responding more favorably to their children as a result of doing better in school.

Prosociality. According to theory outlined in the introduction, understanding how to encourage prosociality should be a chief assessment aim for most schools. Results revealed that all assets scores were moderately to highly correlated with prosociality. Of particular importance to educational institutions is the connection between prosocial attitudes and learning. Results from this study confirm that students who are more *prosocial* reported higher *learning* scores; supporting the claim that there is a connection between cooperation and improved learning potential.

While students at the RA did not significantly differ from the CG or the HS in measures of *prosociality,* the trend depicted for prosociality in Fig. 13.4 is interesting to note. Results show that the RA scores fell in the middle of the HS and CG. Because the difference of scores between CG and HS was significant, and because RA students were reported to be of similar characteristics to the CG in previous years, the trend of scores described here suggests that students in the RA have been still responding favorably to their new social environment, developing a social foundation with which they are incorporating prosocial strategies/mindsets more often than their CG in a randomized controlled design. Furthermore, it may be inappropriate to expect a complete turnaround in these measures after only seven months; since the lives of these students outside of the school remains harsh, it may not be possible for the RA students to abandon the social strategies that have allowed them to succeed in environments beyond the school walls.

Extracurricular Involvement. Students at the RA reported less involvement in *extracurricular activities* (EA) than students at the HS; there was no difference between CG and RA. This result was expected as the budget for the RA did not include funding for involvement in EA. This pattern is consistent with many schools across the nation where extracurricular activities and programs are being cut in an effort to increase time spent on academic instruction.

In opposition to this trend of decreased funding for non-academic activities, we would like to highlight the correlations between *EA* and *learning*, and between *EA* and *school* demonstrated in this study. Students who are involved in EA feel a greater connection to their school and place increased value on learning. These results should encourage schools to expose their students to a wider range of real-world relevant activities and experiences in an effort to engage more student interests and taking advantage of the students' natural tendencies to learn (Dewey, 1911; Gray, 2013, this volume).

Though increased support for EA beyond school hours at the RA was not possible, the design of the RA incorporated opportunities to embed extracurricular learning activities into the school day. A "fun club" program was initiated after the first quarter at the request of the students, who reported that they frequently couldn't relate to the class material and wanted to do things more closely aligned with their own interests. The teachers agreed to give up half of their class periods every Friday, providing a half-day for "Fun Friday." This program allowed students to participate in art activities (e.g., mosaics, drawing, painting, knitting), music (e.g., guitar and piano "jam" sessions), game sessions, juggling and magic/legerdemain classes, and a martial arts program, to name a few. Results from Wilson et al. (2011) indicate that students who participated in this program earned higher grades in their classes, despite the reduced class time.

Religion and Neighborhood Physical Disorder & Collective Efficacy. As should be expected, since the design of the RA did not incorporate any practices targeting these assets, there were no differences between the RA and the other students in reported measures of *religion* or perceptions of *physical disorder* and social capital (*collective efficacy*) in their home neighborhoods.

Other research (Caughy, Nettles, & O'Campo, 2008; Crowder & South, 2003) has demonstrated that neighborhood disorder may contribute to student's disengagement with school. Consistent with this research, students from this study who reported living in neighborhoods with significantly higher levels of physical disorder also reported having a lower connection to their *school*. Interestingly, the students at the RA reported living in the areas with the worst neighborhood physical disorder; yet, as described above, RA students identified school as being a greater asset than did the CG and HS. This pattern suggests that the learning environment at the RA was able to overcome deficits of support in other areas of students' lives.

Interpreting Correlations Between DAP Scales

The results presented in Table 13.3 demonstrate that all internal and external assets are influenced by each other and/or by similar conditions/stimuli, whereby influencing one area of support may overcome the deficits in another or consequently that degradation in one form of support may have disastrous and unforeseen consequences in another connected domain. The results also identify a negative correlation between *physical disorder* and all other measures. This is consistent with findings from other studies (O'Brien & Kauffman, 2012; O'Brien, 2010; Calvert, 2001; Sampson, Raudenbush, & Earls, 1999), suggesting that, for example, individuals are less likely to cooperate as the level of disorder in their neighborhood increases. This pattern of results supports the position that (1) the environment influences developmental trajectories, and (2) that adolescents are shaped by a network of support systems.

Selection Biases and Limitations

Limitations of this study include concerns of low sample size and the single measure design. The concern of low sample size is that only nine students from the comparison group and 25 from the Regents Academy participated in this study. The concerns surrounding this matter have already been addressed in the Methods section. In short, due to the typical behavior for at-risk students to skip class, if there is a selection bias in the CG, it is likely that the odds would be against our favor, as the students who did show up to take the survey should report higher assets than any who skipped. Because of methodological differences between the two schools, students at the RA were not able to skip survey administration if they entered school on these days and this selection bias would be lessened in the RA population.

The single measure design implies that an analysis can only identify associations between variables and cannot establish causation. Furthermore, as these findings are based on a rigorous assessment of the program as a whole, it is not possible to determine whether any particular differences can be attributed to singular implementations of the RA program. In *family* involvement, for example, did students at the RA have improved family relationships because of interventions targeting parent involvement, or simply because the parents were more generally "proud" of their students, who were now performing better in school? Evidence suggests that these assets provide a network of support for the student and that influencing one component can similarly influence another (Benson et al., 2011; Benson & Scales, 2009; Schneider-Munoz, 2011). It is therefore likely that the particular implementations of each design feature matter less than that the feature is included.

Still, at least for *family*, for example, it is likely that at least some of this influence is attributed to the design of the program, as increasing family support was one of the key design features of the school. One of the simple things the staff at the RA did was to call the parents and praise the child, as opposed to the normal routine where parents only hear about student delinquencies. For example, a teacher might have called home to say "we just want you to know that your son or daughter was a pleasure to have in class this week." This particular implementation targeted all students; others required more intensive methods, on a case-by-case basis. As an anecdotal example: one of the RA students held a standing weekly Friday night "date night" with her mother, when they would typically go shopping and have dinner together. After a number of less successful attempts at improving the student's disruptive behavior, the RA staff worked out a compromise between parent, student, and school: when the student had a good behavior report from school for that week, the mother and daughter would go out shopping for their date night; if the student was not able to keep her composure through the entire week, then the mother-daughter date night was spent at home rather than the mall.

What Made It Work?

According to the principal and teachers who worked daily with the RA students, the most important ingredient was the provision of a safe, caring environment. Aside from a closed-campus and smaller class sizes, the unique design features of the Regents Academy during this first year did not address learning content material, nor were they motivated by any immediate relevance to standardized testing. In fact, none of the teachers at the RA changed the curriculum-instruction-assessment (CIA) of their courses from how it had been previously developed and implemented at the high school (where they reported having low success among the at-risk students in their classes in previous years). Instead, using the design principles established by evolutionary science for influencing intentional cultural change (Wilson et al., 2014), teachers and staff created a social environment that worked *with* students' needs rather than *against* them, in the effort to engage the general interest of the learner. When combined with our previous report of improved academic performance in the RA students (Wilson et al., 2011), the results demonstrate that school achievement is influenced by social support and other environmental factors inasmuch as any other academically oriented CIA strategies.

As emphasized earlier in this chapter, while the students at the RA were randomly selected, each of the teachers and staff at the school voluntarily elected to participate in the program. The program could not have succeeded without teachers who find meaning and value to their work, motivated to establish cooperative teacher–learner relationships. The teaching model established at the RA cannot spread if the current trend of educational policy continues to lead toward "increasingly centralized and deeply bureaucratized reform efforts that misrepresent teacher motives and undermine teaching relationships in a desire to maximize control of student outcomes and assure ever increasing student test scores" (Bullough & Pinnegar, 2009, p. 253).

Evolutionary Education Science

None of the ingredients that make up the RA are unusual, but the RA brings them together into an unusual package. It is important to clarify how evolutionary science succeeded in identifying an effective collection of practices, where many other perspectives have failed. Many current educational practices have superficial rationales that ignore unintended consequences. Examples include restricting movement and play (to make more time for instruction), no-touch rules (to avoid sexual harassment), age segregation (to facilitate formal instruction), autocratic rules (because adults know best), and using fear as an incentive (to maintain discipline and focus learning in a narrow sense). All of these practices have a surface logic, but they don't always lead to positive outcomes. Worse, the unforeseen consequences of the practices are often diffuse and indirect and are therefore difficult to trace back to their source (Ellis et al., 2012).

Using a general conceptual framework to formulate educational policy does not automatically result in a single set of practices guaranteed to work. Instead, it alters the perception of what appears reasonable or unreasonable. Some current practices continue to make sense, but others, such as restricting play, begin to appear problematic. New practices, or new combinations of old practices, become reasonable and even obvious in retrospect, although they were obscure from other perspectives. The new ideas that emerge from an explicitly evolutionary perspective are not guaranteed to work. Like all hypotheses, they must be tested in real-world applications.

Of course, environmental interventions for increasing the academic performance of at-risk adolescents have been proposed for decades, but they typically don't work, which is why the problem appears so difficult. None of the design features that make up the RA are unusual, but evolutionary science provides a theoretical framework for bringing them together in a way that led to an unusual degree of success.

A few other programs for at-risk high school students appear to have success rates similar to that of the Regents Academy, including the Sudbury Valley School (Gray & Chanoff, 1986; Gray & Feldman, 2004), Morningside Academy in Seattle (Johnson, 1997), the Juniper Gardens Projects in Kansas City, Kansas (Greenwood, 1991a, 1991b), a natural randomized-controlled study of London high schools by Rutter, Maughan, Mortimore, Ouston, and Smith (1979), and a high school version of the Good Behavior Game (Becker, Bohnenkamp, Domitrovich, Keperling, & Ialongo, 2014; Embry, 2014; Kleinman & Saigh, 2011), which was originally developed for elementary school classes (reviewed by Embry, 2002). A review of these programs reveals that they have largely converged on the practices that we have derived from an evolutionary perspective. Each program first begins by establishing a supportive learning environment that works with students' needs rather than against them. Many are small schools with small class sizes, and they strive to engender a collective-body psychology that cultivates the mindset of "we're in this together." Many of these programs emphasize short-term rewards for long-term learning/achievement goals. These programs have not been widely copied, despite the fact that they work. Evolutionary education science, providing a general theoretical framework for *why* they work, can help best practices spread faster.

Broadening Curriculum-Instruction-Assessment Practices

Cultures Have Curricula

The approach described in this chapter does not intend to downplay the role of curriculum in educational systems. Rather, the evolutionary perspective identifies an implicit assumption that the curricular objectives of modern educational institutions are tasked with ensuring healthy human development alongside more narrow academic goals. Accompanying the learning of culturally relevant information, school curricula must also be designed to incorporate benchmarks of cognitive, behavioral, social, and cultural development (Crone & Horner, 2012; NRC, 2001; Sugai et al., 2000).

Education must focus on teaching all people how to live in an inclusive society where each person is treated with respect and dignity and enlisted to participate fully in the life of the community (Dewey, 1938). In traditional societies, this task is distributed throughout the community, where children tend to experience a diverse array of daily social experiences and many of these traits are indirectly learned through routine interactions (Gray, 2013). But modern society has departed sharply from ancestral learning and teaching environments (Geary, 2008). Even modern schools find themselves embedded in societies very different from when many school policies were designed. In contemporary cultures, most of a young person's social interactions occur within the school. Integrating socio-emotional developmental curricular objectives becomes an even higher priority when one considers the regular patterns of decline in many of the other areas of social support in communities across the nation.

Where incorporating non-academic factors is necessary for all learning objectives, direct instruction may not be. Many skills develop naturally and are absorbed into the hidden curriculum of the learning environment (Kohlberg, 1983; Martin, 1983), e.g., appropriate social interactions. However, this "indirect" learning on the part of the student still requires *active* environmental input. If these characteristics are not appropriately managed, an infinite variety of unintended outcomes can develop.

This highlights the importance of ensuring appropriately trained and motivated staff and teachers. Classroom management is much more than responding to student misbehavior. It "encompasses all that teachers do to encourage learning in their classrooms, including creating an environment that supports instruction to promote and maintain student learning and engagement" (Evertson & Harris, 1999, p.61). The teacher must know how their actions influence the learning environment and must proactively establish a healthy socio-emotional climate.

An Interdisciplinary Approach to Assessment

With the ever-increasing list of demands and assessments that both teachers and students are currently tasked with, the notion of adding more things to that list is appalling—we certainly don't need more tests! What we do need, on the other hand, is to broaden our assessment methods in parallel with the realization of various aforementioned broad goals.

Educational assessment seeks to determine just how well students are learning and is an integral part of our quest for improved education (NRC, 2001). In modern societies, academic success is traditionally measured through standardized subject-based concentration exams. “While adherence to these [forms of assessment] has contributed to their enduring strengths [of measuring content-based knowledge], it has also contributed to some of their limitations and impeded progress in assessment design” (NRC, 2001, p. 19). As implied by the broad goals of education, a thorough assessment of academic achievement should be far more extensive than predictive testing. Independent of tracking student progress, schools should assess student behavioral measures to monitor the performance of not just its students but of the institution itself.

This is not to say that standardized testing has no place in education. When used validly and reliably, standardized tests can provide decision-makers with useful information that no other evaluation method can provide. However, standardized subject-based concentration exams must no longer be the only determinant of student achievement and teacher ability. Other performance measures that target not only academic growth, but also behavioral and socio-emotional development should be decided upon and collected in order to maximize effective teaching strategies that foster healthy, holistic student development.

Though integrating even more assessment into schools appears daunting at first thought, many steps are already well underway toward accomplishing this goal. Where education, in typical practice, traditionally pays little attention to assessing and enriching students’ behaviors and relationships, the applied evolutionary sciences have been establishing proven methods for accomplishing positive behavioral and cultural change at all scales for more than fifty years. One discipline, Prevention Science, is specifically dedicated to finding science-based solutions to a diversity of real-world problems, such as how to prevent classroom environments from becoming disruptive and how to prevent self-destructive behaviors in adolescents (Biglan, 2015; Coie et al., 1993; Embry & Biglan, 2008), all with proper measurement and evaluation techniques for monitoring change at all levels of organization. By incorporating the validated methods of the applied evolutionary sciences, educational assessment can better embody education’s broader function of fostering cultural development.

Conclusion

A child should be educated for life, not taught to be tested. Too often, the cure for low academic performance focuses on increasing test scores. Schools should prepare our young people for a life of health and well-being, to be skilled at collaboration and communication, and to be responsible citizens. In this chapter, we show that the broad and narrow goals of education can be achieved simultaneously.

The key is to envision education as form of cooperation that requires the same core design principles as most forms of cooperation. Two additional design principles required for learning as a cooperative endeavor are to create a safe and secure environment and to make long-term learning goals rewarding over the short term. When schools implement these design principles, children thrive in general terms in addition to mastering their academic subjects. The beneficial effects of the school environment can even spill over to other domains, such as family relationships.

All students can benefit from the design principles that work for at-risk students. Indeed, when schools work well, it is probably because they have implemented the design principles without necessarily having them explicitly in mind. The situation for schools is similar to what Elinor Ostrom discovered for the common-pool resource groups that she studied. Some groups had adopted the design principles without needing to be taught, but the same principles were sadly lacking in other groups. It was variation among the groups that enabled Ostrom to derive the core design principles in the first place. An explicit awareness of the design principles can help to identify the best practices that already exist and to improve the schools that have not already adopted the practices on their own.

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Appendix 13.1: Effects of Covariates on Each Dependent Variable

Covariate	Scale	Type III sum of squares	*F*	*p*	Partial Eta squared
Female[a]	*Well-being*	60.78	.16	.690	.000
	Learning	5189.72	21.54	.000	.052
	Prosociality	5454.69	17.14	.000	.042
	Family	277.15	1.05	.305	.003
	School	1260.64	2.91	.089	.007
	Religion	36.12	.05	.823	.000
	Extracurricular activities	6270.05	7.60	.006	.019
	Collective efficacy	3957.15	7.16	.008	.018
	Physical disorder	1828.37	4.03	.045	.010

(continued)

Covariate	Scale	Type III sum of squares	*F*	*p*	Partial Eta squared
Black[a]	*Well-being*	3291.69	8.63	.003	.021
	Learning	1764.04	7.32	.007	.018
	Prosociality	.00	.00	.999	.000
	Family	293.13	1.12	.292	.003
	School	1491.06	3.45	.064	.009
	Religion	4017.10	5.56	.019	.014
	Extracurricular activities	303.44	.37	.544	.001
	Collective efficacy	5.88	.01	.918	.000
	Physical disorder	15.01	.03	.856	.000
ESL[a]	*Well-being*	1131.65	2.97	.086	.007
	Learning	106.03	.44	.507	.001
	Prosociality	239.80	.75	.386	.002
	Family	599.65	2.28	.132	.006
	School	3522.27	8.14	.005	.020
	Religion	6516.57	9.02	.003	.022
	Extracurricular activities	137.96	.17	.683	.000
	Collective efficacy	266.64	.48	.488	.001
	Physical disorder	2148.75	4.74	.030	.012
SES[a]	*Well-being*	812.69	2.13	.145	.005
	Learning	1104.79	4.59	.033	.012
	Prosociality	1208.92	3.80	.052	.010
	Family	285.32	1.09	.298	.003
	School	444.78	1.03	.311	.003
	Religion	4993.02	6.91	.009	.017
	Extracurricular activities	6547.08	7.94	.005	.020
	Collective efficacy	8014.56	14.49	.000	.036
	Physical disorder	7741.42	17.07	.000	.042

Covariate	Scale	Type III sum of squares	*F*	*p*	Partial Eta squared
Age	*Well-being*	2060.99	5.40	.021	.014
	Learning	228.49	.95	.331	.002
	Prosociality	355.04	1.12	.292	.003
	Family	924.73	3.52	.061	.009
	School	332.99	.77	.381	.002
	Religion	80.74	.11	.738	.000
	Extracurricular activities	5885.93	7.14	.008	.018
	Collective efficacy	45.98	.08	.773	.000
	Physical disorder	2171.98	4.79	.029	.012

(continued)

Covariate	Scale	Type III sum of squares	*F*	*p*	Partial Eta squared
% Absent	*Well-being*	.32	.00	.977	.000
	Learning	297.56	1.23	.267	.003
	Prosociality	897.52	2.82	.094	.007
	Family	396.67	1.51	.220	.004
	School	646.09	1.49	.222	.004
	Religion	486.89	.67	.412	.002
	Extracurricular activities	905.25	1.10	.295	.003
	Collective efficacy	2216.10	4.01	.046	.010
	Physical disorder	231.99	.51	.475	.001

Note: Degrees of Freedom for all variables = 1
[a]Dichotomous variable with “1” equal to the variable’s name

Appendix 13.2: Results of Post-hoc Pairwise Comparisons Between Schools for Each Dependent Variable

Dependent variable	Comparisons		Mean difference (*I* – *J*)	Std. error	Sig.	95 % confidence interval[a]	
						Lower bound	Upper bound
Well-being	CG	RA	–25.97	7.68	.002	–44.44	–7.49
		HS	–23.61	6.65	.001	–39.61	–7.61
	HS	RA	–2.36	4.22	1.000	–12.50	7.78
		CG	23.61	6.65	.001	7.61	39.61
Learning	CG	RA	–12.38	6.12	.131	–27.09	2.33
		HS	–17.22	5.30	.004	–29.96	–4.48
	HS	RA	4.84	3.36	.451	–3.24	12.92
		CG	17.22	5.30	.004	4.48	29.96
Prosociality	CG	RA	–11.38	7.01	.317	–28.24	5.49
		HS	–17.20	6.07	.015	–31.81	–2.60
	HS	RA	5.83	3.85	.394	–3.43	15.08
		CG	17.20	6.07	.015	2.60	31.81
Family	CG	RA	–22.91	6.39	.001	–38.28	–7.54
		HS	–22.54	5.54	.000	–35.85	–9.22
	HS	RA	–.38	3.51	1.000	–8.82	8.06
		CG	22.54	5.54	.000	9.22	35.85
School	CG	RA	–27.74	8.20	.002	–47.46	–8.02
		HS	–16.62	7.10	.059	–33.70	.46
	HS	RA	–11.12	4.50	.042	–21.94	–.29
		CG	16.62	7.10	.059	–.46	33.70

(continued)

Dependent variable	Comparisons		Mean difference ($I - J$)	Std. error	Sig.	95 % confidence interval[a]	
						Lower bound	Upper bound
Religion	CG	RA	1.94	10.59	1.000	–23.52	27.40
		HS	–6.12	9.17	1.000	–28.17	15.93
	HS	RA	8.06	5.81	.499	–5.91	22.04
		CG	6.12	9.17	1.000	–15.93	28.17
Extracurricular activities	CG	RA	–11.22	11.29	.962	–38.37	15.92
		HS	–33.36	9.78	.002	–56.86	–9.85
	HS	RA	22.13	6.20	.001	7.23	37.03
		CG	33.35	9.78	.002	9.85	56.86
Collective efficacy	CG	RA	–14.19	9.29	.383	–36.53	8.15
		HS	–20.31	8.05	.036	–39.66	–.96
	HS	RA	6.12	5.10	.693	–6.15	18.39
		CG	20.31	8.05	.036	.96	39.66
Physical disorder	CG	RA	.86	8.39	1.000	–19.31	21.03
		HS	.93	7.26	1.000	–16.54	18.39
	HS	RA	–.07	4.61	1.000	–11.14	11.00
		CG	–.93	7.26	1.000	–18.39	16.54

Notes: Calculations based on estimated marginal means
[a]Adjustment for multiple comparisons: Bonferroni

References

Allen, L., & Steinberg, A. (2005). *Big buildings, small schools: Using a small schools strategy for high school reform*. Providence, RI: Jobs for the Future and the Education Alliance at Brown University.

Becker, K. D., Bohnenkamp, J., Domitrovich, C., Keperling, J. P., & Ialongo, N. S. (2014). Online training for teachers delivering evidence-based preventive interventions. *School Mental Health, 6*(4), 225–236.

Benson, P. L., & Scales, P. C. (2009). Positive youth development and the prevention of youth aggression and violence. *European Journal of Developmental Science, 3*, 218–234.

Benson, P. L., & Scales, P. C. (2011). Developmental assets. In R. J. R. Levesque (Ed.), *Encyclopedia of adolescence* (pp. 667–683). New York, NY: Springer.

Benson, P. L., Scales, P. C., & Syvertsen, A. K. (2011). The contribution of the developmental assets framework to positive youth development theory and practice. In R. M. Lerner, J. V. Lerner, & J. B. Benson (Eds.), *Advances in child development and behavior* (Vol. 41, pp. 197–230). Burlington, VT: Academic.

Biglan, A. (2015). *The nurture effect: How the science of human behavior can improve our lives and our world*. Oakland, CA: New Harbinger Publications.

Bullough, R. V., Jr., & Pinnegar, S. (2009). The happiness of teaching (as eudaimonia): Disciplinary knowledge and the threat of performativity. *Teachers and Teaching: Theory and Practice, 15*(2), 241–256.

Calvert, W. J. (2001). Neighborhood disorder, individual protective factors, and the risk of adolescent delinquency. *The ABNF Journal, 13*(6), 127–135.

Caughy, M. O. B., Nettles, S. M., & O'Campo, P. J. (2008). The effect of residential neighborhood on child behavior problems in first grade. *American Journal of Community Psychology, 42*(1–2), 39–50.

Coie, J. D., Watt, N. F., West, S. G., Hawkins, J. D., Asarnow, J. R., Markman, H. J., … Long, B. (1993). The science of prevention: a conceptual framework and some directions for a national research program. *American Psychologist*, *48*(10), 1013–1022.

Cox, M., Arnold, G., & Tomás, S. V. (2010). A review of design principles for community-based natural resource management. *Ecology and Society, 15*(4), S1–S19.

Crone, D. A., & Horner, R. H. (2012). *Building positive behavior support systems in schools: Functional behavioral assessment*. New York, NY: Guilford.

Crowder, K., & South, S. J. (2003). Neighborhood distress and school dropout: The variable significance of community context. *Social Science Research, 32*(4), 659–698.

Dewey, J. (1900). *The school and society*. Chicago, IL: University of Chicago Press.

Dewey, J. (1911). *The child and the curriculum*. Chicago, IL: University of Chicago Press.

Dewey, J. (1916). *Democracy and education: An introduction to the philosophy of education*. New York, NY: Macmillan.

Dewey, J. (1938). *Experience and education*. New York, NY: Touchstone.

Ellis, B. J., Del Giudice, M., Dishion, T. J., Figueredo, A. J., Gray, P., Griskevicius, V., … Wilson, D. S. (2012). The evolutionary basis of risky adolescent behavior: implications for science, policy, and practice. *Developmental Psychology*, *48*(3), 598–623.

Embry, D. D. (2002). The Good Behavior Game: A best practice candidate as a universal behavioral vaccine. *Clinical Child and Family Psychology Review, 5*, 273–297.

Embry, D. D. (2004). Community-based prevention using simple, low-cost, evidence-based kernels and behavior vaccines. *Journal of Community Psychology, 32*(5), 575–591.

Embry, D. D. (2014). *PAX Good Behavior Game*. Washington, DC: National Registry of Evidence-Based Programs and Practices.

Embry, D. D., & Biglan, A. (2008). Evidence-based kernels: Fundamental units of behavioral influence. *Clinical Child and Family Psychology Review, 11*(3), 75–113.

Evertson, C. M., & Harris, A. E. (1999). Support for managing learning-centered classrooms: The classroom organization and management program. In H. J. Freiberg (Ed.), *Beyond behaviorism: Changing the classroom management paradigm* (pp. 59–74). Boston, MA: Allyn & Bacon.

Finn, J. D., & Voelkl, K. E. (1993). School characteristics related to student engagement. *Journal of Negro Education, 62*(3), 249–268.

Finn, J. D., & Zimmer, K. S. (2012). Student engagement: What is it? Why does it matter? In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 97–131). New York, NY: Springer.

Flowers, N., Mertens, S. B., & Mulhull, P. F. (1999). The impact of teaming: Five research-based outcomes. *Middle School Journal, 31*, 57–60.

Geary, D. C. (2008). An evolutionarily informed education science. *Educational Psychologist, 43*(4), 179–195.

Gray, P. (2013). *Free to learn: Why unleashing the instinct to play will make our children happier, more self-reliant, and better students for life*. New York, NY: Basic Books.

Gray, P., & Chanoff, D. (1986). Democratic schooling: What happens to young people who have charge of their own education? *American Journal of Education, 94*, 182–213.

Gray, P., & Feldman, J. (2004). Playing in the zone of proximal development: Qualities of self-directed age mixing between adolescents and young children at a democratic school. *American Journal of Education, 110*(2), 108–146.

Greenwood, C. R. (1991a). Classwide peer tutoring: Longitudinal effects on the reading, language, and mathematics achievement of at-risk students. *Reading, Writing, and Learning Disabilities, 7*(2), 105–123.

Greenwood, C. R. (1991b). Longitudinal analysis of time, engagement, and achievement in at-risk versus non-risk students. *Exceptional Children, 57*, 521–535.

Hess, C., & Ostrom, E. (2007). *Understanding knowledge as a Commons: From theory to practice*. Cambridge, MA: MIT Press.

Howley, C., Strange, M., & Bickel, R. (2000). *Research about school size and school performance in impoverished communities*. Charleson, WV: ERIC Clearinghouse on Rural Education and Small Schools.

Hunt, P., Soto, G., Maier, J., & Doering, K. (2003). Collaborative teaming to support students at risk and students with severe disabilities in general education classrooms. *Exceptional Children, 69*(3), 315–332.

Johnson, K. (1997). Morningside academy. *Behavior and Social Issues, 7*(1), 31–35.

Keating, D. P. (1996). Habits of mind for a learning society: Educating for human development. In D. R. Olson & N. Torrance (Eds.), *Handbook of education and human development: New models of learning, teaching, and schooling* (pp. 461–481). Malden, MA: Blackwell.

Kleinman, K. E., & Saigh, P. A. (2011). The effects of the Good Behavior Game on the conduct of regular education New York City high school students. *Behavior Modification, 35*(1), 95–105.

Koenig, H. G., Meador, K., & Parkerson, F. (1997). Religion index for psychiatric research: A 5-item measure for use in health outcome studies. *American Journal of Psychiatry, 154*, 885–886.

Kohlberg, L. (1983). The moral atmosphere of the school. In H. Giroux & D. Purpel (Eds.), *The hidden curriculum and moral education: Deception or discovery?* (pp. 61–81). Berkeley, CA: McCutchan.

Kohn, A. (2000). Standardized testing and its victims. *Education Week, 20*(4), 46–47.

Lee, V. E., & Smith, J. B. (1997). High school size: Which works best and for whom? *Educational Evaluation and Policy Analysis, 19*(3), 205–227.

Martin, J. (1983). What should we do with a hidden curriculum when we find one? In H. Giroux & D. Purpel (Eds.), *The hidden curriculum and moral education: Deception of discovery?* (pp. 122–139). Berkeley, CA: McCutchan.

Meyers, L. S., Gamst, G., & Guarino, A. J. (2006). *Applied multivariate research: Design and interpretation*. Thousand Oaks, CA: Sage.

Montague, M., Enders, C., Cavendish, W., & Castro, M. (2011). Academic and behavioral trajectories for at-risk adolescents in urban schools. *Behavioral Disorders, 36*(2), 141–156.

National Research Council (NRC). (2001). *Knowing what students know: The science and design of educational assessment*. In J. W. Pellegrino, N. Chudowsky, & R. Glaser (Eds.). Washington, DC: National Academies Press.

O'Brien, D. T. (2010). Sociality in the city: Using biological principles to explore the relationship between high population density and social behavior. *Advances in Sociology Research, 8*, 203–216.

O'Brien, D. T., & Kauffman, R. A., Jr. (2012). Broken windows and low adolescent prosociality: Not cause and consequence, but co-symptoms of low collective efficacy. *American Journal of Community Psychology, 51*(3–4), 359–369.

O'Brien, D. T., Gallup, A. C., & Wilson, D. S. (2012). Residential mobility and prosocial development within a single city. *American Journal of Community Psychology, 50*(1–2), 26–36.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge, England: Cambridge University Press.

Ostrom, E. (2010). Beyond markets and states: Polycentric governance of complex economic systems. *American Economic Review, 100*, 1–33.

Raudenbush, S. W. (1984). Magnitude of teacher expectancy effects on pupil IQ as a function of the credibility of expectancy induction: A synthesis of findings from 18 experiments. *Journal of Educational Psychology, 76*(1), 85–97.

Rosenthal, R. (2002). The Pygmalion effect and its mediating mechanisms. In J. Aronson (Ed.), *Improving academic achievement: Impact of psychological factors on education* (pp. 25–36). San Diego, CA: Academic.

Rosenthal, R., & Jacobson, L. (1968). *Pygmalion in the classroom: Teacher expectation and pupils' intellectual development*. Austin, TX: Holt, Rinehart and Winston.

Ross, C. E., & Mirowsky, J. (1999). Disorder and decay the concept and measurement of perceived neighborhood disorder. *Urban Affairs Review, 34*(3), 412–432.

Rutter, M., Maughan, B., Mortimore, P., Ouston, J., & Smith, A. (1979). *Fifteen thousand hours: Secondary schools and their effects on children*. Cambridge, MA: Harvard University Press.
Sampson, R. J., Raudenbush, S. W., & Earls, F. (1997). Neighborhoods and violent crime: A multilevel study of collective efficacy. *Science, 277*, 918–924.
Sampson, R. J., Raudenbush, S. W., & Earls, F. (1999). Beyond social capital: Spatial dynamics of collective efficacy for children. *American Sociological Review, 64*, 633–660.
Scales, P. C., Benson, P. L., Dershem, L., Fraher, K., Makkonen, R., Nazneen, S., … Titus, S. (2013). Building developmental assets to empower adolescent girls in rural Bangladesh: Evaluation of Project "Kishoree Kontha". *Journal of Research on Adolescence*, *23*(1), 171–184.
Scales, P. C., Benson, P. L., Moore, K. A., Lippman, L., Brown, B., & Zaff, J. F. (2008). Promoting equal developmental opportunity and outcomes among America's children and youth: Results from the National Promises Study. *Journal of Primary Prevention, 29*(2), 121–144.
Scales, P. C., Benson, P. L., Roehlkepartain, E. C., Sesma, A., Jr., & van Dulmen, M. (2006). The role of developmental assets in predicting academic achievement: A longitudinal study. *Journal of Adolescence, 29*(5), 691–708.
Schneider-Munoz, A. J. (2011). Developmental assets as a framework for engaging families in out-of-school time. In H. Kreider & H. Westmoreland (Eds.), *Promising practices for family engagement in out-of-school time* (pp. 31–44). Charlotte, NC: Information Age.
Sorhagen, N. S. (2013). Early teacher expectations disproportionately affect poor children's high school performance. *Journal of Educational Psychology, 105*(2), 465–477.
Sugai, G., Horner, R. H., Dunlap, G., Hieneman, M., Lewis, T. J., Nelson, C. M., … Ruef, M. (2000). Applying positive behavior support and functional behavioral assessment in schools. *Journal of Positive Behavior Interventions*, *2*(3), 131–143.
Wilson, D. S., Hayes, S. C., Biglan, A., & Embry, D. D. (2014). Evolving the future: Toward a science of intentional change. *Behavioral and Brain Sciences, 37*(4), 395–416.
Wilson, D. S., Kauffman, R. A., Jr., & Purdy, M. S. (2011). A program for at-risk high school students informed by evolutionary science. *PLoS One, 6*(11), e27826.
Wilson, D. S., O'Brien, D. T., & Sesma, A. (2009). Human prosociality from an evolutionary perspective: variation and correlations at a city-wide scale. *Evolution and Human Behavior, 30*, 190–200.
Wilson, D. S., Ostrom, E., & Cox, M. E. (2013). Generalizing the core design principles for the efficacy of groups. *Journal of Economic Behavior & Organization, 90*, S21–S32.

ERRATUM TO

Chapter 5
Guided Play: A Solution to the Play Versus Learning Dichotomy

Tamara Spiewak Toub, Vinaya Rajan, Roberta Michnick Golinkoff, and Kathy Hirsh-Pasek

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