

The Evolutionary Educator: How John Dewey Would Use Contemporary Cognitive Science to Improve Pedagogical Practice

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ABSTRACT

John Dewey, widely considered America's greatest educational theorist, has also been labeled "evolution's first philosopher." However, the limited research on the brain and human behavior available to Dewey prevented him from drawing on his philosophical inspiration to provide any prescriptions for pedagogical practice. The discoveries of the intervening decades in fields such as cognitive ethology, neuroscience, and evolutionary psychology allow this paper to revisit Dewey's ideas and draw conclusions about the veracity of his claims about the purposeful social transmission of information among humans. To achieve this goal, species with similar life histories to humans were identified and broken into groups that include primates, social carnivores, and cooperative breeders. Within each group, the principal mechanisms for the transmission of the various forms of knowledge identified by cognitive scientists were evaluated and compared to the pedagogical methods promoted by Dewey. Ultimately, this comparative analysis finds that a synthesis can be achieved between the evolutionary philosophy Dewey sought and the educational practices he prescribed.

KEYWORDS

John Dewey, Social Transmission, Cultural Transmission, Teaching, Natural Pedagogy

Ranging from the "teach the controversy" movement to a "debate" about the veracity of evolution as a scientific theory starring Bill Nye to discussion boards critiquing the next generation science standards, it seems evolutionists can find an important conversation about their pedagogical practices around every corner. Additionally, new discoveries within fields such as paleontology, genetics, and developmental biology are changing our understanding about common ancestry on a near daily basis. The access to so much new knowledge (and ignorance) is what allows a journal like *EvoS* to exist. In fact, it seems difficult to imagine that there is an important conversation about evolution not being had. However, I am going to

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argue that the way in which evolution and education are most inextricably bound in our classrooms—through the process of purposely transmitting knowledge—is hardly being discussed.

This oversight should not be surprising. John Dewey, perhaps the most influential person in the formation of modern American education, was also a man labeled by Dewey scholar Jerome Popp as *Evolution's First Philosopher*. Through his works, he used evolution to understand the problems presented not only in philosophy but also in areas as diverse as individual and social psychology and art. Dewey (1966) used evolution to build intellectual bridges because, as he noted in *Democracy and Education*:

No one who has realized the full force of the facts of the connection of knowing with the nervous system and of the nervous system with the readjusting of activity continuously to meet new conditions, will doubt that knowing has something to do with reorganizing activity, instead of being isolated from all activity, complete on its own account ... The development of biology clinches this lesson, with its discovery of evolution. For the philosophic significance of the doctrine of evolution lies precisely in its emphasis upon continuity of simpler and more complex organisms until we reach man. The development of organic forms begins with structures where the adjustment of environment and organism is obvious, and where anything which can be called a mind is at a minimum. As activity becomes more complex, coordinating a greater number of factors in space and time, intelligence plays a more and more marked role ... For the doctrine of organic development means that the living creature is a part of the world, sharing its vicissitudes and fortunes, and making itself secure in its precarious dependence only as it intellectually identifies itself with the things about it, and, forecasting the future consequences of what is going on, shapes its own activities accordingly (pp. 337-338).

Even as he concluded that evolution bound organisms, thoughts, and activities, Dewey did not attempt to make the connection between education and evolution. This conclusion may have arisen from his concern that the public had demonstrated an aversion to evolutionary thought (Popp, 2007) or resulted from his desire to have credible scientific evidence before making any sort of grand claim (Dalton, 2002). What is known, according to Popp (1999), is that “after more than thirty years in philosophy of education ... I cannot remember one discussion of Darwin’s influence [on it]” (pp. 90-91). Dewey separately embraced evolution and education, but for whatever reason, he was not comfortable linking them.

As an educational theorist, he thought that the ideal school would allow individuals to learn from experience, which for Dewey (1966) meant that a learner is able:

“... to make a backward and forward connection between what we do to things and what we enjoy or suffer from things in consequence. Under such conditions, doing becomes trying; an experiment with the world to find out what it is like; the undergoing becomes instruction—[a] discovery of the connection of things” (p. 164).

To him, experiences gave context and meaning to knowledge for all regardless of age, and it was the role of the school and the teacher to provide them

(Dewey, 1956). For anyone invested in education, be they a scholar, a teacher, or a parent, the veracity of this statement and its implications for the learning environment is palpable. Therefore, it becomes the charge of this paper to find a way to marry the timeless educational philosophy of Dewey with contemporary knowledge of the modes of transmission that have been naturally selected in order to provide a prescription of sorts for the educator in all of us that Dewey himself would appreciate.

DEWEY: THE SOCIO-BIOLOGIST

Dewey (1997b) established that, in his estimation, “... doubtless the greatest dissolvent in contemporary thought of old questions, the greatest precipitant of new methods, new intentions, new problems, is the one effected by the scientific revolution that found its climax in the ‘Origin of Species’” (p. 19). In practice, for him this meant that:

The significance of the evolutionary method in biology and social history is that every distinct organ, structure, or formation, every grouping of cells or elements, is to be treated as an instrument of adjustment or adaptation to a particular environing situation. Its meaning, its character, its force, is known when, and only when, it is considered as an arrangement for meeting the conditions involved in a specific situation (Dewey, 1916, p. 93).

This interpretation extended Darwinian theory beyond the more widely accepted application to physiological adaptations and into behavior in a way that served as a harbinger of the socio-biological revolution that began in the 1970s (E. O. Wilson, 1975).

As sociobiology evolved and grew, it began to shape other fields, and it inspired the development of evolutionary psychology. In these new fields, one of the key principles was the understanding that the human organism developed, as all organisms did, in an environment of evolutionary adaptiveness (EEA) (Tooby & Cosmides, 1990). Some debated as to how the EEAs were constituted (Laland, Odling-Smee, & Feldman, 2000; Ridley, 1993). However, it is widely accepted that humans’ EEAs precipitated the development of the modern human brain (Tooby & Cosmides, 2007) and modern human behavior (Symons, 1995). Humans now exist primarily in environmental conditions that differ significantly from their original EEA. This condition suggests that the innate habits used for the expression of biological impulses that Dewey (1929) described are ecologically no longer rational (Cosmides & Tooby, 1994). Dewey (1929) wrote:

Every habit incorporates within itself some part of the objective environment, and no habit and no amount of habits can incorporate the entire environment within itself or themselves. There will always be disparity between them and the results actually attained. Hence the work of intelligence in observing consequences and in revising and readjusting habits, even the best of good habits can never be forgone. Consequences reveal unexpected potentialities in our habits whenever these habits are exercised in a different environment from that in which they were formed (p. 51).

Considering that many human habits are natural instincts generated for success in an EEA that was highly variable (Potts & Clark, 1996; Richerson & Boyd, 2000), it would be reasonable to expect that the classroom environment and curriculum would be dynamic ensuring that those natural impulses would be engaged. However, prior to the development of the Common Core and Next Generation Science Standards, for the most part the environment and subject matter has been largely static, deriving its basis from the culturally defined disciplines and practices established in the 17th century (Dewey, 1966; Foucault, 1973).

Rather than being beholden to the thoughts of his predecessors with regard to curriculum, Dewey (1997a) instead identified three categories of knowledge: skill-based, information based, and abstract reasoning-based (p. 50). The challenge with acquiring and expanding students' capacity for abstract reasoning became a justifiable centerpiece of formal education, but the result of such a practice, according to Dewey, is that

Teacher and student alike tend to set up a chasm between logical thought as something abstract and remote, and the specific and concrete demands of everyday events. The abstract tends to become so aloof, so far away from application, as to be cut loose from practical and moral bearing (pp. 50-51).

Dewey's recognition of the importance of context and emotions for the applicability of knowledge has been demonstrated repeatedly in the fields of cognitive science that emerged after his death (Greenspan & Shanker, 2004). And while he understood that some people would naturally be more inclined to traffic in abstractions, what people fail to realize is that "... what is abstract in one period of growth is concrete at another" (Dewey, 1997a, pp. 136-137). Therefore, once something previously unknown has its meaning fixed it can be manipulated in a physical or mental fashion making it effectively concrete, a supposition supported by recent research in the field of cognitive neuroscience (Malafouris, 2013). Consequently, for the remainder of the paper I will focus on the distinction Dewey drew between learning processes and learning information.

Though he had a front row seat to what could be considered the beginning of cognitive neuroscience (Dalton, 2002), Dewey was unaware that the differences in the ways people learn his two types of knowledge could be traced to regions in the brain. The learning of processes or skills—what some contemporary neuroscientists have termed *procedural knowledge*—can be traced (in part) to the basal ganglia. His second type of knowledge, the assimilation of information termed *declarative knowledge*, principally involves the hippocampus (Blakemore & Frith, 2005; Bransford & Brown, 2000; LeDoux, 1996). Dewey would have appreciated that both of these brain regions are bound to language (Knecht, 2004; Ullman, 2006) which requires the learning of both the skills for production and information required for use. He also would feel vindicated to know that his assumption about language's primary purpose—to influence the social activity of others (Dewey, 1997, p. 179)—has been supported by those researching the use of vocalizations and signals in animals (Dawkins & Krebs, 1978, 1979; Krebs & Dawkins, 1984; Seyfarth & Cheney, 2010) and those researching different human languages (Calude & Pagel, 2011).

Therefore, from Dewey's perspective, for the theorist interested in how knowledge is shared within a social group, " ... the problem...is not how either individual or collective mind forms social groups and customs, but how different customs, established interacting arrangements, form and nurture different minds" (p. 63). Though this quote comes from his work on social psychology, he recognizes that for social learning to occur, it is critical to understand the effect social and cultural transmission patterns have on the development of individual's minds. Today, were Dewey speaking to a group of educators, he would refer to this process as a study of pedagogical methods.

That Dewey was so interested in this line of research as well as the reform of education demonstrates his prescience. In most societies, little information is transmitted through overt teaching in a classroom setting (Hewlett, Fouts, Boyette, & Hewlett, 2011; Lancy, 2008; Lancy, Bock, & Gaskins, 2010). Instead, it occurs as a part of everyday experiences. This conclusion lends further credence to Dewey's repeated refrains (1966; 1956; 1963; 1997a) about the artificiality of the classroom as a place of learning. And perhaps more importantly, it begs the question that we are equipped to ask (and even perhaps answer) today: What are the natural transmission patterns that have evolved for the two distinct types of knowledge identified by cognitive scientists, procedural, and declarative?

ANIMAL MODELS?

Before we attempt to answer this question, model groups for the natural transmission patterns of the two forms of knowledge must be identified. The first group we can look to are modern hunter-gatherer societies who may provide a rough approximation of humans' original EEA (D. S. Wilson, Timmel, & Miller, 2004); some consider these societies the most fertile ground for evaluating the manner in which human education most naturally transpires (Gray, 2011; Muller, 2010). However, the emphasis on cultural rigidity in both hunter-gatherer (Lancy, 2008; Lancy, et al., 2010) and other indigenous non-Western societies (Reagan, 2005) potentially perturbs the natural selection of transmission patterns for procedural and declarative knowledge. The alternative means using non-human animals (henceforth referred to as animals). Instead of using other species as the initial filter, we may discover the methods by which skills and information are transmitted in the absence of the cultural intricacies that are hallmarks of humanity (Pagel, 2012).

Caro and Hauser's (1992) initial investigation into purposeful social transmission in animals led to a definition of teaching. Their definition states that a teacher modifies his or her behavior only in the presence of a pupil, incurs some cost or no immediate benefit, and allows pupils to acquire knowledge or skills more rapidly than they would on their own. The investigation identified what they considered two generalized teaching methodologies deployed in animals. The first is *opportunity teaching*, defined as a situation where the " ... teacher puts [the] pupil in a situation conducive to learning a new skill or acquiring knowledge" (p. 166). The second methodology of *coaching* occurs when the teacher " ... directly alters the behavior of [the] pupil by encouragement or punishment" (p. 167). Neither method

necessarily involves taking the perspective of others that often is associated with the natural human inclination toward the pedagogical method of active teaching (Csibra & Gergely, 2011). However, in a subsequent review of teaching in non-human animals, Thornton and Raihani (2008) established that “... many forms of human tuition do not require teachers to impute mental states to pupils” (p. 1824).

This update to Caro and Hauser’s (1992) landmark paper removed the burden of intentionality when evaluating effective patterns of social transmission. The paper instead placed the burden on the facilitation of learning (Thornton & Raihani, 2008). The shift of focus from the teacher’s actions to the learner’s actions precipitated a classification of instructional techniques based on the type of knowledge being transmitted. The two types are *progressive teaching* for the transmission of procedural knowledge and *fixed teaching* for the transmission of declarative knowledge (Thornton & Raihani, 2008). These types mirror the separation made by cognitive neuroscientists and Dewey. Because Dewey wanted to ground our understanding of humans in evolutionary theory, the net that is cast cannot be too wide. Instead, how the animals are selected for juxtaposition with the more innate patterns of human transmission (Skerry, Lambert, Powell, & McAuliffe, 2013) must be given careful consideration using evolutionary principles as the filter.

Such an endeavor inevitably leads to using primates, the order of which humans are a part and with which humans share most, if not all, of their brain regions and much of the same cognitive architecture (Gazzaniga, 2008). Diet has also been shown to significantly affect the social life and cognitive architecture of animals. Therefore, since the hunting engaged in by groups of the first modern humans was to take down large prey (Pagel, 2012), a practice mirrored by a variety of large-brained social carnivores (King, 1980; Schaller & Lowther, 1969), their transmission patterns should also be investigated. Finally, the practices of pair-bonding and cooperative breeding that make humans somewhat unique among primates require that we investigate animals that develop temporally extended social connections (de Waal, 2009; Gavrilets, 2012; Hrdy, 2009; Marzluff, 2013; Ridley, 1993). Through this approach, my investigation takes advantage of the sort of experimentation Dewey saw as so critical to the advancement of knowledge (Dalton, 2002; Dewey, 1958, 1997b) and the contextual behavior evaluation that is necessary to get beyond the rampant behaviorism that emerged late in Dewey’s career (Hickman & Alexander, 2009; Popp, 1998).

IMITATION AND MIMICRY

Over the past several decades, significant debate has occurred over whether animals possess culture. Much of it centers on varied definitions of culture, for few question whether animals learn behaviors from others (Thornton & Clutton-Brock, 2011; van Schaik & Burkhardt, 2011; Whiten, 2011) or that different communities possess unique behaviors that are transmitted from one generation to the next (Whiten & van Schaik, 2007). The exhibition of these sorts of behaviors and customs has been most readily observed in our closest living ancestor, the chimpanzee (Whiten, 2011). In addition to possessing generally similar neural

architecture, the homologous structures in the brains of primates extend into even the most specialized regions associated with the language development (e.g. Broca's and Wernicke's areas) in both chimps (Gannon, Holloway, Broadfield, & Braun, 1998; Spocter et al., 2010; Tagliatela, Russell, Schaeffer, & Hopkins, 2008) and macaques (Gil-da-Costa et al., 2006). These similarities suggest that chimpanzees and, to a lesser degree, other primates might provide us with significant insight into not only how humans learn, but also how knowledge is best transmitted in the social manner Dewey (1966) championed.

Almost two decades ago, monkeys and apes were shown to possess mirror neurons (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996), which are cells that fire not only when one is performing a task, but also when one is watching it be performed (de Waal, 2009). Prior to this discovery, the hypothesis was that the act of watching facilitates skill learning in primates (Tomasello, Davis-Dasilva, Camak, & Bard, 1987; Tomasello, Kruger, & Ratner, 1993). A similar assumption was made about humans thanks to anthropologists' identification of the cross-cultural practice of learning through observation (Gaskins & Paradise, 2010). The discovery of mirror neurons enabled researchers to link this previous work directly to brain architecture that was shared between humans and other primates (De Waal, 2009; Gazzaniga, 2008).

That observation accelerates skill acquisition suggests that procedural learning occurs through that mode of transmission. However, the studies failed to determine whether learning through mimicry could perpetuate the kind of cultural differences that observational studies suggest exist between chimpanzee troops in the wild (Nakamura & Uehara, 2004). Experimental evidence, however, demonstrates that social customs such as hand-clasp grooming (Bonnie & de Waal, 2006) and skills such as tool use (Whiten, Horner, & de Waal, 2005) can be learned, transmitted, and remain unique among different chimp cultures (Whiten, Schick, & Toth, 2009). The process is similar to what has been called in humans vicarious reinforcement (Bandura, 1977; Gaskins & Paradise, 2010).

This sort of transmission is likely to occur through what has been termed master and apprentice learning. In master-and-apprentice learning (Matsuzawa et al., 2001), naïve chimpanzees in the wild follow and mimic the behavior of experienced and successful individuals (Horner, Proctor, Bonnie, Whiten, & de Waal, 2010). This practice is most readily utilized when learning to use tools while foraging (Whiten, 2011). Such individuals acquire a deferential followership not only because they are dominant, but also because they are considered prestigious (Henrich & Gil-White, 2001). The innate desire to follow those who are successful mirrors the way in which apprenticeship pairings are created both formally (Lancy, 2008; Reagan, 2005) and informally in humans (Crawford, 2009; F. R. Wilson, 1999; Wolseth, 2010). In both humans (Lancy & Grove, 2010) and other primates (Boesch, 1991), often the selected master achieves a prestigious position not because of his or her ability in relation to others in the group, but because a close bond puts the learner in close proximity to a more experienced individual. These observations would not have surprised Dewey. In the book that he wrote with his daughter, *Schools of Tomorrow*, Dewey noted that the goal of a child's imitative play was "... to make his life a replica of the life of his parents" with the impulse for mimicry being so strong that "... children are just as apt to copy the coarseness,

blunders, and prejudices of their elders as the things which are best” (Dewey & Dewey, 1962, p. 79).

As Dewey suggests with humans, the reinforcement of habits learned through mimicry is most likely to occur among individuals engaged in a pair-bond. Therefore, species with this capacity are more likely to develop elaborate greeting rituals that allow for the establishment (and reestablishment) of their relationship (Perry, 2011). Neonatal imitation in primates (Byrne, 2002) allows for vertical transmission between mother and child, who in many primate species, share a strong pair-bond (Hrdy, 1999, 2009). For orangutans, which have the greatest inter-birth interval of all mammals (van Noordwijk & van Schaik, 2005), this provides eight years for the mother and offspring to bond and transmit knowledge vertically. Therefore, though overlapping home ranges between different orangutan mother-child pairs allow for access to similar foods, young orangutans often possess identical feeding habits to those of their mother, while differing significantly from those of their other cohabitants (Jaeggi et al., 2010). Such extensive imitation could be a product of social facilitation—increased comfort with a novel activity due to the presence of conspecifics—though juveniles more often attend to their mothers’ actions when they involve extractive foraging (e.g. termite fishing) as opposed to more simple activities. These observations were often followed by purposeful practice of the activity on the juvenile’s own (Jaeggi, et al., 2010). Such intentional imitation ensures that the offspring maintains dietary preferences similar to their mother’s.

Transmission through imitation is not limited to primates. Dolphins (Herman, 2002) and orcas (Abramson, Hernandez-Lloreda, Call, & Colmenares, 2013), both of whom have extended social networks, also demonstrate purposeful imitation in captivity. In both species, the trainers mediated the animals’ mimicry; however, untrained animals continued to exhibit behaviors of the conspecifics that were trained, as opposed to heterospecifics (i.e. their trainers). Additionally, it has been demonstrated in several animal species that interspecific affiliative pair-bonds can occur (Colbert-White, Covington, & Fragaszy, 2011; Hess, 2008; Perry, 2011). This pair of phenomena suggests that the impetus for this (decidedly) oblique transmission between human trainer and cetacean trainee may in fact be quite similar to that of the vertically transmitting orangutans. Further support for the supposition that mimicry is natural for some cetaceans comes from a juvenile orca not involved in the study. While its mother was being trained, the juvenile attended to her behavior in such a fashion that it spontaneously imitated much of the novel behavioral sequence that was a part of the mimicry training (Abramson, et al., 2013). Its behavior indicates that imitation could play a natural role in the transmitting procedural knowledge for cetaceans.

In spite of similarities, non-human social transmission through imitation differs in several ways from that of humans. Humans’ use of language (Csibra & Gergely, 2011) may be what facilitates the use of teaching and the activation of mimicry (Hewlett, et al., 2011). However, because in many human cultures the primary linguistic contribution of the master to the apprentice’s learning comes in the form of verbal abuse (Lancy, 2008), it may be imitation instead of language that contributes to the successful transmission of procedural learning. This tendency toward exact behavioral replication stands in opposition to other primate species.

Other primates are more apt to emulate, which is defined as attempting to achieve the same results regardless of method (Whiten, 2011). The difference in copying behavior may be attributable to the difference in cause-and-effect reasoning between the species (Csibra & Gergely, 2011; Pagel, 2012), for as Dewey (1966) saw it, a child may:

... note how the other person catches and holds [a] ball in order to improve his own acts. He imitates the means of doing, not the end or thing to be done ... as a matter of fact, imitation of ends, as distinct from imitation of means which help to reach ends, is a superficial and transitory affair ... [that] idiots are especially apt at ... When we find children engaging in this sort of mimicry, instead of encouraging them ... we are more likely to rebuke them as apes (p. 35).

The dichotomy between the imitation of means and ends Dewey presents is not so much a product of species-level differences as a difference in the task complexity engaged in by the two species. Consequently, in both chimps and humans, a greater number of steps before successful completion of a procedure are more likely to produce imitation than emulation (Whiten, 2011).

When engaging in difficult tasks that requires more than imitation, it has been demonstrated that humans find greater success when working in a group (D. S. Wilson, 2008) and among the more difficult regular tasks for pre-industrial humans was bringing down large prey items. Still, contemporary hunter-gatherer societies consume significant quantities of meat (Cordain et al., 2000) primarily from species larger than themselves (King, 1980). This pattern is similar to that of ancestral hominids (MacDonald, 2010), but differs significantly from non-human primates that consume little meat (Stanford, 1995). Because it has been demonstrated that an animal's social organization is a byproduct of its diet, it is possible the organization of human cultures mirrors more closely that of large social carnivores (King, 1980; Schaller & Lowther, 1969; Thompson, 1975).

LEARNING TO COORDINATE (AND COOPERATE)

Pursuing and bringing down prey much larger than the individual predator requires organization by the predatory group, which in turn requires the predator to attend to other members' behavior, whether they are human (MacDonald, 2010) or not (Drea & Carter, 2009). This observation echoes what Dewey's (1929) conclusion that culturally established habits are the product of biological impulse mediated by social interaction. Since Dewey (1963) thought "... education [to be] essentially a social process ... realized in the degree in which individuals form a community group" (p. 58), he would take great interest in the fact that significant coordination of behaviors has been observed in terrestrial (Bednarz, 1988; Creel & Creel, 1995; Stander, 1992b) and aquatic social carnivores (Ramp, Hagen, Palsboll, Berube, & Sears, 2010; Rendell & Whitehead, 2001). Documented cases show the kind of synchronous causal behavior (Visser et al., 2008) rarely observed in non-human primates. Research also shows in-group role specialization (Gazda, Connor, Edgar, & Cox, 2005; Sharpe, 2001; Stander, 1992a) that has not been documented in non-human primates (Drea & Carter, 2009). This specialization primarily was thought to

be unique to humans, effectively creating behavioral niches within a one-species community.

Although human roles are more complex (Pagel, 2012), the interactions with prey and each other in many social carnivore species provide a unique environment for learning not only skills (i.e., procedural knowledge) from each other, but also for learning how to coordinate one's behavior in a group. This capacity is critical to the success of the human lineage (MacDonald, 2010; van Schaik & Burkart, 2011). Dewey was acutely aware of the need to be cognizant of others' behaviors when engaging in purposeful action in a social setting. He thought that students need "... more opportunity for conjoint activities in which those instructed take part, so that they may acquire a *social* sense of their own powers" (Dewey, 1966, p. 40). By engaging in group activities, students have the opportunity to not only grow inwardly through acquiring new knowledge and skills, but also grow outwardly to find their place in the group.

Unfortunately, little experimental research has been done with social carnivores on the coordination of behavior and its relationship to learning. However, Drea and Carter's (2009) work with hyenas demonstrates that experienced individuals modify their behavior in the presence of naïve individuals to promote group success. These individuals do it in a way that allows for learning to occur. However, they do not achieve what Caro and Hauser (1992) consider opportunity teaching in that the group dictates the goal based on the group's immediate needs and not the needs of a naïve individual. For the hyenas, their group-oriented behavior included acting contrary to their position of dominance. This self-handicapping has been observed in other carnivore species and humans. Recently, researchers have concluded that the function of this behavior is to promote interaction (Bekoff, 2001; S.L. Brown & Vaughan, 2009). Anthropologists have observed people in indigenous societies self-handicapping to perpetuate juvenile contribution to both the hunt (MacDonald, 2010) and craftsmanship (Crown, 2010). In humans, this requires that adults provide tools and supplies (Lancy, et al., 2010). This behavior is similar to social canids, who are more apt to share objects that are the focus of play bouts than those who were members of an asocial species (Biben, 1982).

With adults of various human cultures using some of their society's limited resources to facilitate learning in children, the act of self-handicapping to promote learning is approaching cultural universality (Crown, 2010; MacDonald, 2010). This behavior represents the investment identified by Caro and Hauser (1992) and Thornton and Raihani (2008) necessary to be defined as teaching. Among other social carnivores, however, learning takes place because engaging in the hunt is participatory and experiential (Thornton & Raihani, 2008). This participation immediately benefits the group to prevent it from achieving Caro and Hauser's definition of opportunity teaching. It also justifies being granted its own category for social transmission: coordination.

Dewey (1966) thought that the existence of an immediate purpose for the activity—such as the group acquisition of a large prey item—was critical if the goal was to facilitate learning. He proposed that "... primary or initial subject matter always exists as a matter of an active doing, involving the use of the body and the handling of material" (Dewey, 1966, p. 184). Some have posited that the use of the

hand was the vehicle for the encephalization of humans (F. R. Wilson, 1999) and is the mechanism by which our intelligence is best expressed (Crawford, 2009). In human cultures, learning through the handling of materials can happen through tasks as varied as the production of communal crafts (Crown, 2010; Lancy, 2008; MacDonald, 2010), the delivery of messages (Reagan, 2005), and hunting (MacDonald, 2010). Thus, learners contribute to the group's perceived needs in a fashion that makes their actions meaningful and allows for the interactive socialization so critical to Dewey's perception of growth (Campbell, 1995; Dewey, 1966; Popp, 1998). This idea applies to humans and many social animals (S. L. Brown & Vaughan, 2009; Drea & Carter, 2009).

Though all of the above cases involve mammals, the development of novel coordinated behaviors has been observed in other taxa. Ravens have been observed exhibiting a variety of coordinated feeding behaviors. These tactics range from a pair alternating between dispensing whipped cream from a pressurized can and consuming the frothy product, to herding chickens into corners to create easy pickings. In the arctic, two ravens were seen killing a baby seal when one covered the hole in the ice that was the ostensible escape route while the other bludgeoned the pup to death. In this last example, the ravens demonstrated rudimentary collaboration with each individual taking on a specific role during the event. Ravens exhibited more elaborate collaboration when one was observed chasing crossbills through building corridors. His mate ambushed the prey and steered them into glass windows, resulting in a stunned flock that became easy pickings (Marzluff, 2013). Taken together, these anecdotes suggest that at least some corvids are capable of learning to coordinate behavior in a cooperative fashion.

The ability to cooperate—or perhaps more importantly, to learn to cooperate—is not the sole providence of carnivores either. Elephants are among the most cooperative of species. They demonstrate that they understand the necessity of coordination in a rope-pull experiment better than rooks, another highly social corvid (Plotnik, Lair, Suphachoksakun, & de Waal, 2011). For elephants—like ravens—the capacity to cooperate may be due in part to their ability to form affiliative pair bonds. In natural settings, elephants solicit help more often from affiliates with whom they have developed a social bond (Soltis, Leong, & Savage, 2005) with the likely goal of working together to solve shared problems (Poole & Moss, 2008). These bonds initially are facilitated in elephants through extended periods of maternal and allomaternal care that extends up to nine years, followed in females by becoming members of their natal herd and in males by joining an all-bull group (Lee & Moss, 1999).

Dewey would not be surprised by the relationship between affiliative bonds and successful transmission of information. In his last major pedagogical work, *Experience and Education*, Dewey argued that for teachers to be successful, they must feel a part of the community. In such a situation, students cease being a class of individuals and instead become members of a social group where, “The teacher loses the position of external boss or dictator but takes on that of leader of group activities” (Dewey, 1963, p. 59). By reframing the teacher's role, the students see the teacher as an authentic leader and the type of figure they are inclined by evolution to follow (Niedermeyer, 2012). To lead authentically, a teacher would require a significant capacity for social and emotional cognition, which cognitive

neuroscientists have tied, in part, to the possession of *von Economo neurons* (VEN) (Allman, Watson, Tetreault, & Hakeem, 2005). This piece of neural architecture allows for the taking of others' perspectives (de Waal, 2009). Therefore, the bond strength in elephants may be facilitated by the fact that elephants possess VENS (Hakeem et al., 2009), grouping them (perhaps) unsurprisingly with corvids (Bugnyar & Heinrich, 2005; Dally, Emery, & Clayton, 2006), cetaceans (Butti, Sherwood, Hakeem, Allman, & Hof, 2009) and primates (de Waal, 2009), the taxa we have already seen possess pedagogical practices.

COACHING

To this point, I have investigated two methods of social transmission that fall under the heading of what Dewey (1997a) called process learning and what Thornton and Raihani (2008) called progressive teaching. Though both forms of this practice successfully facilitate the learning of procedural knowledge, in neither situation would the facilitating individual necessarily be identified as a teacher. Rather than the transmission being initiated by knowledgeable teachers, in both methods it could instead be ascribed to the cognitive architecture and social inclinations of the learners. However, other practices have been unequivocally identified as acts of teaching, and these have been readily observed in several species that cooperatively breed.

In birds, mammals, and invertebrates, cooperative breeding often is observed in habitats with inconsistent food availability (Doolan & Macdonald, 1996; Heinsohn, 1991; Monnin, Ratnieks, & Brandao, 2003). Though this can apply to group predators, these large social carnivores often migrate with prey items (Andrews, Pitman, & Ballance, 2008; Walton, Cluff, Paquet, & Ramsay, 2001) or at the very least preferentially favor particular prey species (Hayward & Kerley, 2005). As demonstrated earlier, social carnivores most often learn through contribution to the group's overall effort, whereas for most cooperative breeders, foraging is often independent (Doolan & Macdonald, 1996; Heinsohn, 1991; Monnin, et al., 2003), necessitating a different learning modality. At first glance, the method appears to be that of master and apprentice, which should not be surprising given that many of the observed cases of social transmission of foraging strategies occur in primates (Ossi-Lupo, 2010; Rapaport, 1999; Roush & Snowdon, 2001; Ruiz-Miranda et al., 1999). However, being more experienced does not make individuals more prestigious. They are not engaging in a challenging behavioral sequence that necessitates imitation. Rather, the information being transferred is often about the palatability of particular foods (Ossi-Lupo, 2010). Dewey (1997a) stated that such knowledge is, therefore, not so much about a process as it is about information. This knowledge requires not progressive teaching, but fixed teaching that, as described earlier, is expressly for *declarative* knowledge.

Some of the strongest experimental evidence of fixed teaching comes from the research done by Richardson et al. (2007). Their research investigated tandem-running ants using landmarks to identify paths between food and the nest site. In the ants, instructors receive feedback from the learners through antennae taps. The

ants only move toward the food site once they have made contact, and they vary their speed based on the feedback they get from the learner. The cost to the instructor is a four-fold increase in the time it takes to get to the food, but the learner can find its way back to the nest in much less time than it would otherwise. During moves to new nest sites, learners become instructors and carriers of naïve individuals. This action provides for a more efficient move and allows the colony to take advantage of the available resources (Richardson, Sleeman, McNamara, Houston, & Franks, 2007; Thornton & Raihani, 2008).

Using behaviors like the one described above, cooperatively-breeding species are able to out-compete sympatric species that share similar habitat requirements (Zack & Ligon, 1985). Consequently, colony members can help naïve individuals be aware of resource opportunities. Though some food neophobias are overcome by the presence of other individuals eating in cooperative breeders (Perry, 2011), experiments have demonstrated that naïve individuals solicit novel foods more often than familiar foods (Voelkl, Schrauf, & Huber, 2006). Inexperienced individuals appear to be aware of their need to acquire knowledge. The awareness of their ignorance, however, can extend to the experienced colony members, who will share new food items more often than familiar ones, suggesting a desire to facilitate learning in others (Rapaport, 1999). Transmission of declarative knowledge, therefore, happens vertically between parent and child, horizontally between children or between adults, or obliquely between indirectly related adults and children (Thornton & Clutton-Brock, 2011). This activity mirrors that of humans, who learn about palatable and poisonous plants through siblings, cousins, aunts, uncles, parents, and grandparents (Hewlett, et al., 2011; Zarger, 2010).

In humans, the acquisition of environmental knowledge about food often occurs in conjunction with language development (Zarger, 2010). Therefore, it should not be surprising that in non-humans the active sharing described above is associated with vocalizations or gestures (G. R. Brown, Almond, & Bergen, 2004; Midford, Hailman, & Woolfenden, 2000), making it a form of coaching (Caro & Hauser, 1992). The best experimental evidence for teaching the link between vocalization and food comes from pied babblers, a bird species in which adults condition their nestlings to expect food after a purr call. This call elicits a begging response prior to parental food provisioning (Raihani & Ridley, 2008). Increased exposure to purr calls produces earlier learning in the nestlings. Early learning provides the immediate benefit to the learner of increasing its chances to receive food and an extended benefit to the parent and the offspring when fledging occurs. Parents use the purr call to encourage fledged chicks to move toward the parents and away from danger.

Anthropologists have identified that many indigenous societies also utilize the overt linking of call to context (Zarger, 2010). Dewey advocated for the practice as well. According to Dewey (1997a):

... if the idea is not grasped, nothing is gained by using a more familiar word; if the idea is perceived, the use of the term that exactly names it may assist in fixing the idea ... As every meaning is set in the context of some situation, so every word in concrete use belongs to some sentence (it may itself represent a condensed sentence), and the sentence, in turn belongs to some larger story, description, or reasoning process (p. 185).

The pedagogical instinct of Dewey, indigenous tribesmen, and cooperatively breeding animals to link the declarative knowledge of acquired language to both spatial and emotional contexts is justified by contemporary neuroscience. The seat of processing this type of knowledge, the hippocampus (LeDoux, 1996), also is utilized in interpreting the source of emotions (Phelps, 2004) and in the organization of spatial information (LeDoux, 1998).

The hippocampus may seem like a clearinghouse for disparate information until one analyzes these associations from an evolutionary perspective. As an ancient structure embedded within the reptilian portion of the brain, the hippocampus is associated with processing language and vocalizations of a basal nature that likely links different cognitive inputs and outputs. In nature, the alarm call for predators is among the most widespread of call types in the animal kingdom (Seyfarth & Cheney, 2010). This call requires a visual and spatial context in birds (Lachlan, Verhagen, Peters, & Cate, 2010; O'Loughlen, Rothstein, & Sealy, 2004) and primates (Hauser, 1988; Seyfarth & Cheney, 1990) to be learned and utilized.

When initially learning the correct context in which to apply a predator-specific alarm call, vervet monkeys often over-generalize its application, giving the eagle alarm call for birds that do not pose a threat (Hauser, 1989; Seyfarth & Cheney, 1986). This common mistake for vervets is similar to the over-extensions that human toddlers make in applying new words (Clark, 2003). Therefore, these over-extensions may be due to an over reliance on location and its link to language (Skerry, et al., 2013). These kind of errors dissipate with time and experience in humans (Hewlett, et al., 2011) and non-human primates (Seyfarth & Cheney, 1990). The dissipation illustrates that declarative language acquisition is a socially learned process (Janik & Slater, 2000). Since Dewey (1958) considered that, "... all experience is ultimately social: it involves contact and communication" (p. 38), he would commend the natural transmission patterns for declarative knowledge in humans and non-humans because they are experiential, social, and purposeful.

Were one to oversimplify Dewey's prescription that language should be developed through trial and error with little in the way of direct instruction or feedback, Dewey would have bristled—he despised people trying to label him or his philosophy. So, in *Experience and Education*, the book that served as his response to those who misapplied his educational philosophy, Dewey (1963) made clear his frustration with those who had taken student-centered/purely experiential education too far. In the book, he expresses his disbelief in the fear some teachers have when providing not only materials, but also instructions on how they might or might not be used. He concluded that although the teacher abuses his or her station by imposing too many of his or her own ideas on the pupils, "It is impossible to understand why a suggestion from one who has a larger experience and a wider horizon should not be at least as valid as a suggestion arising from some more or less accidental source" (Dewey, 1963, p. 71). In short, Dewey would have expected good teachers to serve as coaches, or to provide what is termed "direct instruction" in the pedagogical literature (Marzano, 2004).

Therefore, Dewey would have been excited to learn that in vervets, when mistaken calls (e.g., giving the eagle alarm for a non-predatory bird) are made, adults echo the call less often. When the call is accurate, they do echo (Caro & Hauser, 1992; Seyfarth & Cheney, 1986). This differential feedback for the learner

may serve as encouragement, especially in light of the anecdotal observation that mothers punish their offspring after inaccurate calls (Caro & Hauser, 1992). Even though adult response calls are not specifically linked to vocal learning in juvenile vervets, exposure to accurate calls has been shown to accelerate the apprehension of their appropriate use (Hauser, 1988; Seyfarth & Cheney, 1990). The adult coach's feedback (or lack thereof) may train young monkeys in this species to call correctly.

Though coaching has been suggested to exist based on anecdotes in a variety of primates (Caro & Hauser, 1992), experimental evidence of the practice is limited. Dewey, a great advocate for experimentation, would therefore have taken great interest in the evidence provided by two species with the kind of strong social bonds that he thought should exist between student and teacher. In the first study, a male baboon was provided experience with unpalatable fruit while the rest of his troop was not. Through aggressive behavior, he threatened approaching juveniles from his troop and kept them from consuming the affected fruit (Fletemeyer, 1978). In the second, experienced tamarins changed their food call rate and the deployment of alarm calls. Their loud noises discouraged inexperienced troop members from consuming a desirable food item that had been peppered (Snowdon & Boe, 2003). In the latter study, individuals with no direct experience with the undesirable object coached others about the appropriateness of avoidance. The new coaches had learned from those with direct knowledge of the food. This transmission pattern also has been observed in crows. For the pair-bonding corvid, the information transferred was not about food, but about a human (a person in a caveman mask) associated with trapping. Researchers showed that the transmission went horizontally and vertically about the specific potential threat (Marzluff, Walls, Cornell, Withey, & Craig, 2010). These coaching examples are a step beyond cooperative learning. Rather than learning together, a knowledgeable individual shapes through feedback a naïve individual's actions, a practice identified as among the most successful in education (Hattie, 2013).

However, though coaching can be quite successful at the transmission of declarative knowledge, it does not play a significant role in acquiring complex procedural knowledge. This omission is because a different pedagogical method is required for this type of learning: progressive teaching.

PROGRESSIVE TEACHING

As described above, one way in which skills are transmitted to a learner is through mimicking the behaviors of an experienced and prestigious master. This practice usually leads to an energetically wasteful period of trial and error. Cognitive scientists from Dewey's time to today (Dewey, 1933, 1997a; van Schaik & Burkart, 2011) recognize that human actions are exacerbated by the inclination for over-imitation (Lyons, Damrosch, Lin, Macris, & Keil, 2011) and may be limited in non-primates by a predilection for asocial learning (van Schaik & Burkart, 2011). Therefore, a pedagogical methodology should have developed in non-primate gatherers whereby the instructor teaches the skill in steps to the pupil. This exact process was observed in meerkats (Thornton & McAuliffe, 2006).

Meerkat adults teach their young how to handle prey that is difficult, such as lizards and spiders, and dangerous prey, such as scorpions. Rather than immediately consuming the prey, the adult incurs a cost by providing dead, disabled, or live prey depending on the pups' developmental level. Caro and Hauser (1992) would have identified this as a refined form of opportunity teaching. The condition of the provisioned prey is determined by changes in begging calls by the young, which suggests there are rules of thumb for the instructors' response to pupils. However, adults do modify their behavior based on feedback they receive from the pupils, nudging prey that is not being engaged, retrieving prey that has escaped, and disabling prey if it is proving too difficult for the young to handle. These handling behaviors were analyzed longitudinally and were shown to accelerate the learners' successful prey acquisition development and provide more instructors to the colony in subsequent years (Thornton & McAuliffe, 2006).

The meerkats adjusting their teaching to their students makes teaching a cooperative endeavor (Thornton & Raihani, 2008). Dewey (1966) would have lauded this conclusion because, as he wrote in *Democracy and Education*:

When the parent or teacher has provided conditions which stimulate thinking and has taken a sympathetic attitude toward the activities of the learner by entering into a common or conjoint experience, all has been done which a second party can do to instigate learning. The rest lies with the one directly concerned ... This does not mean that the teacher is to stand off and look on ... [his role becomes] participation, sharing, in an activity. In such a shared activity, the teacher is a learner, and the learner is, without knowing it, a teacher—and upon the whole, the less consciousness there is, on either side, of either giving or receiving instruction, the better (p. 160).

Therefore, Dewey would not have cared that the meerkat teacher's response to its pupils is rigidly dictated by vocal cues (Thornton & McAuliffe, 2006), even though this research suggests that the teacher is not fully conscious of the students' needs as individuals (Csibra & Gergely, 2011; Skerry, et al., 2013; Thornton & Raihani, 2010). Dewey championed the idea that the individual students' abilities and proclivities must be used to determine instructional practice. This stance seems to place him in opposition to the rigidity of meerkat instructors' responses to their pupils. However, Dewey's would not be concerned because he recognized that a teacher must use his or her own best judgment—conscious or not—for the method selection based on the inputs provided (Dewey, 1966, 1997a). By providing a cooperative experience, the meerkats engaged in what Dewey would have considered effective teaching of a desirable skill.

In the passage above, Dewey's decision to mention not just teachers, but also parents was an insightful one from an evolutionary perspective. Many instances that are defined as teaching in animals are between mother and child (Bender, Herzing, & Bjorklund, 2009; Boesch, 1991; Caro & Hauser, 1992; Raihani & Ridley, 2008; Thornton & Raihani, 2008, 2010). Cheetahs, a solitary carnivore given to social pair-bonds and predatory coordination, use this method. Cheetah mothers provide their young with a variety of prey items exhibiting different stages of distress, from dead Thomson's gazelles to injured hares to intact prey items. This behavior seems to be based on the cubs' ability to consume and capture the target species (Caro, 1994; Caro & Hauser, 1992). This example fits Caro and Hauser's

(1992) aforementioned definition of opportunity teaching where a teacher purposely puts the pupil in a learning position. It is unknown for the cheetahs whether the selective provisioning is based on rigid developmental cues from the cubs—similar to those of meerkat teachers (Thornton & Clutton-Brock, 2011; Thornton & McAuliffe, 2006; Thornton & Raihani, 2008)—or dependent on the mother recognizing individual cubs' needs. It is also not known if the opportunities that the cheetahs do provide are linked to the development of hunting skills. However, it has been shown in another feline that maternal activity can promote behavioral development. House cat mothers provide their kittens with prey items and modify their behaviors in response to the attention the kittens pay to it. The mother cats also appear to modify their provisioning strategies based on the abilities of different kittens of the same age. This teaching probably facilitated the kittens becoming adept predators at a younger age than they would have otherwise (Caro, 1980a, 1980b; Caro & Hauser, 1992). These experimental conclusions for a fellow felid suggest that the purpose of cheetah provisioning is to provide learning opportunities, even if no imputation exists by the mother of the cub's state of mind (Thornton & Raihani, 2008).

In other species that have demonstrated the ability to bond socially, however, some indications show that individuals can identify others' needs. Dolphins and elephants provide targeted help to distressed individuals (de Waal, 2009) and utilize a variety of social transmission practices. In individuals where these two capacities are combined and utilized together, one expects to see informed opportunity teaching take place. And field researchers' observations suggest that they have seen this type of pedagogy in both species.

INFORMED TEACHING

In elephants, simulated estrous provides the best evidence for this form of teaching. During this act, older females that are not in estrous signal their receptivity to males. A 28-year data review rejected the possibility that such behavior is anomalous—the product of hormonal imbalance—or that it has direct benefit to the actor herself. The researchers instead concluded that this odd behavior might be a demonstration for young females in their first period of estrous. Through it, knowledgeable females demonstrate the correct behaviors and the suitors toward which they should be directed, males in musth (Bates et al., 2010). Given that females often spend their entire lives with a stable natal herd (Moss, 1988), and that they become especially close with their bond group (Moss & Poole, 1983), the transmission of this suite of behaviors is most likely to occur between socially bonded individuals.

For some pods of bottlenose dolphins in the Atlantic, the difficult skill that needs to be transmitted is how to capture fish. Analysis of video footage of wild dolphins who were habituated to human presence showed that mothers modified how long they chased prey that had been rooted out of the sand (i.e. they spent additional time). The mothers used more frequent and more exaggerated reorientation behaviors such as redirecting and herding the prey when their own

calves observed them, but not others' calves (Bender, et al., 2009). The researchers concluded that, because the modification occurred only when the calves observed their dolphin mothers and were not just near them, the behaviors were for the express purpose of teaching. This conclusion is bolstered when it is taken into consideration that the still nursing calves were provided with opportunities to pursue a prey item that the mother could use to produce the milk that was the basis of the calves' diets. Still, it is not known whether providing these opportunities for observation and participation accelerates the learning process of the calves. Consequently, the effectiveness of the practice is unknown (Bender, et al., 2009).

However, in orcas—the largest member of the dolphin family—knowledgeable individuals not only have been observed modifying their behavior in the presence of their offspring, but that modification has been linked to the development of a difficult skill. For orcas, one of the more dangerous predation tactics involves intentional stranding on a beach to try to capture elephant seal pups in the shallow surf (Guinet, 1991; Guinet & Bouvier, 1995). Widely deployed in the southern hemisphere (Guinet & Bouvier, 1995; Lopez & Lopez, 1985; Rendell & Whitehead, 2001), this ability becomes refined over several years. The ability begins as a sort of social play when naïve juveniles join their parents or other adults in the pod in group-stranding events. These events initially occur without the presence of prey items. As the calves grow and become more experienced, the stranding takes place when prey are present (Guinet, 1991). This occurred in a pod that took up temporary residence around the Crozet archipelago in the southern Indian Ocean. Two juveniles were in the group. One made frequent forays onto the beach accompanied by an adult, most often its mother. The other's trips onto the prey-covered beach mostly were unaccompanied. The former received support from its mother through prodding with her rostrum. Initially the support was a shove in the direction of the seal pups. When the juvenile orca secured the prey item, the mother provided additional support by pushing the juvenile toward the safety of the water (Guinet & Bouvier, 1995). The other juvenile had no such assistance on most of its forays. This may explain why the former calf became a successful predator of elephant seals a year earlier in its development than the latter (Rendell & Whitehead, 2001).

These behaviors seem to meet Caro and Hauser's definition of the acts required of opportunity teaching. However, because of the small sample size and the observational nature of the studies, it is difficult to definitively conclude that informed teaching is taking place. As described earlier, meerkats can teach without imputing the mindset of the pupils. Based on the elephants' and dolphins' capacities for imitation and targeted helping and considering the behavioral processes above, these teachers have may have recognized the students' relative naiveté. In these instances, the knowledgeable participant demonstrated and allowed the learners to observe the activity and experience it on their own accord. This would have struck Dewey as a very natural and human form of transmitting information and skills. According to him, "The word, the gesture, the act, the occupation of another, falls in line with *some impulse already active* and suggests some satisfactory mode of expression, some end in which it may find fulfillment" (Dewey, 1997a, p. 160). By taking the pupil's natural inclination toward observation and the aim of the act itself (e.g. courtship in elephants, feeding in the members of the dolphin family), the

method came to be inextricably bound to the subject. They all may look different, but all are forms of opportunity teaching by an informed instructor.

This implicit desire for pedagogical categorization may be why Dewey sought to extol the virtue of a teacher having a thorough understanding of general methodologies while at the same time not being bound to them. To him:

Part of [a teacher's] learning, a very important part, consists in *becoming* master of the methods which the experience of others has shown to be more efficient in like cases of getting knowledge. These general methods are in no way opposed to individual initiative and originality—to personal ways of doing things. On the contrary they are reinforcements of them. For there is radical difference between even the most general method and a prescribed rule. The latter is a *direct* guide to action; the former operates indirectly through the enlightenment it supplies as to ends and means (Dewey, 1966, p. 171).

By becoming a master of methodology, an expert in their subject, and by knowing their students, teachers are better able to create opportunities for their students to learn, be they human or animal. Through possessing these characteristics, the teacher develops the trust (Corriveau & Harris, 2009; Harris & Corriveau, 2011) and prestige (Horner, et al., 2010) necessary for his or her demonstrations to effectively transmit information. The possession and exhibition of these traits can facilitate active teaching, the final and most purposeful form of social transmission.

ACTIVE TEACHING: THE FINAL FRONTIER

Other than in humans, this form of teaching only has been observed in our closest living relative, the chimpanzee. Boesch's (1991) study shows that chimp mothers modify their behaviors so their offspring can develop one of the most difficult skills for a chimpanzee, nut cracking. Rather than exhibiting the typical practice of carrying their hammers when they leave to forage for the nuts, mothers with offspring that have begun to show interest in nut-cracking leave the hammers and anvils on the ground. The mothers offer most of the nuts to the novice cracker in a fashion that mirrors the tool and toy provision observable in countless human societies in order to facilitate learning in children (Lancy, 2008; Lancy, et al., 2010).

Beyond providing the opportunity to crack the nuts, however, the mothers observed their offspring. On two occasions, the mothers intervened in what seems to have been an attempt to change their offspring's' behaviors. On the first occasion:

... Salome was cracking nuts of the very hard *Panda* species. Sartre, 6, took 17 of the 18 nuts she opened. Then, his mother watching, he took her stone hammer and tried to crack the nuts by himself. These nuts are tricky to open as they consist of three kernels separately embedded in a hard wooden shell, and the partly opened nut has to be replaced precisely each time to gain access to the different kernels. After successfully opening a nut, Sartre replaced it haphazardly on the anvil in order to attempt access to the second kernel. But before he pounded it, Salome took it in her hand, cleaned the anvil, and replaced the piece carefully in the correct position. Then, with

Salome observing him, Sartre successfully opened it and ate the second kernel (Boesch, 1991, p. 531).

So, though her son was doing as she might have expected when she handed over the tool, Salome interrupted both her and her son's activity (observation), making the teaching active. In the second instance:

... Ricci's daughter, 5-year-old Nina, tried to open nuts with the only available hammer, which was of an irregular shape. As she struggled unsuccessfully with this tool, alternately changing her posture, hammer grip and the position of the nut, Ricci was resting. Eventually, after 8 min of this struggle, Ricci joined her and Nina immediately gave her the hammer. Then, with Nina sitting in front of her, Ricci, in a very deliberate manner, slowly rotated the hammer into the best position with which to pound the nut effectively. As if to emphasize the meaning of the movement, it took her a full minute to perform this simple rotation. With Nina watching her, she then proceeded to use the hammer to crack 10 nuts (of which Nina received six entire kernels and a portion of the other four). Then Ricci left and Nina resumed cracking. Now, by adopting the same hammer grip as her mother, she succeeded in opening four nuts in 15 min. Although she still had difficulties and regularly changed her posture (18 times), she always maintained the hammer in the same position as did her mother. (Boesch, 1991, p. 532)

In this instance, the intercession was much more elaborate and demonstrative, becoming an activity unto itself. It was active teaching.

Observed instances of active teaching have only been seen in this population of wild chimps and only in anecdotes with language trained chimps correcting other language trained chimps (Caro & Hauser, 1992). The rarity of observed instances of active teaching may explain why Caro and Hauser (1992) and Thornton and Raihani (2008) did not include active teaching as one of their principle teaching modes. Several researchers have concluded that humans are the only animal to possess a natural pedagogy (Csibra & Gergely, 2011; Premack & Premack, 1996). Yet the natural pedagogy we are thought to possess (Csibra & Gergely, 2011), while potentially unique, does not need to be deployed often. So, even as our natural pedagogy requires the highest levels of cognition to use, it does not mean that it is the best method to use in every instance. I think Dewey recognized this paradox. As he wrote early in his career as an educator, a teacher should not be:

... concerned with the subject-matter of the science as *representing a given stage and phase of the development of experience*. His problem is that of inducing a vital and personal experiencing. Hence, what concerns him, as teacher, is the ways in which that subject may become a part of experience; what there is in the child's present that is usable with reference to it; how such elements are to be used; how his own knowledge of the subject-matter may assist in interpreting the child's needs and doings, and determine the medium in which the child should be placed in order that his growth may be properly directed. He is concerned, not with the subject-matter as such, but with the subject-matter as a related factor in a total growing experience (Dewey, 1956, p. 23).

Dewey saw that the teacher's job was to determine how best to proceed with a given lesson based on his or her knowledge of the subject, of the student, and of pedagogical methods. Dewey thought this knowledge came from a teacher's own experiences and from those who shaped his or her species into the highly social, pair-bonding primate the human is today. Therefore, as evolutionists we may not find success affecting *what* it is we are expected to teach in our classrooms; however, we may be able to affect *how* our students are taught. And a shift in practice may have a greater impact on our students and our society.

While it remains possible that improving education will require new methods and technologies, I would argue that the more likely conduit for improvement would come from reflecting on the marriages made between knowledge type and transmission method by our social living brethren and a prescient turn-of-the-century philosopher. Age-old problems do not necessarily require radical new solutions; rather, all they may need are time-tested techniques demonstrated to be effective through a (naturally) selective process. In education, this will require teachers to get out of their comfort zones. At times, they will need to have the students serve as apprentices, while at others it will place the teacher in the role of the coach. Some instances will call for teachers to model, while others will necessitate student-directed experimentation. John Dewey, evolution's first *educational* philosopher, would not only appreciate the methods animals have developed for transmitting particular types of knowledge, but he would consider them part of the collective experience of teaching. By incorporating this knowledge into our practice, we have the opportunity to become more effective as educators. Realizing Dewey's vision will ensure that our students are not only taught well, but they are taught right.

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