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What Teaching in Nonhumans Can Teach Us about Teaching?

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Teaching among humans is a remarkable achievement. At the very least, it allows cultural innovations to be preserved (Ando, 2009; Strauss, 2005). The topic of teaching in nonhuman animals has begun to gain traction in the animal behavior literature. It is one among a number of forms of social learning. Various positions have been staked out regarding how we can define teaching and what similarities and differences exist between human and nonhuman animal teaching. Part of what is at stake here concerns the debate around the continuity of cognitive evolution. Due to space constraints, we discuss continuity very briefly.

Social learning

Social learning can be accomplished through many forms. There is some agreement among biologists and cognitive psychologists as to what these forms are. For instance, Leadbeater & Chittka (2007) noted exposure, imitation, inadvertent social information, local stimulus enhancement, matched-dependent learning, observational conditioning, public information, signal, social cues, social learning. Similarly, Whiten (2000) wrote about the following in an attempt to describe the origins of primate culture: contagion, exposure, social support, matched dependent learning, stimulus enhancement, observational conditioning, imitation, and goal emulation.

In addition to these forms of social learning is teaching. Humans and nonhuman animals teach. But what we mean by the term “teach” depends on how it is defined.

Definitions of Teaching

There are two main kinds of definitions of teaching. One pertains to human teaching. It has appeared in psychology and education circles. The other comes from the animal behavior literature.

Teaching Among Humans: An Intentional Definition

There is no agreed-upon definition of teaching coming from the professional literatures in psychology, education and philosophy. It is a very slippery concept. Yet with all of its elusiveness, at the heart of definitions of human teaching is what has been termed theory of mind (ToM). Here, teaching involves an understanding of others’ mental states. Teachers understand others’ (in our case, learners’) knowledge, beliefs, desires, etc.; they recognize that there is a knowledge gap between people; they attempt to foster others’ knowledge or understanding in an attempt to reduce the knowledge gap and do so intentionally (i.e., try to cause learning in others’ minds).

Thus, a ToM definition of teaching refers to both the intentionality involved in teaching and the knowledge component, as follows: teaching is an intentional activity that is pursued in order to increase the knowledge (or understanding) of another who lacks knowledge, has partial knowledge or possesses a false belief (Ziv & Frye, 2004).

A definition of teaching that includes intentionality makes it possible to separate the goal from the outcome of teaching which allows activities that occur in unsuccessful teaching, where the purported learner did not learn, to be part of teaching.

Teaching among Nonhuman Animals: A Functional Definition

An influential article written 20 years ago shaped much of the debate about nonhuman teaching (Caro & Hauser, 1992). Their functional definition of

teaching, which has its origins in evolutionary theory and research in animal behavior, has four components:

- “An individual actor A can be said to teach if it modifies its behaviors only in the presence of a naïve observer, B,
- at some cost or at least without obtaining an immediate benefit for itself.
- A’s behavior thereby encourages or punishes B’s behavior, or provides B with experience or sets an example for B.
- As a result, B acquires knowledge or learns a skill earlier in life or more rapidly or efficiently than it might otherwise do, or that it would not learn at all.” (p. 153).

This definition is radically different from the intentional definition of human teaching. It is a functional, operational definition that *excludes* intention and mind-reading (or ToM, in general) and does not rely on inferences about the internal mental states of nonhuman teachers. According to this definition, the learner’s behavior must change as a consequence of the teacher’s behavior. As such, it excludes instances in which teaching was attempted but was not successful and, consequently, must identify teaching retrospectively (Ziv, Solomon & Frye, 2008).

The exclusion of ToM leads to a rather generous definition of teaching and one would expect it to lead to a number of nonhuman taxa coming under its jurisdiction. Or at least there should be more nonhuman animals teaching by Caro & Hauser’s definition than there would be were ToM to be a criterion for teaching.

Which Nonhuman Animals Teach?

Surprisingly, Caro & Hauser found that only felids (cheetahs, lions, domesticated cats, etc.) teach. However, recent research shows that two additional taxa meet Caro & Hauser’s (1992) criteria for teaching: tandem running ants and meerkats.

Tandem-Running Ant (*Temnothorax albipennis*)

These ants use what is known as tandem running where one ant, the knowledgeable teacher, teaches another ant, the naïve learner, the location of a

food source. The leader/teacher ant leads the follower/learner ant from their nest to food. Franks & Richardson (2006) show that when the leader leads the follower to food, the follower maintains contact with the leader by tapping it on the legs and abdomen with its antennae. When the follower loses contact with the leader, the latter stops until the former re-establishes contact.

If the leader ant doesn't have a tandem follower and is in the presence of knowledgeable ants, it does not stop on its way to the food source. Thus, the leader alters its behavior when in the presence of a naïve follower, which fulfills the first criterion in Caro & Hauser's definition of teaching. With regard to the second criterion, that the teacher incurs a loss or at least does not gain immediate benefit from teaching, Franks and Richardson (2006) found that it takes four times the amount of time to get to the food source in the presence of a follower than when it is going to the food source alone. A delay in arriving at a food source can have ramifications for the ant's survival. The leader provides the follower with experience, which meets the third criterion. As for the fourth criterion, Franks and Richardson showed that tandem running ants learn to get to the food source more quickly when taught than when not taught.

Meerkats (*Suricata suricatta*)

A second animal that teaches is the meerkat, a species that lives in harsh desert conditions in South Africa. They are small mammals that belong to the mongoose family. They have little body fat and, as a consequence, they must constantly forage for food. They eat insects, spiders, snakes, etc. and, most important for our purposes here, they eat scorpions.

Thornton & McAuliffe (2006) studied meerkats in the wild and captivity and observed that they provision their offspring with scorpions in one of three ways: dead, disabled (alive but with their sting removed) or alive and completely intact with their sting. There seems to be a developmental sensitivity to which kinds of prey the offspring are fed. The youngest pups are provisioned with the dead scorpions; older pups are given the disabled scorpions while the oldest are given the intact scorpions. Adult meerkats do not provision meerkats that know how to disable scorpions, thus meeting Caro and Hauser's (1992) first criterion for teaching. As for the second criterion,

by denying themselves food by provisioning it for their young, they incur a cost. Adults provide pups with experiences in handling scorpions, thus meeting Caro & Hauser's third criterion. It was also found that practice with disabled scorpions improved their skills in handling the prey efficiently, which fulfills the fourth criterion offered in Caro & Hauser's definition.

Interestingly, meerkat pups make purring noises and their purrs are different at different ages. Thornton played recorded purring calls of young pups when the provisioners were in the presence of older pups. They provisioned food to the older pups as if they were younger, suggesting that provisioning scorpions is not based on the pups' age or skill levels but as a result of purr calls they hear. In this sense, their teaching may be seen as hard-wired.

What can we learn from these studies? First, there is teaching in nonhuman animals when Caro & Hauser's (1992) definition is applied. The findings on tandem running ants and meerkats have been reported only recently. Given these reports, and growing interest in nonhuman animal culture, there is reason to believe that researchers may be more on the look out for teaching than before, and we may see further reports of other taxa teaching. For potential taxa in which teaching may be found in the future, as well as reasons for why, see Thornton & Raihani (2008, 2010).

Second, for the moment, there doesn't seem to be anything connecting these species other than their teaching. This suggests that we may have to speculate about what evolutionary pressures brought about the evolution of teaching on a case by case basis. If enough cases accrue, we may be able to find a commonality among these diverse species. But, for the moment, it appears we must do with describing local adaptations when describing teaching.

The findings regarding nonhuman teaching provide support for Caro & Hauser's argument that having both a ToM and the intention to teach are not prerequisites for teaching. However, they raise a new, intriguing question regarding the relation between the two forms of teaching—that of humans and that of nonhuman animals. We argue that the differences between the psychological and functional definitions mark a deep, unbridgeable divide that separates human from nonhuman teaching.

The Chasm between Human and Nonhuman Teaching

The two definitions of teaching seem to be incompatible. How can we escape this conundrum?

Based on the idea that one definition is preferable than more than one, one could suggest a definition that is deeper than both and from which the two definitions can be derived. We are not aware of such a definition.

Another way to resolve the contradiction between the two definitions is to use only one definition and to try to fit all cases into it. This can happen in two ways.

First, we could accept the human definition and use it to describe both human and nonhuman teaching. Thornton & Raihani (2008, 2010) wisely counsel us against this anthropocentric view. Were we not to heed their suggestion, we would not observe teaching in other animals because the taxa that teach do not have a ToM in the broad sense of that term.

Second, we could accept Caro & Hauser's functional definition of nonhuman teaching and attempt to describe human teaching with it. Byrne & Rapaport (2011) showed that the functional definition has difficulty describing human teaching. But even were we able to avoid the problems they noted, we caution against such a move because in finding common ground with other animals, human teaching would be stripped of both its uniqueness and power.

It appears, then, that, for the moment, we have two incompatible definitions of teaching, a functional one that excludes mentalizing among nonhuman animals and a psychological one that includes that very mentalizing.

This conundrum brings us to a set of issues that surround cognitive evolution. Darwinian theory suggests that there should be continuity between nonhuman and human behaviors. In this view, we should be able to line up human and nonhuman animals on a continuum and describe them in terms of small, incremental changes from one to the other. This has been shown at the biological level. At the cognitive level, there has been a tendency among comparative cognitive psychologists to view differences between humans and nonhuman animals as being continuous, as differences of degree and not of kind.

As opposed to this view, however, some argue that the rule of thumb for

the cognitive domain appears to be discontinuity rather than the continuity that Darwin expected (Penn, Holyoak, & Povinelli, 2008; Premack, 2007; Tomasello & Moll, 2010).

Premack (2007) uses teaching as a case in point regarding this discontinuity. He believes that at the heart of the debate is obfuscation between similarity and equivalence. Two behaviors can appear to be similar; however, they are not necessarily equivalent.

In an example not found in Premack (2007), both humans and meerkats adjust their teaching to the developmental levels of the learners. Ziv, Solomon & Strauss (2012) reported that 5-year-olds teach contingently, i.e., they adjust their teaching to the gradual change in the learner's knowledge. Similarly, Thornton & McAuliffe (2006) showed that meerkats adjust their teaching of younger and older pups by provisioning them with dead scorpions and disabled scorpions, respectively.

Humans and meerkats are similar in that they teach differently when the learners differ in developmental levels. However, human teaching is based on an understanding of the learner's mental state, whereas the meerkats' teaching rests on the purr calls of the pups. This suggests that despite their similarity, human and meerkat teaching behaviors are not equivalent, which is Premack's point.

As Penn et al. (2008) show, the list of what separates humans from non-human animals has grown increasingly short, something that gives credence to the continuity claim. But they argue that there is discontinuity in that humans have capabilities to create and understand symbol systems and re-interpret higher order structural relations from perceptual relations. They claim that these two capabilities are not found in nonhuman animals. Furthermore, they argue that these differences lead to many behaviors and abilities that separate humans from nonhuman animals. For example, humans infer unobservable causes, such as mental states.

Intentional teaching rests of the notion that one can cause unobservable learning in another's unobservable mind by acting in ways (teaching) that are thought to change the unobservable knowledge state of a learner (Strauss, 2001, in press). Penn et al.'s (2008) claim suggests that teaching can be added to the list of what separates humans and nonhuman animals.

Tomasello & Moll (2010) also claim that that there is discontinuity between human's and other primate's social cognition. In a series of studies,

they found little difference between chimpanzees', orangutans', and human children's cognition about the physical world for tasks that tapped their understandings of space, time, causality, etc. However, they did find differences between these three primates' social cognition. These differences, they argue, are due to shared intentionality which is found among humans and is quite absent among other primates. Shared intentionality is at the heart of teaching.

In sum, we maintain that teaching is one among a number of forms of social learning. There are two definitions of teaching: one for humans and one for nonhuman animals. These definitions seem to be incompatible. Teaching appears to be an ability that is discontinuous in the evolution of cognition.

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