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LONG ARTICLE

Skill and Collaboration in the Evolution of Human Cognition

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Abstract I start with a brief assessment of the implications of Sterelny's anti-individualist, anti-internalist apprentice learning model for a more historical and interdisciplinary cognitive science. In a selective response I then focus on two core features of his constructive account: collaboration and skill. While affirming the centrality of joint action and decision making, I raise some concerns about the fragility of the conditions under which collaborative cognition brings benefits. I then assess Sterelny's view of skill acquisition and performance, which runs counter to dominant theories that stress the automaticity of skill. I suggest that it may still overestimate the need for and ability of experts to decompose and represent the elements of their own practical knowledge.

Keywords Action · Collaboration · Collective cognition · Coordination · Expertise · Skill

As a project in the "empirical, conjectural and substantive" philosophy of nature, *The Evolved Apprentice* (Sterelny 2012a; EA hereafter) motivates and defends an ambitious apprentice learning model of "the evolution of the distinctive features of human cognition and human social life" (EA, p. xi). It aims to explain the evolution of the cognitive capacities that sustain the distinctive features of human social life, especially over the period of the stabilization of behaviorally modern human cultures. Kim Sterelny identifies a suite of linked changes in brains, bodies, life histories, the mechanisms and practices of social learning, and organized environments. These incremental transformations, by way of multidimensional interacting feedback loops, together explain our ancestors' expanded practices of cross-generational social learning. Increases in the bandwidth, the reliability, and the creativity or flexibility of learning by apprenticeship all derive from changes in the coevolving, interconnected parameters of our capacities for coordination and information-pooling in structured environments, rather than from any single key biological innovation.[1]

I aim in this selective response to push Sterelny on two core features of the constructive account developed in this magnificent book, rather than addressing his nuanced critiques of a range of alternative target views. But it's worth first briefly underlining the pleasure of engaging with the multifaceted array of sources and disciplines that feed the model. Repeated reading reveals just how richly research from an extraordinary range of fields is assessed and incorporated: I count references from around 50 distinct contributing domains, many with radically different methods and assumptions. The fact that this synthesis is achieved not by a large and heterogeneous team but by the single multidisciplinary toolbox that is Sterelny gives the project its unity and its theoretical bite. I pick up in particular on his commitments, as announced in the book's preface, to forging and applying a form of naturalistic empiricism that is neither individualist nor internalist in that "human cognitive competence is a collective achievement" that "often

Colloquium on Kim Sterelny's *The Evolved Apprentice: How Evolution Made Humans Unique.*

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[1] This article is one of four in *Biological Theory's* Colloquium on Kim Sterelny's *The Evolved Apprentice: How Evolution Made Humans Unique* (Sterelny 2012a). See also Downes (2013, this issue); Gerrans (2013, this issue) and Sterelny (2013, this issue).

depends on epistemic engineering: on organizing our physical environment in ways that enhance our information-processing capacities" (EA, p. xii). Focusing first on coordination, I probe some difficulties for the anti-individualist part of this picture, which seem underplayed in Sterelny's account, relating to the fragility of the conditions under which collaborative cognition brings benefits. I then assess his view of skill acquisition and skilled performance. It offers, I argue, a persuasive if understated challenge to dominant views in both philosophy and psychology, which stress the automaticity of skill. But in doing so, it retains just one element of internalism, perhaps overestimating the need for and ability of experts to decompose and represent the elements of their own practical knowledge.

Before addressing those two main topics, I want first to pause on some further celebratory preliminary considerations about Sterelny's radically historical approach. In explaining its differences from the modularist "standard model" of the evolution of cognition, he notes that

> In my view, human worlds have been heterogeneous psychologically as well as socially and physically: the psychology of other agents has also varied over the last hundred thousand years. The standard model rules this possibility out. If our minds are (mostly) ensembles of (largely) prewired modules, then human nature is largely the same everywhere and when. But we are pervasively and profoundly phenotypically plastic: our minds develop differently in different environments. The extent and nature of this plasticity is controversial, but its existence is not. (EA, p. 5)

Against the history of debate about what anthropologists have often called "the psychic unity of humankind," this can be read as updating and enriching Clifford Geertz's (1973, 2000) minimalist version of that thesis as against the biologized version defended in contrast by Tooby and Cosmides (1992; see also Downey and Lende 2012; Shore 1996). For Sterelny, the motivational, emotional, cognitive, and social mechanisms of mind are so plastic and open in our species that differences in complex learning ecologies mean different minds. Detailed comparison of the radically disparate socio-foraging worlds in which our ancestors lived, spanning hot inland deserts, extreme seasonal variation, tropical rainforests, shallow tropical seas, and large-game specialization suggests for Sterelny that "most of what these different peoples need to know will be *specific* to their circumstances" rather than any information that could be prewired into the human head. Given that these ecological differences interact with many other features of human life, "these foraging peoples live in different social and psychological worlds, not just different ecological worlds" (EA, p. 19).

Sterelny applies this approach to bring entirely new perspectives to bear on distinct problems in paleoanthropology. For example, he transforms the longstanding puzzle of the sudden development of "behavioral modernity," long after the appearance of biologically modern humans, by treating behavioral modernity in ecological terms, as a "collective capacity to retain and upgrade rich systems of information and technique" which is "constituted by the organization of social life," rather than as an internal feature of individual minds (EA, p. 56). On this account, behavioral modernity is transmitted culturally rather than biologically, and so its various components can be lost if cultural change stops being cumulative, even if the initial biological resources of the individual members of the cultural groups remain the same: Sterelny suggests that this may have happened repeatedly in the course of human evolution, both for specific innovations and in some cases, such as ancient Australia, perhaps for a whole array of interconnected skills in an utterly new and hostile cognitive ecology. Another application is in the book's coda, where Sterelny asks how the apprenticeship model can extend from its core historical context in Pleistocene foraging cultures, to deal with the different socio-cognitive demands of early farming societies in the Holocene period. In a sad meditation on the origins of hierarchical socio-political systems and the triumph of free-riding elites, Sterelny identifies a new puzzle: if the apprenticeship learning model is on the right track for the earlier period, in its focus on collective action for mutual benefit in small groups, we need a new explanation for collective action in the later, vertically stratified worlds in which some members of larger societies are systematically "excluded from wealth and power" (EA, p. 194; see also Sterelny 2012b). This is just one example of how productively the model can generate ideas in a thoroughly historical cognitive science. Such a project requires specific cognitive theory, and theory of this kind which predicts and seeks out the cognitive aspects of technological, cultural, and ecological differences in our engineered learning environments (compare Hutchins 2010a, 2011; Smail 2008; Tribble and Keene 2011; Tribble and Sutton 2011). In its focus on collaboration and skill as key components of apprenticeship learning, as I discuss below, the apprenticeship model directs our attention to capacities that are heavily theorized for specific cultural contexts by historians and social scientists. Historical and cultural changes are on this view no longer merely external triggers to or background for human cognition, but intrinsic components of the situated, scaffolded human mind.

Coordination and Collaborative Cognition

Sterelny asks us to focus firmly on the key challenges posed to our ancestors in cooperative foraging for uncertain resources, and especially in cooperative hunting of dangerous targets. "Hunting and killing large animals with a

sharp stick is no easy project. Both the risks and the rewards are great. These are large, concentrated resource packages. But catastrophe is just a moment's inattention away," he writes (EA, p. 12). Such dynamic tasks, he notes, often require on-the-fly adjustments to any shared plans, and "high-stakes decisions under time pressure" with "limited prospects for communication and consultation." The psychologies of sports teams and military collectives offer parallels to help us see how multilayered attunement arises in these rich cooperative activities: interpersonal alignment will be perceptual, cognitive, motivational, and affective all at once, revealed both in public, mutual commitments and in the kind of "sensitivity to subtle cues" which grows from "a history of successful coordination" (EA, p. 118). Social learning and joint action are collective both in the way the relevant capacities are transmitted across generations, and in the rich cognitive interdependence involved in coordinating these kinds of collective action.

Though he doesn't belabor his terminological choices, Sterelny treats "cooperation" as the highest-level category here, with the active "coordination" involved in collective action as its central form. Of all of the challenges of cooperation, standard models often address almost exclusively the problems of free riding, policing and punishment. While building alternative accounts of trust and loyalty, control and commitment into his account, Sterelny wants us to start instead by considering the care and skill, the mutual awareness and cognitive interdependence, required to solve the decision-making problems faced by small but enduring groups of hunters and foragers whose members share activities and experiences over time, who are in a clear sense all in it together. In this context, active information pooling at different time scales, and the effective management of tools, techniques, and reliable environmental features, are more pressing challenges than cheater detection:

> Imagine a foraging party trying to decide whether a swollen river is too dangerous to ford, which animal in a pack to target, how to interpret the ambiguous behaviour of a neighbouring group. There is no temptation to defect here. (EA, p. 137)

Whether hunting medium-large herbivores, or extracting scarce resources from plants, our ancestors worked together both in the long processes of transmitting and acquiring detailed understandings of natural history and material culture, and in immediate contexts of high affective intensity. Trust and trustworthiness are the products, rather than the intrinsic preconditions, of such "costly, high-arousal activity" (EA, p. 116). In the next section I take up questions about the nature of the skills acquired in longer-term forms of collaborative cultural learning. First I probe the conditions under which collaborative cognition in online decision making and in the performance of joint actions might have brought sufficient benefits. My aim here is not to challenge Sterelny's general picture of the centrality of coordination and collaboration for the evolution of human cognition, but to point to the need for extra detail in further work regarding the nature of the groups, tasks, and interactive processes.

In his discussion of risk and network shape, Sterelny further underlines his case that information pooling "is less subject to defection problems than some forms of ecological and reproductive cooperation" (EA, p. 137). For example, the openness or mutual availability of both the processes and the products of information sharing, in groups of certain sizes and shapes, tends to diminish potential intra-network competition. But deception is by no means the only kind of threat to successful cognitive collaboration. In addition to other motivational and affective factors that can trouble group processes, such as social loafing and affective contagion, there are also basic socio-cognitive hurdles that small groups must clear before the kinds of assembly bonuses that collaboration promises, in the form, for example, of novel and emergent shared understandings or solutions, can be reliably achieved. Features of the task and the pattern of information distribution, and features of the nature of the group interaction, can lead to the various forms of "collaborative inhibition" which have been studied in cognitive psychological research on memory and decision making alike (Stasser and Titus 2003; Harris et al. 2008; Hope et al. 2008; Rajaram and Pereira-Pasarin 2010). In his optimism about group decision making, Sterelny references results which depend on all group members voting independently and having "mutual knowledge of each agent's assessment of noisy signals, together with trust in consensus" (EA, p. 137). But it is not clear that these conditions would have been met any more reliably in the case of forager societies than they are now.

Where information is unevenly spread among group members, for example, and needs to be pooled in a non-obvious way for the superiority of one decision alternative over others to become apparent, key unshared information is less likely to be sampled in the group interaction than shared information, and will thus often remain hidden (Stasser and Titus 1985). It is often costly to acquire, transfer, and use certain kinds of "sticky" information if group members have more heterogeneous skills and frames of reference (von Hippel 1994). Further, as collaborative processes converge, confidence can increase and attention narrow, leading in the extreme to resistance to new information and to "myopic disregard of alternative viewpoints" (Minson and Mueller 2012). Most directly, in various experimental settings, the performance of a collaborative

group in recall or judgment tasks is worse than the pooled output of the same number of individuals (a "nominal group"). The standard explanation for these surprisingly robust results is that individual retrieval or decision-making strategies are easily disrupted by the group process (Basden et al. 1997; Weldon and Bellinger 1997). These are not problems of self-interest in a translucent social world, but unintended outcomes of the way cognitive mechanisms are engaged in certain collaborative settings even in more transparent communicative contexts.

Those of us who believe that ordinary social-cognitive collaboration does in fact often bring process gains thus have to respond to such troubling empirical evidence of process loss in the form of various conformity, misinformation, and groupthink effects (D'Agostino 2008; Sutton et al. 2010; Weldon 2000; Theiner 2013). The challenge to Sterelny's picture here is not that the stabilization of effective collaborative processes would have required group-level selection on some unified set of capacities. Rather, the question is about the conditions driving selection of the disparate cognitive mechanisms which are shared by social and individual learning, including notably "memory, the control of attention, an ability to inhibit impulse, and the ability to monitor the results of one's own actions" (EA, p. 34), and also probably disparate lower-level mechanisms of multimodal interpersonal alignment (Tollefsen et al. 2013). Sterelny can reply, plausibly, that even in the absence of complete mutual knowledge and entirely beneficial informational environments, collaborative cognition in foraging cultures likely involved groups, tasks, materials, and processes dramatically different from the rather artificial scenarios of relevant lab work (compare Barnier et al. 2008; Meade et al. 2009; Harris et al. 2011). But what were these conditions that could drive just enough collaborative facilitation, rather than collaborative inhibition?

Although he doesn't pose the problem in quite this form, Sterelny's account already suggests some promising answers. Informational exchange in foraging cultures, he argues, involved built-in public scrutiny in many-to-many networks with redundant or overlapping sources. As group size increases, more substantial division of labor brings specialization and thus a more distributed or heterogeneous spread of information: but even such distributed expertise allows for or even facilitates the iterative integration of shared beliefs and skills over time (compare Gupta and Hollingshead 2010; Wegner et al. 1985 on transactive memory systems). This is one symptom of the way that the conditions of collaboration are transformed, relative to the psychologists' standard forms of uncommitted turn taking among groups of strangers, when joint decisions and actions are embedded in and spring from a rich shared history. Such long collective experience in no way guarantees that the forms of cognitive interdependence among group members will operate according to effective dynamics. But it does mean that a group's aggregation procedures for reaching consensus are sensitive to factors beyond the immediate moment, in principle at least tapping in to the distinct individual capacities and skills that have accumulated and been available to the group over time, and in the ideal case involving mechanisms to encourage cross-checking or dissent.

By repeatedly bringing us back to "the phenomenology of male hunting" (EA, p. 113), Sterelny also points a potential discussion of collaborative cognition away from the more formal settings and purely declarative content often addressed in social ontology (List and Pettit 2011), and towards the more improvisational dynamics of those forms of collective action which mobilize procedural knowledge in flexible ways. There is some evidence that learning and remembering how to do or make things together, in transactive teams, may more easily produce collaborative benefits than working together to make judgments or remember semantic information (Liang et al. 1995; Theiner 2013). Further, hunting animals, at least with the early forms of spear technology, was arguably a task that could not, in principle, be accomplished alone: group performance on such "Hutchins-type" tasks, like the navigation of a US Navy frigate as studied by Hutchins (1995, 2010b), cannot be assessed against the pooled performance of a nominal group aggregated mechanically, because the individuals in that nominal group simply can't perform the disparate proper parts of the task in isolation. Finally, to bring another of Sterelny's central themes to bear on these problems about collaborative inhibition, stabilities and traces in the environment can structure or channel the coordination of cognition in small groups. Enduring items of technology or material culture, more or less rhythmic regularities in the natural world, and reliable patterns of routine or ritual can all operate as nudges or anchors for shared decision making, as residual cues or condensed reminders: when we think or act together, we often do so in settings and contexts that our own previous actions have partly engineered, so that we are not starting again from scratch (Sutton 2008). These factors, then, likely played some part in setting the conditions for collaborative cognition in the Pleistocene such that its reliability was just good enough to ward off or counteract the socio-cognitive barriers to successful collective decision and action. Sterelny's robust defense of teamwork and collective action as a key setting for enhanced social learning should encourage further attention to the precise mechanisms and contexts of effective interaction and cooperation.

Skills, Expertise, and Templates

The apprenticeship model ascribes the evolution of the human mind in large part to changes in the ways our ancestors acquired and transmitted cognitive and motor skills. This does not make it another single-factor account, because it treats these transformations in the practices and mechanisms of skill learning as tightly interwoven with a range of distinct demographic, ecological, and biological developments, and also because skill learning itself is a multifaceted phenomenon, reliant on both social and ecological scaffolding in highly structured environments. While Sterelny does not explicitly anchor this part of his story in either the cognitive psychology of expertise or the philosophy of action and know-how, his picture of skill acquisition—the heart of apprenticeship—draws richly on and has intriguing implications for these fields. The expanding scope of social learning involved a range of new channels of information flow, both within and across generations.

"Apprenticeship" is not just direct demonstration or instruction in single teacher-learner relationships, but could also involve gradual pickup of lore and patterned practice from peers and other group members. So apprenticeship learning, on this view, is a hybrid process in a number of ways, engaging both procedural and declarative knowledge, both unsupervised and supervised learning routines and regimes. In tracking and hunting animals, foraging for and preparing food, or making tools, complex sequences of practiced actions must be available for deployment and redeployment swiftly and flexibly, in a range of organized settings, but with care and attention to changing environmental contingencies.

The "effortless mastery" of the expert practitioner (EA, p. 3) may look modular, in that fluent responses in the specialist domain are rapid and apparently automatic. But this does not mean that we should treat skills as resting just on more bodies of domain-specific knowledge, analogous to our mastery of language or, perhaps, theory of mind. For Sterelny, the forms of know-how employed in tracking or toolmaking, as for us now in playing sport or in reading (EA, p. 37), remain distinct from any amount of factual knowledge: apprenticeship in such skill domains takes trajectories different from those involved in learning language, however that is to be explained. There are alternative routes to the capacity for rapid skillful response, when exploratory trial and error in information-rich learning worlds has been supported by wide cross-generational access to experts, and then by active pedagogy. This point drives one of the most striking features of the apprenticeship model, its focus on the residual openness of skillful practice to various forms of influence and intervention. Though Sterelny doesn't highlight this, it thus challenges widespread consensus about skilled action, though I disagree on one way that Sterelny develops the idea.

The central claim is that expert practice itself must remain flexible. For this reason, even in motor domains, it cannot be "mindless," cognitively inaccessible or encapsulated (again, contrasting with the information underlying linguistic cognition). Certainly, response speed and efficiency is enhanced by the rich chunking of complex knowledge or action sequences developed over long and effortful apprenticeship. But this does not equate to automaticity, either in the sense that responses cannot be modified or altered online, or in the sense that awareness and attention are entirely absent. Instead, at different time scales, experts must be able to redeploy and redirect the components of their skillful practices. The online performance of skilled action in ordinarily challenging conditions, with fragile or volatile materials or in hostile environments, must be subtly responsive to novelty, to conditions beyond specific previous experience. Likewise, in taking skills offline for pedagogical, strategic, or collaborative consideration, experts will be able to access and tap in to aspects of their trained capacities. Those capacities thus remain open to at least two kinds of influence: both higher-level forms of cognitive control, and explicit or declarative labels. In each respect, the apprenticeship model runs counter to other leading views.

Naturalistic philosophers of mind are accustomed to suspicion of self-report, aware of our tendencies to confabulate about the springs of action. But the evidence that finds us offering spurious rationalizations for our decisions has not always been gathered in optimal settings and conditions, and does not extend unambiguously to experts (Ericsson and Williams 2007; Fox et al. 2011). Another influential approach to skilled action, in phenomenological philosophy, sees cognitive control or "mindedness" as "the enemy of embodied coping" (Dreyfus 2007, p. 353): the chunked patterns of perceptual-motor responses called on in intuitive responses "lose their individual identities and become, in a sense, inaccessible" (Ennen 2003). Such intuition-based accounts of know-how also find surprising support, with respect to the ways in which experts *access* their skills, in intellectualist theories which offer dramatically different accounts of the content or nature of skill knowledge, such as Jason Stanley's. Stanley too sees the *deployment* of skill knowledge as occurring "automatically and without reflection," in that "perfectly general" automatic mechanisms guide action "directly" (2011, pp. 24, 173, 183–184). The picture of skilled action embedded in the apprenticeship model can effectively counter these more "mindless" approaches, by pointing out how actively experts will *resist* the intuitive automation which Dreyfus and others privilege, because it limits their ability to make adjustments on the fly. To put the point in contemporary

terms, flexibility in skill execution in those complex task domains in which perturbing factors abound often requires some measure of top-down strategic cognitive control, increased and mobile attention in response to challenge, and enhanced (rather than reduced) situation awareness (Ericsson and Kintsch 1995; Chaffin et al. 2002; Sutton 2007; Sutton et al. 2011).

As well as being (imperfectly) accessible and amenable to cognitive control, expertise can also be (imperfectly) tapped and honed by way of the specialist and technical vocabularies used by skilled practitioners to mark salient distinctions and practical norms, to help in generalizing from unique exemplars or episodes, and to identify and discuss more abstract patterns of cases across their skill domain. In an important passage, Sterelny describes the interaction and mutual dependence of such principles or labels with tacit know-how:

> A skilled craftsperson has a good deal of explicit information at his or her fingertips: rules of thumb, the lore of the trade. This explicit, articulated, detachable information co-exists and interacts with pattern-recognition capacities; well-tuned habits; information that can be made explicit, but only with the right prompts; know-how. Often explicit principles take time to be smoothly integrated with fluent practice; often they can only be partially extracted from that practice. The distinction between explicit and tacit is not sharp: a cabinet-maker may be able to explain, say, the reasons why she rejected one source of raw materials in favour of another, but only slowly and partially, reconstructing the decision rather than reporting on it. Likewise a skilled birder can probably decompose the jizz of a raptor into some explicit components about glide, wing beat, and habitat. But again this is likely to involve some mix of reconstruction and report. (EA, pp. 168–169)

This depiction of the pervasive interactivity between explicit and tacit cognitive processes is richer than that found in some dual process models of the mind. It occurs in the context of a persuasive discussion of moral competence: Sterelny rejects more intellectualist views, such as nativist accounts of "moral grammar," by pointing out how often articulated and communicable generalizations or evaluations are involved in our individual and collective moral behavior over time. Such explicit principles are sometimes epiphenomenal and confabulatory, for sure, but not always: they do partly and imperfectly influence our evaluative responses (compare Christensen and Sutton 2012; FitzGerald and Goldie 2012; Mackenzie 2012). Sterelny cites approvingly both Paul Churchland's exemplar-based account of moral judgment as anchored in pattern recognition and pattern transformation, and Clark's (1996, 2000) focus on the manipulative role of moral language as a tool for error-correction (EA, pp. 163, 208). His own account is closer to Clark's focus on the indirect utility of moral norms and nudges in collaborative moral action than to Churchland's (2000) thoroughly proceduralized internalism. This response to those who stress uniquely the blind automaticity of our moral and social psychology could be fruitfully transferred back to the core topic of skill acquisition and performance. Although Sterelny suggests that explicit instruction plays more of a role in moral apprenticeship than it does in either skill transmission or language acquisition (EA, p. 163), the book as a whole successfully depicts active pedagogy as a key factor also in the evolution of the capacity for reliable social learning of skills. This brings me to my only minor concern about the precise connections between expert practice, detachable knowledge, and teaching.

It is one thing to point to the balance between tacit and embodied practice, on the one hand, and more organized or scaffolded apprenticeship situations, involving deliberately engineered learning environments. As Sterelny argues, this broad picture is supported by ethnographic data on craft skills in traditional societies, which involve some explicit teaching among distinctively modified balances of such disparate resources (see now also Lave 2011). But Sterelny sees particularly tight connections between skillful practice and pedagogy, connecting both to the capacity to decouple the components of skilled action and rework them out of context. In organizing the "learning trajectory of an apprentice," experts often combine "task decomposition and ordering skill acquisition, so that each step prepares the next" (EA, p. 35). Both processes require high-level, abstract task analysis, so Sterelny identifies experts' knowledge, which is "partially declarative, not just procedural" as facilitating their meta-cognitive capacity "to represent their own skills" (p. 41). His striking hypothesis is that there is a direct "correlation between the complexity of a skill and the capacity to represent one's own experience": the more expert the practitioners and the more complex the domain, the more we will see the kind of "self-reflective expertise" which permits a task to be "overtly decomposed into segments, each of which can be represented and practiced individually." The most effective pedagogy in such domains springs not merely from "fluent natural performance," but from "performances that are stylized and accompanied by metacommentary" (EA, pp. 145–146).

On this view, then, the most expert practitioners in a domain will also be the leading theorists of that domain, and thereby the best coaches and teachers of novice performers. But this seems too neat, and indeed to sit in some tension with Sterelny's own acknowledgement (as quoted above) of the imperfect links between explicit principles

and online skills. Fluent performers must have *some* means of and mechanisms for gaining, maintaining, and tapping into awareness of and access to the component elements of their skillful action: but the abilities to describe and decompose those components are arguably different skills from the performance capacities themselves. Some critics can't play, and some experts can't teach. It is not clear, therefore, that the full-scale decomposition of a task into context-free steps is always an effective pedagogical exercise, especially in motor domains where the ecological information available may be altered by rendering the stimulus array artificially simple. In a companion paper on relations between language, gesture, and skill in the evolution of cognition, Sterelny again links "top-down awareness of the structure of these skills" with the ability to "take crucial elements off line, and autocue their practice" (Sterelny 2012c, p. 2144). The idea is that being able to detach distinct components of an action sequence improves not just learning, but also the expert's capacity "to recognize and diagnose errors in the operations of the less skilled," and that therefore this kind of abstract awareness and the metacognitive representation of one's own capacities arose "because we have been selected to teach as well as learn." Sterelny offers helpful examples:

> Think, for example, of a batsman practising his footwork in front of a mirror, or a young forager practising blowpipe skills by pursing her lips and exhaling explosively but silently. We can demonstrate and practise components of complex operations, as when a bowler demonstrates her grip on the ball, or her follow-through. Furthermore, we can extract and reuse elements of a skill. It is less easy to hammer a nail in straight than it sounds, but once you have acquired this skill, you can redeploy that subprogramme in many contexts. (Sterelny 2012c, p. 2144)

But while the closed skill of hammering a nail in straight is indeed relatively encapsulated and transportable, in many open skill domains (like team sports, combat, or hunting) the state of the relevant materials or targets, the position and actions of collaborators or teammates, and even the goals of the action sequence may all be changing dynamically and simultaneously. This can limit the transferability of skills honed in peace, shielded from such interactive transformation of constraints. In ecological sports psychology, indeed, practice of detached component skills out of context is actively discouraged: robust evidence now shows, for example, that batting practice with a ball projection machine (like the bowling machines popular in cricket) dramatically changes the perception-action constraints of the task, and leads to significantly different biomechanical sequences than representative practice against human bowlers (Pinder et al. 2011a, b). The kind of free-floating attentional control and strategic situation awareness needed to adapt effectively in situ may sometimes lean more on the way attention has been educated in richly changing real-world settings than by way of internally generated structures for practice.

There need be no sharp lines here, and Sterelny has undoubtedly pointed to factors of great significance, which will operate differently in distinct skill domains and for different learners and teachers. But this same paper on language and skill also suggests just one other respect in which Sterelny may not have departed entirely from certain forms of internalism about skilled action. As he describes learning in EA, novice toolmakers, for example, can often take advantage of partially completed or discarded artifacts, as well as finished products, against which to model or check their own skills. Raw or processed materials and fragments are "available to guide action," and Sterelny helpfully describes them as "artifact templates" that function as environmental supports for social learning (EA, pp. 35, 68, 135). This aligns nicely with his long-standing attention to the ways we create and use "epistemic technology" as "cognitive prosthetics," where such external models or templates can have informational effects in addition to any utilitarian functions (EA, pp. xi, 27). But in working through possible stages of our ancestors' toolmaking capacities in greater detail in the context of explaining how we came to be able to communicate in stimulus-independent ways that "escape the here and the now," Sterelny gives the notion of a "template" in skillful motor performance a surprising twist:

> Initially, behavioural programmes (or their precursor) did not need to be guided by a mental template of the end product of the action sequence: they could be anchored in the raw materials being transformed …. But as action sequences become longer and more complex, … the sequence as a whole must be guided and initiated by a mental template. Its execution depends on a representation of the intended product, rather than being anchored in the raw materials being processed. (2012c, pp. 2145–2146)

With increasing sophistication, our action sequence comes to be "driven by internal rather than external cues."

There is no dispute that these capacities to represent what is not yet present or is merely imagined are of dramatic cognitive and evolutionary importance: but my query here concerns the way Sterelny equates advances in our cognitive and motor skills with giving up reliance on external, material templates in favor of these novel "mental templates." I am worried here partly by the kind of general suspicion of planning theories in the philosophy of action recently articulated by Preston (2012). More specifically,

Andy Clark and Edwin Hutchins have each argued that increased task complexity does not necessarily lead to a decreased density of coupling with external resources. Rather, the task demands may require us to anchor our planning and decision making more thoroughly in external, material symbols, creating and maintaining what Clark (2005) calls "surrogate situations" within which to work and think (see also Hutchins 2005). Sterelny here draws on the anthropologist Stout's (2011) account of culture change in the Acheulian, which describes increasingly hierarchical cognitive goal structures underlying complex action sequences. But Stout too acknowledges that even skilled toolmakers, who have a multi-level (internal) goal structure which "adds flexibility" and "reduces the requirement for extended contingency planning" can still take advantage of specific external material forms and fragments, each of which will remain "as a continuously available external resource structuring behaviour" (Stout 2011, p. 1054). I take it that Sterelny too will accept the need for regular, online interplay between the "inner template" that he sees as gradually coming to guide skilled human action and such external material templates. But then perhaps it is precisely this capacity continually to work between mind, body, and world, or effectively to manage the distributed resources of organized cognitive ecologies, that should be seen as the tougher, more demanding later stage of the evolution of skill, rather than the capacity to retreat to and plan increasingly by way of internal templates.

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