The Study of Behavioral Inhibition and Temperamental Shyness Across Four Academic Generations

Louis A. Schmidt, Kristie L. Poole, Nathan A. Fox, and Jerome Kagan

It is the supreme art of the teacher to awaken joy in creative expression and knowledge.
—Albert Einstein

Introductory Remarks

The idea for this chapter originated from three events that transpired at the most recent Biennial Meeting of the Society for Research in Child Development (SRCD) in Baltimore, Maryland, March 2019, and three "take-home" points from these events. The first event occurred while preparing notes for my role as a discussant in a symposium on transactional models in child development. While all three papers in the symposium were very thoughtful, timely, and important, I was somewhat surprised that all three presentations ostensibly assumed that the idea of transactional models was a relatively recent occurrence in the field of child development. I soon reflected on the first course I taught as a new assistant professor over 20 years ago on the history of psychology. In the class that week, I was covering functionalism and functionalist schools of thinking and, in particular, the work of John Dewey. Of course, if you are going to cover Dewey, a good place to begin is his seminal paper, *The Reflex Arc Concept in Psychology*, published in *Psychological Review* nearly 125 years ago. In this paper, Dewey (1896) was opposed to the traditional

L. A. Schmidt (✉) · K. L. Poole
Department of Psychology, Neuroscience & Behaviour, McMaster University, Hamilton, ON, Canada
e-mail: schmidtl@mcmaster.ca

N. A. Fox
University of Maryland, College Park, MD, USA

J. Kagan
Harvard University, Cambridge, MA, USA

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stimulus-response understanding of the reflex arc, which later became a dominant theme of behaviorism. Dewey suggested that stimulus and response (i.e., action) were not distinct and separate events, but were transactional in nature. As others later noted (e.g., Biesta, Miedema, & van IJzendoorn, 1990), Dewey's reconstruction of the reflex arc informed transactional paradigms and, in my opinion, could be argued as the nascent beginnings of transactional models in human development, nearly a half century before John Bowlby and his theory on attachment (Bowlby, 1958). Take-home point #1: Appreciate the history of ideas and historical precedents in science.

The second event transpired while in the audience of a symposium on *Developmental Models of Shyness* organized by one of my current doctoral students, Kristie Poole. In this symposium, there were contributed papers from my current doctoral student (Kristie Poole) and me, a second from my former doctoral student (Alva Tang) and my doctoral advisor and mentor (Nathan Fox), and a third by my colleague (Rebecca Brooker) for whom I served as a mentor on her NIH K-99 transition to independence award. Another one of my graduate supervisory mentors (Ken Rubin) served as the symposium discussant. I reflected on the fact that not only are ideas shaped in science by larger generational influences and the historical eras in which they occur, but these ideas also are shaped intimately within and across academic generations, and what largely links us to the past, present, and future is the academic intergenerational transmission of these ideas. Take-home point #2: The student-mentor relationship is lifelong and key to the transmission and shaping of ideas and, interestingly, transactional in nature in the spirit of Dewey.

The third event took place when I was preparing notes for my role as a panel member on a roundtable on *Solitude and Social Withdrawal*. Given that SRCD was held in Baltimore, I thought that right at the outset of the roundtable, I would pay homage to two of Baltimore's most famous historical residents, Edgar Allan Poe and Billie Holiday, both of whom spent time living in Baltimore and struggling with social relationships. I wondered what they each had to say about solitude. For Poe, what came to my mind was his 1829 poem, entitled "Alone," in which he writes in the opening stanza, "From childhood's hour I have not been; as others were – I have not seen; as others saw – I could not bring…and all I lov'd—*I* lov'd alone." Scholars have interpreted this poem as Poe lamenting on his uniqueness and his inability to fit in with others in childhood and the resulting melancholy that haunted him throughout his life. For Holiday, the lyrics of her 1952 song, "Solitude," are a poignant reminder of her own struggles with relationships, "In my solitude, you haunt me with reveries of days gone by… in my solitude, I'm afraid." Take-home point #3: Pursue inherently interesting psychological phenomena that deeply impact the human condition and also transcend time.

The purpose of these introductory remarks and chapter is to illustrate these three take-home points: (1) Appreciate the historical precedent of ideas linked to the phenomenon under investigation; (2) student-mentor relationships are critical in shaping ideas across time; and (3) study inherently interesting phenomena that have long been a part of the human condition. To this end, this chapter focuses on a discussion

of the phenomenon of behavioral inhibition and temperamental shyness as viewed from representatives of four academic generations that span seven decades and multiple student-mentor relationships.

In the first section (Generation I), Jerome Kagan discusses the origins of the idea of behavioral inhibition and traces these ideas across seven decades of his work in this area. In the second section (Generation II), Nathan Fox, a student of Jerome Kagan, reflects on the behavioral and physiological correlates and consequences of behavioral inhibition and discusses the development of these ideas across five decades of inquiry. In the third section (Generation III), Louis Schmidt, a student of Nathan Fox, considers three issues important to understanding temperamental shyness (heterogeneity, context, and function) that he has been exploring over the last three decades. In the fourth section (Generation IV), Kristie Poole, a student of Louis Schmidt, presents her ideas and work on the developmental origins and adaptive aspects of temperamental shyness that she has been studying for several years. We conclude the chapter with some reflections on where future generations may want to go in the study of behavioral inhibition and temperamental shyness.

Louis Schmidt

Generation I: Jerome Kagan

The Origins of the Idea of Behavioral Inhibition

The concept of behavioral inhibition (BI), as well as its opposite, the uninhibited child, had its origins in three sets of observations, rather than an a priori hypothesis. The first occurred in the 1960s when Howard Moss and I were analyzing the relations between his ratings of the behaviors of 89 white children born between 1929 and 1939 in southwest Ohio and the data I had gathered on these individuals as adults. The narrative descriptions were based on frequent and direct observations of the child in the home and at the Institute from infancy to 14 years of age. Moss made separate ratings for the intervals birth to age 3 years, 3–6, 6–10, and 10–14 years with no knowledge of the adult information. These individuals were in their third decade in the late 1950s when I interviewed them with no knowledge of the childhood information.

A small proportion of children consistently withdrew from unfamiliar people and settings during the first 3 years. We called this bias "passivity." These children preserved this bias through age 14 and, as adults, were more likely than others to report being dependent on a love object, parent, or friend when a challenge arose. This relation was stronger for females than for males. In the book-length summary of this work, we wrote of the possibility that "a predisposition to passivity is a function, in part, of biological variables" (Kagan & Moss, 1962, p. 83). I did not pursue this observation because my politics and the emphasis on S-R learning theory when I

was a graduate student at Yale in the 1950s bred a resistance to acknowledging the influence of biology on personality.

Nature gave me a second opportunity to study this phenomenon in the 1970s when Richard Kearsley, Philip Zelazo, and I were conducting a study designed to assess the effects on early development of attendance at a day care center. We had planned to enroll only African-American families, but the suspicions held by a black political group in Boston in the 1970s forced us to exclude black infants from the study. They argued that racists would interpret any result as implying blacks were deficient. If our curriculum at the day care center did not help black infants, racists would say that black infants could not profit from benevolent interventions invented and supervised by white Harvard faculty. If the black infants who remained at home were no better than those at the center, racists would argue that black mothers were incompetent.

Because NIH had given us the funds, we needed to enroll other ethnic groups. Fortunately, the minister of the Chinese Christian church came to our rescue. He suggested we study Chinese-American and white infants from the same social rank, mainly working class. We enrolled infants who were 3–5 months old and studied them until they were 29 months old. Thirty-three infants (16 Chinese and 17 white) attended the day care center 5 days a week, and 67 infants were raised only at home (30 Chinese and 37 white). We observed all the infants in a variety of test situations on eight occasions between their age at enrollment and 29 months. There were minimal differences between the infants attending day care and those raised only at home. But the differences between the Chinese and white infants were striking. The former were less vocal, were less likely to smile, stayed closer to their mother, were more inhibited in unfamiliar settings, were more likely to cry when the mother left them temporarily, and had less variable heart rates at rest (Kagan, Kearsley, & Zelazo, 1978). Because Freedman (1974) had reported similar results, I became receptive to the idea that temperamental biases were far more influential than I had been willing to acknowledge.

I was now ready to study the bias we called BI more directly. One of my students, Cynthia Garcia-Coll, probed this idea for her doctoral thesis. She observed the behaviors of a large sample of 21-month-old white children in varied laboratory settings because she did not have confidence in the accuracy of parent reports. Each child encountered a variety of unfamiliar, but harmless, events, and the video records were coded for signs of BI. About 20% of the sample displayed consistent BI responses, and a somewhat larger proportion displayed the opposite pattern called uninhibited (Garcia-Coll, Kagan, & Reznick, 1984). Members of both groups were observed 40 months later in their kindergarten classrooms. Those who had been BI were shyer than the uninhibited children (Gersten, 1989). Nancy Snidman replicated Garcia-Coll's finding with 31-month-olds. Observations of the two samples at 5 and 7 years revealed modest preservation of the BI behavioral profile. However, the BI children displayed higher and less variable heart rates, larger pupillary dilations during cognitive tasks, and less pitch period variability (jitter) in vocal utterances (Kagan, Reznick, & Snidman, 1987, 1988). The biological evidence implied

greater sympathetic tone on the cardiovascular system as well as greater muscle tension in the larynx.

The data gathered by the late 1980s led us to believe that some children who showed a BI profile in unfamiliar contexts had inherited a neurochemistry that rendered the amygdala and/or sites connected to the amygdala more responsive to unexpected events. But we also believed that life experiences could establish a BI profile in children without any biological bias. Hence, the next challenge was to study young infants to discover if BI children who inherited a biological bias showed any signs of their predisposition. This research led to the discovery of highly reactive 4-month infants who react to unexpected events with vigorous motor activity and crying and signs of an excitable amygdala (Kagan & Snidman, 2004).

Our current view is that about 20% of white infants raised under benevolent home conditions inherit a lower threshold to unfamiliar or unexpected events. This bias leads to BI responses during the first year or two. But with each succeeding year, some of these children learn to suppress withdrawal and timidity to the unexpected. By adolescence, only a small proportion of high reactives continue to show BI profiles. However, high reactives who learned to hide their timidity to the unexpected find it difficult to suppress the private feelings of tension that fuel the BI profile. Evidence from EEG and fMRI confirm this claim (Schwartz et al., 2012).

The adults who had been high reactive infants and BI during the first year or two but find a life setting that is congruent with their temperament often lead satisfying lives. T.S. Eliot is an example. The less fortunate who do not possess the talents that make a more solitary life possible, as well as those who cannot avoid frequent challenges, are at risk for an anxiety disorder. This claim is consistent with the biological data indicating that the animal's setting makes a major contribution to its behavioral profile. Highly reactive infants who develop a BI profile are apt to develop a maladaptive adjustment if they encounter a stress that triggers a reaction in a setting in which the reaction is inappropriate.

Consider a pair of monozygotic twin sisters who had been highly reactive infants and who grew up in a supportive family in a small town. Both conquered the BI characteristics they had displayed as children. One sister remained in the town, became a librarian, and married a man she dated in high school. Her sister decided to go to Los Angeles to attend UCLA. She did not make many friends during her freshman year, had poor grades, and developed an anxiety disorder.

The studies of BI over the past 50 years have taught me three lessons. First, do not rely on one source of evidence, whether a parent report or behavior in one setting, as the basis of a psychological category. Second, always examine a corpus of data for different patterns of measures for males and females as well as social class and ethnic groups. Finally, remain open to any outcome. Do not let a favored hypothesis blind you to an important idea. Psychology is a young discipline and its most important insights continue to evade us.

Generation II: Nathan Fox

Correlates and Consequences of Behavioral Inhibition

My initial entry into the area of temperament and then to the study of behavioral inhibition was the result of a series of fortuitous and perhaps serendipitous events. After completing a fellowship on cross-cultural psychology with Jerry Kagan as my mentor where I spent 1 year in his lab studying infant cognitive development and a second in Israel studying infants raised on communal farms (kibbutzim), I found myself in his office trying to figure out what to do next. He told me he had received a call from Michael Lewis, a developmental psychologist, who years earlier had studied with Jerry at the Fels Institute, asking if Jerry knew of anyone who could fill a postdoc/research position in New York City to work on a study of the effects of prematurity on infant development. Jerry suggested I call Michael, which I did, and then subsequently visited him at his office which at the time was at the Educational Testing Service in Princeton New Jersey. Michael offered me the position with the idea that I would set up a lab to assess infants born prematurely, mostly to measure their attention to visual and auditory stimuli using heart rate measures. After leaving Jerry's office and walking across the campus I bumped into Richie Davidson who had just finished his graduate work and was taking a position as an assistant professor in psychology at SUNY Purchase. We talked and decided to look each other up, me in NYC and him in Westchester. Richie had studied EEG asymmetry in graduate school and was setting up a psychophysiology lab at Purchase. After many visits to his lab and intense discussions, he and his research associate Cliff Saron helped me set up a psychophysiology/EEG lab at Roosevelt Hospital where I was based. Three things happened: First, between Richie and Cliff, I learned intensively about EEG. Second, I focused my work on the development of infant emotion, and third, in collaboration with Richie, we published a series of papers on the development of emotion and EEG asymmetry (Davidson & Fox, 1982; Fox & Davidson, 1986, 1987, 1988). The conceptualization was that frontal EEG asymmetry reflected the motivational states of either approach or withdrawal (right frontal EEG asymmetry reflecting withdrawal, left frontal EEG asymmetry reflecting approach) (Fox, 1991). Richie and I published a paper in which we demonstrated that we could predict infant response to maternal separation based upon their pattern of asymmetry. Indeed, we suggested that this pattern might reflect a temperamental bias to approach or withdraw from novelty (Davidson & Fox, 1989).

Around that time, Jerry along with a number of other senior developmental scientists had received funding from the MacArthur Foundation to organize a working group on social and emotional development. Jerry invited me to attend the meetings and join his subgroup. I had read his work on behavioral inhibition and suggested that we could assess EEG asymmetry in these children to see whether they showed the predicted pattern of right frontal EEG asymmetry associated with avoidance. That set off my first grant application to recruit a sample of infants, screening them

in the same manner that Jerry and his group had done in their initial work, and follow them to assess their social behavior and EEG asymmetry. I was joined at this time by Ken Rubin who at that time was at the University of Waterloo and who had been invited to present at Jerry's MacArthur working group. Ken studied peer relationships, and he and I decided that we would follow these temperamentally reactive, behaviorally inhibited infants long enough to be able to assess their peer competencies and relationships. Our first grant was funded (after a site visit that included Manny Donchin and Michael Lamb), and we set off to study behavioral inhibition.

There were four significant observations from that work. First, when we screened 4-month-old infants for motor and affective reactivity, we identified not only the high negative reactive infants that Jerry found but also a group of infants who displayed equally high motor reactivity but coupled with positive affect. We call these infants temperamentally exuberant, and they have their own unique biology and behavioral profile. Second, we found that behaviorally inhibited infants (assessed using Jerry's laboratory paradigm) did in fact display right frontal EEG asymmetry (Fox et al., 1995; Fox, Henderson, Rubin, Calkins, & Schmidt, 2001). Third, as these toddlers aged into preschool, they displayed social reticence in the presence of unfamiliar peers (Rubin, Coplan, Fox, & Calkins, 1995). And fourth, with regard to change and continuity, among the behaviorally inhibited children, they were equally likely to go on to display social reticence as not (Fox et al., 2001).

Among the many insights that Jerry had regarding the biology of behavioral inhibition was the possibility that their biology was analogous to the systems being described at that time by Joe LeDoux and Michael Davis, who were studying rodents and describing the biology of fear conditioning. The behavioral outputs in their work—freezing and avoidance and the autonomic reactivity and startle—were quite similar to that observed in the behaviorally inhibited child. Jerry's work here was taken up by biological psychiatrists at that time with an interest in understanding the etiology of anxiety. The behaviorally inhibited child, as it turns out, is the best "phenotype" for understanding the origins of anxiety and particularly social anxiety in the clinical literature. I pursued study of the physiological responses of behaviorally inhibited children with my then graduate student Louis Schmidt. We examined their neuroendocrine responses (Schmidt et al., 1997) and fear potentiated startle (Schmidt & Fox, 1998) finding patterns analogous to those of the fear conditioned animal.

Yet another fortuitous event in my career studying behavioral inhibition came when Danny Pine, a child psychiatrist and neuroscientist, moved from his academic position at Columbia to head a lab at the National Institute of Mental Health. The children in our first cohort were just turning 12, and we already had a second, larger cohort of young children who were again screened at 4 months of age, and we were now following to examine biology and social behavior. Danny brought his expertise in clinical ratings to this work and his interest in neuroscience. We began scanning the brains of these children and working together in a collaboration that has continued to this day—because it is so interesting and so much fun.

A final fortuitous event and one that has played an important role in the work we have conducted on behavioral inhibition over the past almost 20 years involved recruiting Heather Henderson. At one meeting of the MacArthur group, Ken and I spoke and he mentioned that he knew of an outstanding graduate/Master's student who needed a good home for her doctoral work. He recommended, and I recruited Heather who at that time was at the University of Guelph to come work with me. Heather has many gifts and a broad knowledge of social development, but most importantly she is a keen observer of behavior. She worked on the first longitudinal cohort and was instrumental in the design of the second. But most importantly, it was her interest in why some behaviorally inhibited children were able to "cope" with their temperament and be just fine as they got older while others could not and had increased risk for social anxiety that influenced our research direction.

Heather (reading the Berkeley Growth Study and Letzring, Block, & Funder, 2005) argued that these kids appeared stuck, rigid, and unable to be flexible in their responses—overcontrolled in their behavior. She looked around for assessments of cognitive control and found the Flanker task. The interesting thing about the Flanker is that one could assess behavioral performance with regard to accuracy and reaction time but also if one recorded EEG while the participant was performing the task one could synchronize the EEG to the button press (as well of course to the stimulus presentations) and examine an ERP component called the error-related negativity. So, with another graduate student of mine at the time (Jennifer McDermott), we tested the adolescents in our first cohort and found that behaviorally inhibited children displayed enhanced ERN responses (they were, if you will, more sensitive to errors). More surprising was that those behaviorally inhibited children with elevated ERN responses were more likely to go on to have a diagnosis of social anxiety (McDermott et al., 2009).

We have pursued this idea of cognitive control and temperament now for some time. It is counterintuitive. Why should a skill that is supposed to help you adapt (control) work to increase the likelihood of anxiety in this temperamental group? For a reasoned account, see Henderson, Pine, and Fox (2014).

But what is more important for this essay is the nature of inquiry itself. It relies not only on preparation but also serendipity: I took advantage of good graduate training, a brilliant advisor and smart colleagues and graduate students, to observe nature and carve it at its joints.

Generation III: Louis Schmidt

Heterogeneity, Context, and Function in Temperamental Shyness

I have had an inherent interest in, and natural curiosity about, the phenomenon of shyness and related traits such as introversion for as long as I can remember. However, my scientific and research interests in the study of shyness developed dur-

ing my undergraduate years in the mid-1980s and can be traced to at least three factors during that time. The first was an undergraduate special topics course on shyness that I took in 1985 taught by Tom Robinson (a personality psychologist and psychophysiologist) at the University of Maryland Baltimore County which also coincided with a newly published edited volume on *Shyness: Perspectives on Research and Treatment* by Jones, Cheek, and Briggs (1986) that was assigned reading for the course. I was fascinated by the idea that shyness could be studied scientifically, and by the range of ideas covered in class and in the edited volume on the topic of shyness, particularly the chapters by Jerome Kagan on temperament and shyness and Arnold Buss on the development of shyness subtypes.

The special topic course led to the second factor: an opportunity to do research with Tom Robinson and the late Alice Isen (a social psychologist) which we also continued after she moved to Cornell University. This work was focused on understanding individual differences in adult shyness and examining their psychophysiological correlates during resting states and during mood induction and social challenges using heart rate measures. This research was particularly rewarding as it exposed me to the complex conceptual and methodological issues around conducting psychophysiological research and an appreciation of the difficulties inherent in this work.

The third factor was a talk by Jerome Kagan in the early spring of 1987. A group of students, including myself, went to hear Jerry give a keynote address on behavioral inhibition at the College of Notre Dame of Maryland (now Notre Dame of Maryland University). The College was hosting a weeklong series of speakers in celebration of "The Week of the Child." This event was particularly memorable as Jerry was discussing his recent research at the time on behavioral inhibition (now seminal work) that he was doing with his students which had been recently published (Garcia-Coll et al., 1984) and other work that was soon to be published (Kagan et al., 1987). During his talk, Jerry spoke very affectionately of one of his former graduate students, Nathan Fox, and the cutting-edge work Nathan was doing down the road at the University of Maryland, College Park, using brain-based measures (EEG) to understand individual differences in infant and child temperament. The timing was coincidental, as I was, independent of Jerry's talk, becoming quite familiar with Nathan's important series of recent studies and publications on the EEG correlates of infant emotion and temperament (e.g., Davidson & Fox, 1982; Fox & Davidson, 1984, 1986, 1987), aligning with my emerging interests in the biological basis of individual differences in personality.

It soon dawned on me that if I were going to truly understand shyness, it is likely too late to study it in adulthood. This, coupled with the realization that although the peripheral psychophysiological measures that I had been using provided indirect information about the brain, I really needed to know what was going on in the brain. The timing was perfect; two newly emerging disparate lines of research inquiry were interfacing: the phenomenon of behavioral inhibition and the brain within a developmental framework.

And my story begins. The desire to take a developmental perspective to the study of shyness and extend research questions to central brain-based measures, in addi-

tion to the peripheral cardiovascular measures that I was already examining, led me to work with Nathan, a truly inspirational and supportive lifelong mentor, now colleague and friend. I was also very fortunate during my graduate studies at Maryland to discuss many of my ideas with very supportive members of my doctoral committee (Stephen Porges, Ken Rubin, Jay Schulkin), providing me with an opportunity to examine ideas from diverse areas of inquiry and perspectives. Since then, I continue to be very fortunate to work with supportive colleagues and highly passionate and bright students.

Over the last 30+ years, dating to my undergraduate and graduate days and continuing in the research that my students and I are conducting today, issues of heterogeneity, context, and function have been foundational to my research interests and program on shyness. Below I briefly discuss some of our earlier and recent selected, representative work on these three topics.

One of the first studies we did on the heterogeneity of shyness was to empirically test Buss' (1986) Theory of Shyness Subtypes. Over two decades ago, Tom Robinson and I found that Buss' early developing shyness subtype was associated with lower self-esteem than a later developing shyness subtype (Schmidt & Robinson, 1992). A couple of years later using the Cheek and Buss measurement model on the independence of shyness and sociability (Cheek & Buss, 1981), the first study I completed as a graduate student with Nathan was to examine whether we could distinguish shyness subtypes on "state-related" behavioral, central (regional EEG), and peripheral (cardiac vagal tone) psychophysiological measures in anticipation of an unfamiliar social interaction in a sample of adults (Schmidt & Fox, 1994). We found evidence that shyness and sociability were distinguishable on a psychophysiological level. Five years later, as a new assistant professor at McMaster, my laboratory was able to extend these earlier findings on the independence of shyness and sociability on "state-related" psychophysiological measures to "trait-related" central physiology measures using resting EEG (Schmidt, 1999).

In a series of studies since that time, my students and I have provided empirical support for the distinction among shyness subtypes and the independence of shyness and sociability on a range of measures, ages, and populations (Jetha, Schmidt, & Goldberg, 2009; Poole, Khalesi, Rutherford, Swain, Mullen, Hall, & Schmidt, 2019; Poole, Van Lieshout, & Schmidt, 2017; Schmidt, Miskovic, Boyle, & Saigal, 2008; Tang, Beaton, Schulkin, Hall, & Schmidt, 2014; Tang, Santesso, Segalowitz, & Schmidt, 2016; Tang, Santesso, Segalowitz, Schulkin, & Schmidt, 2016; Xu, Poole, Van Lieshout, Saigal, & Schmidt, 2019). Considering heterogeneity in shyness increases conceptual clarity and enhances prediction.

A second major theme in our work has been a consideration of context. Does temperamental shyness generalize to other contexts? My graduate student Paul Brunet and I used what was then considered a recent methodological advance in computer-mediated communication to address long-standing questions in experimental social psychology and person x context interactions (Brunet & Schmidt, 2007, 2008). We found that adults who were classified as temperamentally shy

looked no different than socially outgoing individuals on computer-mediated self-disclosures when they interacted in dyads without a webcam present, but shy adults exhibited fewer self-disclosures than sociable adults when the webcam was present and turned on, mirroring findings from traditional face-to-face interactions of reduced self-disclosures in shyness, suggesting the importance of context in understanding shyness in social interactions.

In more recent work, we have considered shyness within more ecologically salient contexts than used in the past. Using arguably one of the most stressful and anxiety-provoking contexts (i.e., the surgical setting), my graduate student Cheryl Chow and our group recently found that temperamentally shy children were consistently less anxious than socially outgoing children in response to impeding elective surgery across two visits: a preoperative visit and day of surgery (Chow, Nejati, Poole, Van Lieshout, Buckley, & Schmidt, 2017). Although this seems paradoxical, we speculated that perhaps temperamentally shy children were better able to regulate their emotions in some contexts, given that they may have learned how to cope overtime with these same emotions in their everyday environments.

Still a broader context that we have also recently considered is the generation context, or birth cohort, in which the child is socialized. Caspi and his colleagues (Caspi, Bem, & Elder, 1988; Kerr, Lambert, & Bem, 1996) reported that shy children born in the 1920s and 1950s had delayed marriage and parenthood, less stable careers, and lower occupation attainment as adults than other children. We were interested in knowing whether these effects still held true today? My graduate student Alva Tang and our group recently reported that shy children born between 1977 and 1982 who outgrew their shyness (i.e., decreasing trajectory) were indistinguishable from those who were consistently low on shyness measures on social (e.g., marriage and parenthood) and economic (income levels) outcomes (Schmidt et al., 2017). Considering shyness within different contexts is important to increase reliability and generalizability of findings.

A third issue we have been exploring over the years concerns the function of shyness. What is its function? In two recent studies with my graduate student Kristie Poole, we have found empirical evidence of a relatively lower ratio of spectral power in faster (alpha) to slower (delta) EEG frequencies in children's shyness (Schmidt & Poole, 2018, 2019a). This EEG ratio was used as a proxy of brain maturation. We have speculated that a relatively lower frontal alpha-to-delta ratio score might reflect a delaying of brain maturation possibly linked to the approach-avoidance conflict that characterizes some aspects of shyness. We have further argued that this delaying of maturation may reflect the process of neoteny (i.e., the delaying of maturity and retention of childhood features) (Schmidt & Poole, 2019b). The function of this delaying of frontal brain maturation may allow for additional learning to take place about conspecifics intentions and motives before acting. Accordingly, it is possible that some types of shyness may be adaptive. Considering some aspects of shyness as adaptive has implications for how we view the "pathologizing" of shyness in society today.

Generation IV: Kristie Poole

On the Developmental Origins and Adaptive Aspects of Temperamental Shyness

Having been an extremely shy child, I was frequently asked: *Why were you so shy as a child*? It was a question that (particularly as a youngster) was very difficult to answer; a question that as an adult is still very difficult to answer; but importantly, a question that has fueled my passion and interest in better understanding the developmental origins of children's shyness; and a question that has been the launching point of my research to date.

I have always had an innate interest in trying to understand individual differences in shyness. As an adolescent, I remember spending hours reading papers online (that I had limited access to) related to shyness. Without realizing it, I had begun my informal research into studying what contributes to the development of shyness. It was, however, not until the second year of my undergraduate studies that I discovered that the systematic study of shyness was an actual area of research. One of my favorite undergraduate elective courses was developmental psychology. During the lecture on social development, my professor very briefly skimmed over the topic of shyness, which of course sparked my interest. She referred the interested student to contact Dr. Louis Schmidt who she mentioned was an expert in the study of children's shyness. I remember excitedly writing down Louis's name on my lecture notes and reading his work online. Two years later, I was fortunate enough to do a senior undergraduate research project with Louis. Shortly thereafter, I enthusiastically began my doctoral research under his supervision, and my passion to formally begin research on the developmental origins of shyness was realized.

Previous generations of research into the biological and developmental origins of temperamental shyness have been foundational to my own research (Fox et al., 1995, 2001; Fox, Henderson, Marshall, Nichols, & Ghera, 2005; Kagan et al., 1987, 1988; Schmidt et al., 1997; Schmidt, Fox, Schulkin, & Gold, 1999). In conjunction with this earlier theoretical and empirical work, there have been advances in both theory and methodology related to developmental psychology that have placed current generations of academic researchers in a position to further study human behavior in general and temperamental shyness in particular.

For example, there have been increases in theoretical frameworks for understanding human development, such as an increasing interest in elucidating epigenetic mechanisms and testing developmental programming hypotheses, which posit that the prenatal and early postnatal environments can exert long-term influence on social-emotional and physical development (Gluckman, Hanson, & Buklijas, 2010; Harris & Seckl, 2011). Recently, we tested the hypothesis that temperamental shyness may be developmentally programmed in utero in response to stressors, using a sample of individuals who were born at extremely low birth weight (ELBW; <1000 g) as a developmental model of programming. We found that individuals who were exposed to the greatest relative levels of early stress (i.e., ELBW and fetal

exposure to synthetic steroids) in the perinatal period exhibited the highest levels of childhood shyness which remained stable into their early 30s compared to individuals born ELBW and not exposed to synthetic steroids and normal birth weight controls (Poole, Saigal, Van Lieshout, & Schmidt, 2019). We interpret these findings to imply that for some individuals, there may be adaptations that take place in utero in response to early stressors that prepare the fetus for a threatening postnatal environment through physiological modifications. Although adaptive in a stressful prenatal environment, if the postnatal environment is not as comparably harsh and threatening as the prenatal environment, the individual may be more prone to manifest threat sensitivity and hypervigilance, which may lay the developmental blueprint for temperamental shyness. We speculate that this study provides preliminary evidence that temperamental shyness may have its very early developmental origins in utero for some individuals.

There also recently has been an increase in the availability of statistical techniques and analytical frameworks that have facilitated the quest for examining stability and change in behavior across development. Indeed, advanced statistical modeling such as latent class growth curves and multilevel modeling have allowed researchers to systematically chart developmental change in shyness and related constructs (e.g., Booth-LaForce & Oxford, 2008; Degnan et al., 2014; Oh et al., 2008). Likewise, these longitudinal frameworks have been a central theme of our own work and have allowed us to begin charting the trajectory of shyness across developmental periods and investigating factors that influence different developmental pathways of shyness and its long-term outcomes (Lahat et al., 2018; Poole, Cunningham, & Schmidt, 2019; Poole, Santesso, Van Lieshout, & Schmidt, 2019; Poole, Van Lieshout, McHolm, Cunningham, & Schmidt, 2018; Tang et al., 2017). Importantly, longitudinal data analytic techniques have allowed us to not only examine the trajectory of shyness but to also begin investigating the longitudinal trajectories of the psychophysiological processes such as autonomic and brain activity that had been previously proposed to underlie the development of shyness and related phenotypes in typical (Poole, Santesso, Van Lieshout, & Schmidt, 2018; Poole & Schmidt, 2018; Schmidt & Poole, 2018) and atypical (Poole, MacMillan, & Schmidt, 2018) development. Together, this idea has furthered our understanding of the developmental and biological processes that may underlie the emergence of shyness and its long-term behavioral and physiological correlates.

Finally, a relatively recent line of research that has been of interest is to move beyond the idea that shyness is always inherently maladaptive. While there are indeed some individuals for whom shyness may be problematic, researchers have long illustrated that not all shy individuals are alike (Buss, 1986; Crozier, 1999; Schmidt, 1999; see also, Schmidt, this chapter). We have been particularly interested in identifying sources for heterogeneity in shyness, including differences in developmental onset, contextual elicitors, social motivations, and emotional expression (Poole & Schmidt, 2019b). The objective of this research has been to better understand why some subsets of shy children seem to thrive whereas other shy children seem to struggle.

To this end, we have recently begun a series of studies investigating how emotional expression in shy children can result in different outcomes. We found support for the idea that the expression of positive affect is adaptive for shy children and that these children were not distinguishable from their non-shy counterparts on measures of sociability, fear, and social anxiety (Poole & Schmidt, 2019a). This research is consistent with previously published work examining the role of positivity in shyness (e.g., Colonnesi, Napoleone, & Bögels, 2014; Colonnesi, Nikolić, de Vente, & Bögels, 2017; Nikolić, Colonnesi, de Vente, & Bögels, 2016). Most recently, we have begun investigating the developmental origins and biological correlates of different adaptive and maladaptive subtypes of shyness (Poole & Schmidt, 2019c, 2019d). This work has provided preliminary evidence that not only do shy children show heterogeneity in terms of their adaptive and maladaptive developmental outcomes, but some types of shyness may also have different underlying developmental and biological origins. In the future, it will be informative to integrate our emerging findings related to adaptive subtypes of shyness within longitudinal frameworks in order to better understand the developmental trajectory of various shyness subtypes.

Concluding Remarks

This chapter traces the study of temperamental shyness across four academic generations and multiple student-mentor relationships. Kagan's essay (Generation I) illustrates the importance of ideas, observations, using multiple sources of information, and remaining open to multiple outcomes in the study of behavioral inhibition. Fox's reflections (Generation II) demonstrate the importance of solid preparation and at the same time serendipity in research. Schmidt's essay (Generation III) highlights the importance of historical precedent in research when considering issues such as heterogeneity, context, and function in the study of temperamental shyness. Poole's reflections (Generation IV) showcase the importance of considering different origins of temperamental shyness reflected in developmental programming and developmental methods. Several consistent themes also emerged across the four academic generations presented in this chapter that inform recommendations for future generations.

1. *Directly observe behavior*. Some of the first known published research on the scientific study and discussion of shyness, well over a century ago, was rooted in observations (Campbell, 1896; Darwin, 1877; Hall, 1897). These studies were largely based on behavioral and clinical observations of fearful children and adults, not losing sight that, as psychologists, we are interested in understanding behavior as our primary objective. Understanding behavior is particularly salient in this day and age where there is a heavy emphasis on biological methods at the exclusion of the behavior we seek to understand. Accordingly, we run the danger of method-driven rather than theory-driven research. Methods will come and go, but good questions transcend time.

2. *Considering context is critical*. In the study of children's personality development, we often limit our studies to peer and familial/caregiving contexts and traditional conceptualizations of context, reflecting exogenous influences on the child. Macro-level exogenous influences such as cultural (Chen & Schmidt, 2015) and generational (Schmidt et al., 2017) contexts are an important source of variance as is the endogenous context within the child across early (Schmidt, Fox, Perez-Edgar, & Hamer, 2009) and later (Fortier et al., 2014) development. Rethinking traditional definitions of context is important to understanding heterogeneity in children's personality development as well as observing children in ecologically salient and natural settings, and using new computer-mediated communication methods in controlled laboratory environments to exploit longstanding questions in personality science regarding context may also prove fruitful (e.g., Brunet & Schmidt, 2007, 2008).
3. *Explore and establish measurement properties*. Many of the behavioral and biological measures that we use today have not undergone rigorous psychometric testing. Is the measure reliable, valid, and internally consistent? Does the measure have the same meaning across age, sex, and personality type (i.e., have issues of measurement invariance been established, see, e.g., Putnick & Bornstein, 2016; see also Brook & Schmidt, 2019)? Ironically, although subjective, self-reported personality measures are sometimes viewed pejoratively, they are often the measures in the psychological sciences that are the most rigorously subjected to psychometric and measurement testing. At the end of the day, biological and behavioral indices are similar to items on personality surveys that need to be psychometrically tested and measurement issues established before being rolled out. Perhaps some of the replication crisis confronting the psychological sciences today is due to a lack of establishing psychometric properties and measurement soundness of the many behavioral and biological measures used, which is ironic given that the establishment of psychometric properties of measures, test construction, and measurement rigor has been arguably one of the major hallmarks and contributions of the field of psychology (e.g., Cronbach & Meehl, 1955).
4. *Engage the history of ideas*. Many phenomena that we study today in the psychological sciences are linked to a rich past. An appreciation of this history ultimately helps us to refine theory, questions, and hypotheses in the pursuit of inquiry.
5. *Appreciate the importance of student-mentor relationships*. The student-mentor relationship and its transactional nature are critical to linking us to the past, present, and future.

Perhaps Pavlov (1936) said it best for advice to future academic generations. In a bequest of Pavlov to the academic youth of his country translated from Russian and published in the journal *Science* just before his death, he asks: "What can I wish to the youth of my country who devote themselves to science?" His advice: gradualness, modesty, and passion.

Louis Schmidt

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