Teaching Is a Natural Cognitive Ability for Humans

Sidney Strauss[1] and Margalit Ziv[2]

ABSTRACT— We suggest that a multidisciplinary approach to teaching has potential to widen its scope. In that vein, we revisit our original claim that teaching is a natural cognitive ability among humans. We elaborate on three requirements for such an ability and report that, first, teaching strategies may be developmentally reliable. Findings indicate a possible normative developmental trajectory from age one year through adulthood. Second, teaching seems to be species-typical, that is, it is a universal human achievement. Third, human teaching with a theory of mind (ToM) is species-unique. Nonhuman animals may teach without a ToM.

Teaching is often seen exclusively as what happens when an adult teacher teaches children in school settings. However, teaching's reach is greater than that. Adults teach youngsters in societies where there are no schools. Regardless if there are schools or not in a particular society, young children teach each other. These and other findings about teaching led us to claim, a decade ago, that teaching is a natural cognitive ability in humans (Strauss, Ziv, & Stein, 2002). That claim was subsequently expanded by Strauss (2005). In the ensuing years, the idea has been picked up by others, especially Csibra and Gergely (2009), and has been elaborated and expanded. We revisit our claim in light of advances occurring in a number of fields that impinge on our idea. In this article, we provide a panoramic view of teaching, define teaching, characterize properties of natural cognitive abilities, discuss the claim that teaching is a natural cognitive ability with emphasis on its being developmentally reliable, and make some final remarks.

[1]Center for Academic Studies, Tel Aviv University
[2]Alqasemi Academic College of Education, Tel Aviv University

Address correspondence to Sidney Strauss, School of Psychology, Center for Academic Studies, Or Yehuda, Israel or School of Education, Tel Aviv University, Tel Aviv 69978, Israel; e-mail: sidneystrauss@yahoo.com or sidst@post.tau.ac.il

A PANORAMIC VIEW OF TEACHING

Teaching, as an area of scholarship and research, has often been viewed within the prisms of solitary fields. It has been the focus of many disciplines, yet researchers often work in domain-isolation, perhaps unaware of work carried out in other domains. For example, researchers who investigate teaching in the field of education are often unaware of research in the field of cultural evolution and vice versa. We suggest that teaching research can benefit from an integrated multidisciplinary effort. Domains that have potential to add to our basic knowledge about teaching include the ontogenetic development of human teaching (Davis-Unger & Carlson, 2008a, 2008b; Strauss et al., 2002), anthropology (Greenfield, 2004), cultural evolution (Mesoudi, Whiten, & Laland, 2006), cognitive evolution (Arbilly, Motro, Feldman, & Lotem, 2011; Shultz, Nelson, & Dunbar, 2012), nonhuman animal teaching (comparative psychology) (Thornton & Raihani, 2008, 2010), brain sciences (Battro, 2007, 2010), artificial intelligence (Dessus, Mandin, & Zampa, 2008), cognitive archeology from prehistoric periods (Goren-Inbar, 2011), psycholinguistics (Bartsch, Wright, & Estes, 2010), philosophy (Scheffler, 1965), intelligent tutoring systems (Kopp, Britt, Millis, & Graesser, 2012), computer–human interface systems, silicon–biology interfaces, and more.

We believe, however, that at the core of human teaching stands cognition and its development. Teaching's mirror image, learning, has been a major focus of the cognitive sciences. But the flip-side of learning, human teaching that occurs when a teacher intends to cause learning in others has, by and large, been flying below the radar in the cognitive and developmental sciences. We suggest that a multidisciplinary study of teaching has potential to unlock a deep understanding of a fundamental aspect of human cognition. These insights can also shed a focused light on teaching that could, in turn, serve the education of our children.

When scientists and scholars express interest in teaching, they often do so in an attempt to explain other important phenomena. For instance, in the field of cultural evolution, teaching is invoked when scientists explain the cumulative nature of human culture (Tomasello, Kruger, & Ratner, 1993;

Whiten, 2011). Another example comes from comparative psychology where human and nonhuman cultures are compared and teaching is seen as one of the differences between the two (Whiten, Horner, & Marsall-Pescini, 2003) that might have significance for human culture versus nonhuman tradition.

In contrast, teaching is stage center in our work. Instead of it being used to explain phenomena, we believe that teaching itself is in need of explanation (and description). An avenue into this is through the multidisciplinary approach we are advocating. This does not deny the significance of explaining phenomena via teaching. It merely shifts the figure and ground. We see both projects as complementary.

DEFINITIONS OF HUMAN TEACHING

Definitions of teaching are suggested in varied disciplines and are incongruent. In philosophy, Green (1964), for example, presents a teaching continuum running from training to instruction and excluding conditioning and indoctrination. In psychology (e.g., Pearson, 1989), intentionality stands at its core, and in education (e.g., Scardamalia & Bereiter, 1989) several conceptions of teaching are suggested, such as cultural transmission, training of skills, fostering natural development, and producing conceptual change. In computer sciences (e.g., Dessus et al., 2008), emphasis is placed on monitoring others' minds and systematically communicating knowledge and feedback. Thus, teaching is a slippery concept.

Yet with all of its elusiveness, at the heart of definitions of *human* teaching may be theory of mind (ToM) (Olson & Bruner, 1996; Strauss, 1993; Strauss & Shilony, 1994). According to this definition, teaching involves an understanding of others' mental states. Teachers understand others' (i.e., learners') knowledge, beliefs, desires, and so on; they recognize that there is a knowledge gap between a knowledgeable person in a certain domain and a learner who has less knowledge; they foster others' knowledge or understanding in an attempt to reduce the knowledge gap and do so intentionally (i.e., teachers attempt to cause learning in others' minds). Thus, a ToM definition of *human* 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). Armed with this definition of teaching, we can now progress to our major claim that teaching is a natural cognitive ability.

TEACHING AS A NATURAL COGNITIVE ABILITY

What is a natural cognitive ability? According to Cosmides and Tooby (n.d.), natural cognitive abilities have five properties. They (1) are complexly structured for solving a specific type of adaptive problem, (2) develop without any conscious effort and in the absence of any formal instruction, (3) are applied without any conscious awareness of their underlying logic, (4) are distinct from more general abilities to process information or behave intelligently, and (5) reliably develop in all normal human beings. To this list, we add the following: they are (6) species-typical, that is universal, and (7) species-unique. Species typicality, or universality, has importance because it indicates that the natural cognitive ability under discussion, teaching in our case, is not restricted to certain groups but, instead, is a characteristic of all human beings. It also suggests that all humans are exposed to teaching, which is a prerequisite for development. The property that teaching is unique to human beings suggests there may be phylogenetic differences between humans and animals that make human cognition unique. This, in turn, suggests that there might not be continuity in the phylogeny of cognition. One much-discussed candidate for a natural cognitive ability is human spoken language. Others are face recognition, navigation through space, and the interpretation of a threat (Cosmides & Tooby, n.d.). Each solves an important adaptive problem.

We previously suggested that all seven properties hold for teaching (Strauss, 2005, 2011; Strauss et al., 2002). Due to space constraints, we won't discuss all seven properties in detail. We briefly present our ideas about the first four and then elaborate on the final three.

With regard to the first property, concerning complexity, teaching may be complexly structured for solving a specific type of adaptive problem. An adaptive problem has two main characteristics. First, it is one that has appeared during the evolutionary history of our species. Second, adaptive problems have affected the reproduction of organisms. That adaptive problem for teaching is passing on information, ideas, and procedures to others more effectively than were learning to be unassisted and in a manner that addresses great variability among learners (Premack & Premack, 1996). The complexity of human teaching is remarkable. It involves assumptions about learning (Olson & Bruner, 1996), defining goals and standards of the required change (Premack & Premack, 1996; Ziv, Solomon, & Frye, 2008), applying multiple teaching methods while adapting them to the learner (Ziv et al., 2008), providing feedback (Premack & Premack, 1996) and more. For a fuller discussion of how teaching is complexly structured for solving problems of communication, see Strauss (2005).

Regarding the second property, that teaching is learned effortlessly and without instruction, despite teaching's complexity (Strauss, 2005), youngsters seem to learn it and spontaneously engage in teaching effortlessly, without intentional instruction. Children teach peers and adults how to play certain games (Ziv & Frye, 2004) and to perform skills such as dancing moves and building constructions with blocks. Young children are exposed to teaching, of course. But we believe it is rare that they are taught how to teach.

The third property is that teaching occurs without teachers being aware of its underlying logic. Research conducted on professional adult teachers' mental models of others' minds and of how learning occurs revealed that teachers were not aware of their models' underlying logic (Strauss, 1993; Strauss & Shilony, 1994). Teachers could speak about what they did when teaching and they offered reasons why they did what they did. For example, teachers said that they broke up complex material so that it would be easier for their pupils to learn (Steiner, 2002; Strauss & Shilony, 1994). However, they could not clearly explain the cognitive principles underlying the procedures of reducing complexity of what was being taught nor did they speak about how that was connected to other understandings they had, such as pacing the lesson so that it does not cover material too quickly or teaching too much material.

Teaching is distinct from more general abilities to process or transmit information, which is the fourth property. Teaching is one of many forms of social learning (e.g., imitation, emulation, local stimulus enhancement contagion, etc.), and all concern the transmission of knowledge from one conspecific to another (Leadbeater & Chittka, 2007; Whiten, 2000). But teaching is unique in its psychological causality. At the heart of teaching is the intent to cause learning in someone else. No other kind of social learning has that at its core. In that sense, it is distinct from other abilities to process information.

Developmental Reliability in Human Ontogenesis

An additional criterion for teaching to be a natural cognitive ability is that it should be shown to be reliably developing. We elaborate on this criterion because it highlights the importance of including developmental studies in the domain of teaching. Two questions ought to be answered for making a determination regarding the developmental reliability of teaching. First, what does it mean that something is developmentally reliable? The answer provided by Cosmides and Tooby (n.d.) is that the ability under examination universally follows a similar developmental trajectory among children in the normative range (i.e., without serious developmental disabilities) who are exposed to a conventional social environment, no matter what that society might be.

Second, what ability should we describe in order to claim that it is developmentally reliable? The answer for teaching is complex and not obvious. Strauss and Ziv (2012) noted that there may be four separate, yet intertwined, strands of cognitive abilities each of which follows a developmental course and all of which are related to teaching: (1) cognitive templates necessary for teaching but which are not specific to teaching, e.g., executive functions (Davis-Unger & Carlson, 2008b), (2) cognitive prerequisites not specific to teaching, e.g., language (Premack & Premack, 1996) and ToM (Strauss et al., 2002; Ziv & Frye, 2004), (3) cognitive prerequisites specific to teaching, such as understanding intentional and knowledge-related aspects of teaching, e.g., that teaching is an intentional act, that one can be a source of knowledge for someone else, and that teaching relies on the teacher's beliefs about the learner's knowledge or understanding, and (4) actual teaching (Strauss et al., 2002; Ziv, Solomon, & Strauss, in press). In this article, we review only the fourth developmental course, actual teaching, and restrict that to teaching strategies. This has two versions: the proto-teaching of episodic knowledge and the teaching of generalizable knowledge.

The distinction between passing on episodic and generalizeable knowledge comes from work by Miller (2000) and Csibra and Gergely (2009). Here-and-now information passed on in proto-teaching activities is episodic. For example, in the case where were we to ask you, the reader, what time it is, and were you to tell us, you would not have taught us the time. What you did was pass on information that is correct for that particular moment. Had we asked the same question at the same time to a friend in a different place, say Budapest, or to the same person at a different time, say 5 min later, the answers would be different.

In contrast, information that is passed on in teaching activities is generic and generalizeable. That information goes beyond the here and now. For example, were a 5-year-old to ask you to teach her how to read the time on a clock, and were you to do that, you would be passing on information that is generalizeable and that goes beyond both the place and the moment. You would be teaching her. This distinction assists in portraying the developmental course of teaching. We now present the developmental story ordered by age.

Nonverbal children *age 1* seem to be capable of closing a knowledge gap. An experimenter "accidentally" pushes an object off a table in full view of a child and when the experimenter looks for it and cannot find it, she asks the child where it is (Liszkowski, Carpenter, Striano, & Tomasello, 2006; Liszkowski, Carpenter, & Tomasello, 2008). The infant points to its location. Their research indicated that infants at this age did not want the object for themselves nor did they want the adult to do something with the object. Liszkowski and his colleagues interpreted these findings as evidence for cooperative informing, via pointing, an ability that seems to be unique to humans.

Here is how we interpret their findings, as they relate to teaching. First, there is a knowledge gap: the experimenter "does not know" where the object is and the infant does. And second, the infant points and, as a consequence, closes the knowledge gap. However, this is a case of proto-teaching because the knowledge being passed on is episodic. Now it is to the left of the table but later it might be to the right. Nevertheless, at least two parts of teaching may be in evidence among 1-year-olds: perhaps "recognizing" a knowledge gap and acting to close it, which may be an intentional act. Similar research was conducted by Akagi (2012). In the presence of 1-year-olds, an experimenter made a mistake by trying to put a triangular-shaped object in a round hole, and the infants often pointed to the correct hole to put it in. Here, too, it might be the case that fundamental aspects of teaching are present at a very early age.

The only study to assess *2 and 2-½-year-olds* (Ashley and Tomasello, 1998) indicated that what they do cannot be considered teaching. However, the task they used to tap teaching was not simple. It required children to perform two actions in order to get an attractive sticker: moving a lever that moved a plate with the sticker on it in a plexiglass tube to a window and rotating a handle 180° which opened the window and allowed a child to remove the sticker. It is possible that a reason children at these ages did not teach was not because they couldn't but because the task used had cognitive demands that exceeded 2 and 2½-year-old children's information processing capabilities for teaching. More work is needed at these ages that extends Liszkowski et al.'s (2006, 2008) work.

Several studies tapped children's teaching from age 3. Children were taught how to play a game, and after they learned it, they were asked to teach a friend how to play the game so that they could play it together. For expository purposes, we now present a task used by Strauss et al. (2002). Later we use it to illustrate children's teaching strategies. It is a board game whose purpose is to collect three flowers of different colors according to the rules of the game. Each child has a turn to roll a die that has four flowers of different colors on four of its six faces. The two remaining faces had a picture of a smile and a frown. A player can take a flower that is on the board when the upward face is a color of a flower. For example, if after rolling the die, the cube has a red flower facing up, the child who threw the die can take a red flower from the board. If the smile is the face that is up, the participant can take any color flower she wants. If a frown appears, the participant cannot take a flower from the board. A detailed description of the game is found in Strauss et al. (2002).

Children *age 3* engage in emergent teaching and do so despite their low performance on ToM tasks, as tested by classic false belief tasks and false belief tasks for teaching (Bensalah, Olivier, & Stefaniak, 2012; Davis-Unger & Carlson, 2008a, 2008b; Strauss et al., 2002). As teachers, 3½-year-olds predominantly demonstrate how to play a game with little explanation accompanying those demonstrations. Others, who did not assess ToM, also reported that demonstration was the principal teaching strategy among 3½-year-olds (Ashley & Tomasello, 1998; Ellis & Rogoff, 1982; Feldman, Devin-Sheehan, & Allen, 1976; Feshbach, 1976; Feshbach & Devor, 1969; Maynard, 2002, 2004; Wood, Wood, Ainsworth, & O'Malley, 1995).

Explanations of the game's rules were found among children at this age but were not the dominant teaching strategy. It was also found that when the learner errs, 3-year-olds often ignore these errors or correct them by performing themselves the required move instead of the learner. For example, in the above-mentioned board game, if the learner mistakenly picks a blue rather than a red flower, as indicated by the die, a 3-year-old teacher will typically ignore this mistaken move and will progress to throwing the die for his turn or replace the learner's blue flower with the correct red one. This response reflects emerging awareness and monitoring of learners' behavior. Hence, 3-year-olds recognize learners' lack of knowledge and engage in peer teaching that relies on demonstration and entails some correction of learners' behavior. This pattern correlates with 3-year-olds' success in tasks that test recognition of knowledge gaps between teachers and learners (Ziv & Frye, 2004) but low performance on tasks that test more complex mental aspects of teaching, e.g., teachers' beliefs about learners' knowledge and the distinction between intentional teaching and learning by imitation (Ziv et al., 2008).

Children *age 5* teach by explaining the game's rules, and that is accompanied by demonstrations (Bensalah et al., 2012; Davis-Unger & Carlson, 2008a, 2008b; Strauss et al., 2002). Children at this age also demonstrate the way the game is played, but the dominant teaching strategy is explanation. The majority of these children pass ToM tasks as tested by classic and teaching false belief tasks. It was found that when the learner errs, a 5-year-old teacher will typically repeat or remind her of a rule that has previously been explained, usually in a shortened version or by demonstration. For example, a 5-year-old teacher first explained the rule: "You have to throw the die and if it shows red, you pick the red flower." In response to the learner's mistaken picking of a blue flower, the teacher explained and demonstrated: "Look, the dice shows red, so I pick a red flower, not blue, see?" Hence, 5-year-olds are better than 3-year-olds at monitoring the learning process and begin to adapt their teaching to the learner's progress and errors. This pattern correlates with their better performance on false belief and intention tasks, as well as on teaching tasks. As for teaching tasks, 5-year-olds showed understanding of teacher's beliefs regarding learner's knowledge (Strauss et al., 2002; Ziv & Frye, 2004) and could distinguish between intentional teaching and learning by imitation (Ziv et al., 2008).

Children *age 7* engage in more systematic contingent teaching (Wood et al., 1995; Ziv et al., 2008). In this kind of scaffolded teaching, a teacher teaches a learner and as that learner's knowledge state does or does not change (she gains more knowledge and becomes increasingly competent, or the knowledge state does not change, or the learner becomes confused and what was seen as sure knowledge is now shaky), the teacher adjusts his teaching to his representation of that changing knowledge state. Wood, Wood & Middleton (1978) noted that a rule for contingent teaching is: If the learner succeeds, when next intervening, offer less help. If the learner fails, take over more control when next intervening. Children age 7 were quite proficient at this. This is an on-line ToM and is an advance over the ToM found among 5-year-olds.

Regarding children ages *9* and *11*, Garbarino (1975) and Ludeke and Hartup (1983) found teachers' behaviors that were similar to those found among 7-year-olds. One exception was that 9-year-olds offered strategic advice regarding alternative choices available to the learner.

In showing that there seems to be a developmental trajectory from proto-teaching to demonstration, to explanation and to contingent teaching, we presented each in general terms. Table 1 illustrates the variety and richness of teaching strategies children use over the course of development and can assist in refining analyses of children's teaching in future studies. It shows, for example, that there are several kinds of demonstration and verbal explanations. The table does not include ages because, for the major categories of strategies, there is a change in emphasis rather than an absence at a certain age and then a presence at another. For example, for the tasks at hand, which were almost always teaching a peer how to play a game, even the 3-year-old children explained here and there. However, it was not the dominant strategy; demonstration was. Similarly, among 5-year-olds, where explanation was the main teaching strategy, there were always demonstrations as well.

We now jump to teaching among adults but note that there is surely more development concerning actual teaching between age 9 and adulthood. This is a lacuna in need of filling. Research on adults' teaching explored the mental models about the mind and its dynamic workings which underlie how they teach. Previous studies focused on mental models of professionals regarding the workings of *dynamic* physical objects. An example is mental models engineers have about running a power plant. In acquiring knowledge about it, they learn a considerable amount about physics, engineering, mathematics, and so on. But when actually running the power plant, they do not necessarily consult that knowledge. Instead, they use shortcut rules they mentally constructed about how to keep the plant running as it changes dynamically, e.g., when there is an increase in pressure, reduce the temperature. These rules and their relations comprise mental models (Johnson-Laird, 1983; Norman, 1983; Seel, 2006).

Studies on people's mental models of teaching and learning initiated by Strauss and colleagues (Haim, Strauss, & Ravid, 2004; Mevorach & Strauss, 2012; Strauss, 1993, 2001, 2011; Strauss, Ravid, Magen, & Berliner, 1998; Strauss, Ravid, Zelcer, & Berliner, 1999; Strauss & Shilony, 1994) involved a move that changed the above. Instead of describing people's mental models of dynamic physical objects in the environment, one can describe adults' mental models of the dynamic workings of pupils' minds when learning occurs. Unlike a power plant, nobody has seen a mind. It is tacit, and there is little agreement about its structure and workings. Nevertheless, people seem to have mental models about the structure of minds and how learning takes place as a result of teaching.

One can conceptualize two kinds of mental models: (1) espoused, which can be culled from the ways people speak about their teaching and (2) in-action, which can be inferred from peoples' actual teaching. Strauss (1993, 2001, 2011) and Strauss & Shilony (1994) found that teachers have a direct transmission, source-recipient espoused mental model of the mind, how learning takes place there, and how teaching brings about learning. Knowledge is possessed by teachers who stand outside the learners' mind. Teaching is an engineering task of how to get the teacher's knowledge inside children's minds and to get it to stay there. This same espoused mental model was found for professional teachers and professionals with the same level of university degrees who were not teachers, such as journalists.

Teachers' in-action mental model was revealed by videotaping and analyzing teachers' teaching (Haim et al., 2004; Mevorach & Strauss, 2012; Strauss, 2011; Strauss et al., 1998; Strauss et al., 1999). Findings show that teachers' in-action mental model is comprised of the following: (1) cognitive goals that teachers want their pupils to achieve, (2) cognitive processes that teachers think lead to these cognitive goals, (3) assumptions about how teaching in a particular way leads to these cognitive process that, in turn, lead to the cognitive goals, and (4) meta-assumptions about learning and teaching.

These two mental models, the espoused and in-action, reflect adults' fundamental folk psychology understandings about the mind and its dynamic workings when learning occurs there. The findings correspond with Olson and Bruner's (1996) notion of teaching according to which teachers' teaching reflect their assumptions and beliefs about learner's mental abilities. They argue that the majority of adult teachers regard learners as capable of understanding and applying rules and accordingly teach mainly by explaining rules. Only a minority of teachers regard pupils as thinkers and engage them in conversations and activities in which they express and refine their opinions and ideas.

The espoused mental model is common to adult teachers who teach in kindergarten through university, as well as adults with no formal teaching training and experience. The in-action mental model is common to experienced and novice teachers who teach different subject matter and to those whose subject matter knowledge is extensive and deeply organized and those with impoverished and shallow subject matter knowledge organization.

To summarize, teaching appears to be developmentally reliable. The trajectory is from proto-teaching among 1-year-olds who do not yet speak, to demonstrations among 3-year-olds, then explanations found in 5-year-olds, followed by contingent teaching among 7-year-olds and culminating

Table 1
Strategies That Children Use While Teaching, Examples and Studies' Authors

Strategy	*Examples*	*Authors*
Direct assistance	Teacher makes a move for the tutee	Garbarino (1975) Ludeke and Hartup (1983) Strauss et al. (2002) Wood et al. (1995)
Demonstration		
Physical demonstration	Teacher performs pertinent features of the game	Ashley and Tomasello (1998) Bensalah et al. (2012) Howe et al. (2006) Howe et al. (2012) Strauss et al. (2002)
Demonstration without learner involvement	Teacher takes the correct color flower.	Howe et al. (2012)
Demonstration with learner involvement	Teacher takes the correct color flower and then asks the learner to do it.	Howe et al. (2012)
Gradual demonstration	Teacher performs parts of the required behavior.	Ziv et al. (in press)
	Teacher slowly performs the required move.	Ziv et al. (in press)
Demonstration with some explanation	While exhibiting, teacher says: "do this, like you did before"	Davis-Unger and Carlson (2008a, 2008b) Strauss et al. (2002) Wood et al. (1995)
Explanations		
General explanation category		Davis-Unger and Carlson (2008a, 2008b)
Description of materials	"You get a yellow leaf."	Ashley and Tomasello (1998) Howe et al. (2006)
General orienting statements	"Pick up the train and see what color there is."	Wood et al. (1995) Davis-Unger and Carlson (2008a, 2008b)
General rule statements	"We take turns."	Davis-Unger and Carlson (2008a, 2008b) Strauss et al. (2002)
Rule repetition		Ludeke and Hartup (1983)
Specific rule statements	"A smiley face means you can take any flower."	Davis-Unger and Carlson (2008a, 2008b) Strauss et al. (2002)
Starting rules	"Put the cubes in the center of the board around the track."	Strauss et al. (2002)
Strategic advice	"Don't pick a flower whose color you already have."	Ludeke and Hartup (1983)
Outcome rules	"If you get four different colors first, you win."	Strauss et al. (2002)
Outcome of the game	"You won."	Brachfeld-Child and Schiavo (1990) Strauss et al. (2002)
Specific response to learner		
Attention directive	"Look here."	Howe et al. (2012)
Checking in	"Do you understand?"	Davis-Unger & Carlson (2008a, 2008b)
Scaffolding	"Look closely at the color of the die."	Howe et al. (2006)
Calling attention to learner's mistakes	"You picked the red flower Instead of the blue one."	Ludeke and Hartup (1983)
Feedback	"That's the right move."	Davis-Unger and Carlson (2008a, 2008b) Garbarino (1975) Howe et al. (2006) Howe et al. (2012) Wood et al. (1995)
Praise/encouragement	"Very good."	Feshbach and Devor (1969) Ludeke and Hartup (1983)

in mental models among adults. Adults' direct transmission mental model corresponds with Olson and Bruner's (1996) argument that most teachers regard learners as capable of understanding and applying rules and less as independent and creative thinkers. Interestingly, it resembles the dominance of rule explanation in the teaching of children from age 5 and raises questions regarding conventional school-related teaching.

Teaching as Species-Typical and Universal

Studies in anthropology and cultural evolution suggest that human teaching is an extraordinary achievement which may be partially responsible for cultural evolution in that it preserves innovations by transferring them to others (Strauss, 2005; Tomasello, 1999). Humans have been extraordinarily successful by living in virtually every habitat on planet earth. To do that, technological and social systems were devised that allow us to adapt to our surroundings. Those adaptations result from the cognitive niches (Pinker, 2010) that allow humans to understand how to create adaptive technologies and improve on them, and cultural niches (Boyd, Richerson, & Henrich, 2011) that allow humans to create intricate and complex information and to transmit that information to each other in ways that allow humans to keep that information in place. Despite disagreements generated by advocates of the two kinds of niches, it is clear that both kinds are necessary for adaptive and cumulative culture to exist.

An adaptation begins with an innovator and gets passed on to others in nongenetic ways. It is cumulative in the sense that Tennie, Call, and Tomasello (2009) suggested with the "ratchet" metaphor. Past innovations are held in place as new ones come into existence. The result is cumulative human culture in its varied forms. One way to pass on that information may be unique to humans, that is, teaching.

But is teaching universal? At this point you might be asking yourself: What? It isn't universal? A second question comes fast on the heels of the first: By "merely" asking if teaching is universal, aren't we restricting the domain of discourse? Our answer is in the affirmative. Of course, we would want to know many details of significance, such as who teaches whom, under what conditions does teaching occur, what its frequency is in different societal arrangements and more. But the claim that teaching is universal and, hence, it may be a natural cognitive ability, does not depend on answers to these questions of detail, as interesting and important as they are.

It is impossible to make a determination about universal teaching for each and every society, of course. As a result, one recourse is to review samples of ethnographic accounts of the existence or nonexistence of teaching in various kinds of societal organizations. Were we to find teaching in samples of each of these groups, we could cautiously extrapolate to other exemplars within those kinds of societies. We very briefly present a sketch from three kinds of societal organizations: WEIRD (Western, educated, industrialized, rich and democratic), horticultural/farming, and hunter-gathering societies. These categories are not fixed. For example, there are mixes where some groups are hunter-gatherers and farmers (Bird-David, 1990).

Ethnographic work on teaching reveals a split. Teaching is sometimes ignored. An indication of this is that Brown's (1991) extensive catalog of cultural universals does not include teaching. It does include, say, child-rearing, but not teaching. This does not mean that teaching is not universal or a near-universal. It simply means that teaching may be flying below the radar for some anthropologists.

Concerning WEIRD societies, ethnographers do not study if teaching exists there because it is clear that it does. It appears on playgrounds where children teach each other, in homes between parents and children and between babysitters and those under their care, and in those specially designated places where teaching and learning are central: schools (Frye & Ziv, 2005; Strauss, 1993, 2001).

With respect to horticultural/farming societies, researchers reported teaching. For example, Greenfield (2004) and Maynard (2002, 2004) found teaching in such a society in Mexico, as did Hewlett, Fouts, Boyette, and Hewlett (2011) in the Congo in Africa. Maynard (2002) found that in a Mexican village that had no schools, children were taught weaving by adults. In those teaching situations, there were many teachers per child, and the adult teachers were physically close to the learners and their language use was informal. For the purposes of our point, we stress that these interesting differences between teaching in schools and in nonschool situation should not obscure the idea that teaching was found there.

The question as to whether or not teaching is found in hunting and gathering societies is an understudied area in need of research (Hewlett et al., 2011). For the moment, it is in controversy. As far as we know, there are only two anthropologists, Fiske (n.d.) and Lancy (2010), who believe that there are hunting and gathering societies that have no teaching whatsoever. They claim that people in these societies learn by participation in cultural events, observation, and imitation. Reasons are offered by those who argue that teaching among hunter-gatherers should be rare or nonexistent. Hunting and gathering societies have as core values egalitarianism (access to resources in similar among young and old and men and women) and autonomy (there is no coercion). Were there to be no teaching among hunter-gatherers, our claim that teaching is a natural cognitive ability may be in jeopardy.

However, some research suggests that teaching can be found in hunting and gathering societies. Three main sources of information contribute to this claim. First is self-reports. For example, Hattori (as cited in Hewlett et al. 2011) reports that Baka hunter-gatherer women and men report that they were taught about 90 kinds of plants from their mothers and fathers, respectively. Second, analysis of videotapes of everyday life among the Bakas indicated that teaching occurs (Hewlett et al., 2011). The predominant type of teaching is vertical (between a parent and his/her child). Some instances of oblique knowledge transmission (between an adult and a child who is not a son or daughter) have been recorded. And cases of horizontal teaching (e.g., older children teaching younger children) have also been found. Because researchers may not been on the lookout for the last kind of teaching, Hewlett et al. (2011) suggest that there is a need for systematic research in this area. Third, acts of teaching were "evoked." For example, Ando (2012) conducted a preliminary study among members of a hunting and gathering pygmy tribe in Cameroon. He played a solitary game in the presence of members of the tribe and found that when a man found interest in the game, others did as well. That man then taught others how to play the game. Prior to that happening, it did not appear that there was teaching in that society.

Similarly, in a hunting and gathering society in the Congo basin (Hewlett, in press, reported in Hewlett et al., 2011), an anthropologist asked tribeswomen to teach her to be like an Aka (the band's name) woman. She was taught intensively (several hours per day) how to weave a basket over an extensive period of time (several weeks) by a band-woman and her daughter. For example, the woman made part of a basket in the presence of Hewlett, undid what she had done and then handed the material to Hewlett for her to weave the pieces together. This appears to be a demonstration where the task was broken up into parts. It is possible that the teacher here understood, perhaps implicitly, that the task at hand was too complex to be grasped in its entirety via one demonstration. If this speculation could be confirmed, we might tentatively suggest that the teacher had an understanding of others' information processing constraints and that her teaching took that into account. Interestingly, there was little reported teaching among members of that very same society. This discrepancy is in need of explanation.

It appears, then, that teaching among humans may be ubiquitous. Were we to find that it is universal, its profundity would be emphasized, as would the claim that teaching is a natural cognitive ability among humans. And if it were to be found that teaching is a near-universal, it would be of importance to understand why teaching does not exist in certain societies and what replaces it. So far, so good for humans. But is teaching species-unique for humans or are there animals other than humans that teach? This, too, must be addressed in our search for support for the claim that teaching is a natural cognitive ability. Here we want to know if human teaching is unique to our species. If so, we would have more evidence that teaching is a natural cognitive ability.

Teaching Among Nonhuman Animals

Until 20 years ago, teaching among nonhuman animals was hardly discussed (however, see Boesch, 1991; Ewer, 1969). Caro and Hauser (1992) famously proposed a functional definition of teaching based on the fields of evolution and animal behavior. Their definition, 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. (Caro & Hauser, 1993, p. 153).

This definition is radically different from the ToM-based definition of intentional 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.

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 and Hauser's definition than there would be were ToM to be a criterion for teaching. Armed with this rather liberal definition, one that excludes ToM and intentionality, Caro and Hauser found that only felids taught. However, over the past several years, research indicates that, according to the functional definition, teaching occurs in two additional taxa: tandem running ants (*Temnothorax albipennis*) and meerkats (*Suricata suricatta*). New taxa may be found to teach now that research has begun to progress in this area (see Thornton & Raihani, 2010).

An important questions concerns human's teaching with a ToM and nonhuman animals without: What are the similarities and differences between these two types of teaching (Strauss & Ziv, 2011)? This is a nontrivial question. For example, in both human teaching and that of tandem running ants there is some kind of contingency. We already indicated what contingent teaching is for humans. For tandem running ants, Franks and Richardson (2006), Leadbeater, Raine, and Chittka (2006), and Richardson, Sleema, McNamara, Houston, and Franks (2007) showed that it goes as follows: An ant knows how get to the location of a food source and a naïve ant does not. The former, the teacher, leads the latter, the learner, to that location. The learner maintains constant contact with the teacher by tapping its antennae on the teacher's legs and abdomen. If contact is lost, the teacher stops until it is re-established. The teacher also stops on occasion at a time when there is contact with the learner. When that happens, the learner explores the landscape. It is possible that the learner is gathering information about the landscape which enables it to recognize it when going to the food source alone. Thus, the teacher adjusts its teaching behaviors to the changing situation of the learner.

Premack (2007) made an important distinction between similarity and equivalence when comparing humans and nonhuman animals. The similar contingent teaching among humans and ants should not be understood to be such that their teaching is equivalent. Human contingent teaching is based on an understanding of the learner's mental state, whereas the ants' teaching almost surely rests on hard-wired behaviors that do not draw from ToM. This suggests that despite their similarity, human and ant teaching behaviors are not equivalent. Premack and Premack (1996) emphasized that human pedagogy is unique in its motivational basis to lead the novice towards performance that meets the pedagogues' standards and additionally, in the ability to judge the quality of the learner's performance and modulate the teaching accordingly. The comparative psychology studies described above support the argument regarding unique human features of teaching.

FINAL REMARKS

We attempted to show that teaching may be a natural cognitive ability, and three areas of research and scholarship were brought to bear on that claim. This had not been suggested before our original work a decade ago (Strauss et al., 2002), and we pursued this idea here, based on new findings in domains of consequence for teaching.

In a larger perspective, we believe that the field of teaching may be on the cusp of a paradigm shift. This shift can occur were scientists from different domains to join in a multidisciplinary effort to understand one of the human race's greatest achievements: teaching. We called for a far-ranging, coordinated, multidisciplinary scientific view of teaching, one that includes the myriad domains that touch on and inform teaching. This can help make teaching better understood, can aid us to see how teaching explains many important phenomena, and can assist us in uncovering a profound aspect of human cognition. All of these insights, were they to be harnessed, would significantly deepen our understanding of teaching and could help us find ways to apply this understanding in teaching children and thus better educate our children. This is a place where recent developments in science can be wed to the goal of bettering the lives of children.

REFERENCES

Akagi, K. (2012). Development of teaching behavior in typically developing children and children with autism. In *CARLS series of advanced study of logic and sensibility* (pp. 425–435). Tokyo, Japan: Keio University Press.

Ando, J. (2012). On "Homo educans" hypothesis. In S. Watanabe (Ed.), *CARLS series of advanced study of logic and sensibility* (pp. 147–156). Tokyo, Japan: Keio University Press.

Arbilly, M., Motro, U., Feldman, M. W., & Lotem, A. (2011). Evolution of social learning when high expected payoffs are associated with high risk of failure. *Journal of the Royal Society, Interface*, *8*, 1604–1615. doi: 10.1098/rsif.2011.0138

Ashley, J., & Tomasello, M. (1998). Cooperative problem-solving and teaching in preschoolers. *Social Development*, *7*(2), 143–163.

Bartsch, K., Wright, J. C., & Estes, D. (2010). Young children's persuasion in everyday conversation: Tactics and attunement to others' mental states. *Social Development*, *19*, 394–416. doi: 10.111/j.1467-9507.2009.00537.x

Battro, A. (2007). Homo educalibis: A neurocognitive approach. In M. S. Sorondo (Ed.). *What is our real knowledge of the human being?* (*Scripta Varia* Vol. 109, pp. 46–60). The Vatican: Pontifical Academy of Sciences.

Battro, A. (2010). The teaching brain. *Mind, Brain and Education*, *4*, 28–33.

Bensalah, L., Olivier, M., & Stefaniak, N. (2012). Acquisition of the concept of teaching and its relationship with theory of mind in French 3- to 6-year-olds. *Teaching and Teacher Education*, *28*, 303–311. doi: 10.1016/j.tate.2011.10.008

Bird-David, N. (1990). The giving environment: Another perspective on the economic system of gatherer-hunters. *Current Anthropology*, *31*, 189–196.

Boesch, C. (1991). Teaching among wild chimpanzees. *Animal Behaviour*, *41*, 530–532. doi: 10.1016/s0003-3472(05)80857-7.

Boyd, R., Richerson, P. J., & Henrich, J. (2011). The cultural niche: Why social learning is essential for human adaptation. *Proceedings of the National Academy of Sciences of the USA*, *10*, 10918–10925. doi: 10.1073/pnas.1100290108

Brachfeld-Child, S., & Schiavo, R. S. (1990). Interactions of preschool and kindergarten friends and acquaintances. *The Journal of Genetic Psychology*, *151*(1), 45–57.

Brown, D. E. (1991). *Human universals*. Philadelphia, PA: Temple University Press.

Caro, T. M., & Hauser, M. D. (1992). Is there teaching in nonhuman animals? *The Quarterly Review of Biology*, *67*, 151–174.

Cosmides, L., & Tooby, J. (n.d.). *Evolutionary psychology: A primer*. Unpublished manuscript, Center for Evolutionary Psychology, University of California at Santa Barbara, Santa Barbara, CA.

Csibra, G., & Gergely, G. (2009). Natural pedagogy. *Trends in Cognitive Sciences*, *13*, 148–153.

Davis-Unger, A. C., & Carlson, S. M. (2008a). Development of teaching skills and relations to theory of mind in preschoolers. *Journal of Cognition and Development*, *9*, 26–45.

Davis-Unger, A. C., & Carlson, S. M. (2008b). Children's teaching: Relations to theory of mind and executive function. *Mind, Brain, and Education*, *2*, 128–135.

Dessus, P., Mandin, S., & Zampa, V. (2008). What is teaching? Cognitive-based tutoring principles for the design of a learning environment. In S. Tazi, & K. Zreik (Eds.), *Common innovation in e-learning, machine learning and humanoid (ICHLS6)* (pp. 49–55). Paris, France: Europia/IREEE.

Ellis, S., & Rogoff, B. (1982). The strategies and efficacy of child versus adult teacher. *Child Development*, *53*, 730–735.

Ewer, R. F. (1969). The instinct to teach. *Nature*, *222*, 698. doi: 10.1038/22269890

Feldman, R. S., Devin-Sheehan, L., & Allen, V. L. (1976). Children tutoring children: A critical review of research. In V. L. Allen (Ed.), *Children as teachers: Theory and research on teaching* (pp. 235–252). New York, NY: Academic Press.

Feshbach, N. D. (1976). Teaching styles in young children: Implications for peer tutoring. In V. L. Allen, (Ed.), *Children as teachers: Theory and research in teaching* (pp. 81–97). New York, NY: Academic Press.

Feshbach, N. D., & Devor, G. (1969). Teaching styles in four-year-olds. *Child Development*, *40*, 183–190.

Fiske, A. (n. d.). *Learning culture the way informants do: Observing, imitating and anticipating*. Unpublished manuscript, Department of Anthropology, University of California at Los Angeles.

Franks, N. R., & Richardson, T. (2006). Teaching in tandem-running ants. *Nature*, *439*, 153.

Frye, D., & Ziv, M. (2005). Teaching and learning as intentional activities. In B. D. Homer & C. S. Tamis-LeMonda (Eds.), *The development of social cognition and communication* (pp. 231–258). New York, NY: Erlbaum.

Garbarino, J. (1975). The impact of anticipated reward upon cross-age tutoring. *Journal of Personality and Social Psychology*, *32*, 421–428.

Goren-Inbar, N. (2011). Culture and cognition in the Acheulian industry: A case study from Gesher Benot Ya'aqov. *Philosophical Transactions of the Royal Society B*, *366*, 1038–1049. doi: 10.1098/rstb.2010.0365

Green, T. F. (1964). A topology of the teaching concept. *Studies in Philosophy and Education*, *3*, 284–391. doi: 10.1007/BF00375980

Greenfield, P. M. (2004). *Weaving generations together: Evolving creativity in the Maya of Chiapas*. Santa Fe, NM: School of American Research Press.

Haim, O., Strauss, S., & Ravid, D. (2004). Relations between EFL teachers' formal knowledge of grammar and their in-action mental models of children's minds and learning. *Teaching and Teacher Education*, *20*, 861–880. doi: 10.1016/j.tate.2004.09.007

Hewlett, B. S., Fouts, H. N., Boyette, A. H., & Hewlett, B. L. (2011). Social learning among Congo Basin hunter-gatherers. *Philosophical Transactions of the Royal Society B*, *366*, 1168–1178. doi: 10.1098/rstb.2010.0373

Howe, N., Brody, M.-H., & Recchia, H. E. (2006). Effects of task difficulty on sibling teaching in middle childhood. *Infant and Child Development*, *15*, 455–470. doi: 10.1002/icd.470

Howe, N., Recchia, H. E., Della Porta, S., & Funamoto, A. (2012). "The driver doesn't sit, he stands up like the Flintstones!": Sibling teaching during teacher-directed and self-guided tasks. *Journal of Cognition and Development*, *13*, 208–231. doi: 10.1080/15248372.2011.577703

Johnson-Laird, P. N. (1983). *Mental models: Towards a cognitive science of language, inferences and consciousness*. Cambridge, UK: Cambridge University Press.

Kopp, K. J., Britt, M. A., Millis, K., & Graesser, A. C. (2012). Improving the efficiency of dialogue in tutoring. *Learning and Instruction*, *22*, 320–330. doi: 10.1016/jlearninstruc.s011.12.002

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

Leadbeater, E., & Chittka, L. (2007). Social learning in insects: From miniature brains to consensus building. *Current Biology*, *17*, R703–R713. doi: 0.1016/j.cub.2007.06.012

Leadbeater, E., Raine, N. E., & Chittka, L. (2006). Social learning: Ants and the meaning of teaching. *Current Biology*, *16*, R323–R325. doi: 10.1016/jcub.2006.3.078

Liszkowski, U., Carpenter, M., Striano, T., & Tomasello, M. (2006). 12-and 18-month-olds point to provide information for others. *Journal of Cognition and Development*, *7*, 173–187. doi: 10.1207/s15327647jcd0702_2

Liszkowski, U., Carpenter, M., & Tomasello, M. (2008). Twelve-month-olds communicate helpfully and appropriately for knowledgeable and ignorant partners. *Cognition*, *108*, 732–739. doi: 10.1016/cognition.2008.06.013

Ludeke, R. J., & Hartup, W. W. (1983). Teaching behaviors of 9- and 11-year-old girls in mixed-age and same-age dyads. *Journal of Educational Psychology*, *75*, 908–914.

Maynard, A. E. (2002). Cultural teaching: The development of teaching skills in Maya sibling interactions. *Child Development*, *73*, 969–982.

Maynard, A. E. (2004). Cultures of teaching in childhood: Formal schooling and Maya sibling teaching at home. *Cognitive Development*, *19*, 517–533.

Mesoudi, A., Whiten, A., & Laland, K. N. (2006). Towards a unified science of cultural evolution. *Brain and Behavioral Sciences*, *29*, 329–383.

Mevorach, M., & Strauss, S. (2012). Teacher educators have different in-action mental models in different teaching situations. *Teachers and Teaching: Theory and Practice*, *18*(1), 25–41.

Miller, S. A. (2000). Children's understanding of preexisting differences in knowledge and belief. *Developmental Review*, *20*, 227–282.

Norman, D. A. (1983). Some observations on mental models. In D. Gentner & A. L. Stevens (Eds.), *Mental models* (pp. 7–14). Hillsdale, NJ: Erlbaum.

Olson, D., & Bruner, J. (1996). Folk psychology and folk pedagogy. In D. R. Olson & N. Torrance (Eds.), *The handbook of education and human development* (pp. 9–27). Cambridge, MA: Blackwell.

Pearson, A. T. (1989). *The teacher: Theory and practice in teacher education*. New York, NY: Routledge.

Pinker, S. (2010). The cognitive niche: Coevolution of intelligence, sociality, and language. *Proceedings of the National Academy of Sciences of the USA* (Suppl. 2), 8993–8999. doi: 10.1073/pnas.0914630107

Premack, D. (2007). Human and animal cognition: Continuity and discontinuity. *Proceedings of the National Academy of Sciences of the USA*, *104*(35), 13861–13867. doi: 10.1073/pnas/0706147104

Premack, D., & Premack, A. J. (1996). Why animals lack pedagogy and some cultures have more of it than others. In D. R. Olson & N. Torrance (Eds.), *The handbook of education and human development* (pp. 302–323). Cambridge, MA: Blackwell Publishers.

Richardson, T. O., Sieeman, P. A., McNamara, J. M., Houston, A. I., & Franks, N. R. (2007). Teaching with evaluation in ants. *Current Biology*, *17*, 1520–1526. doi: 10.1016/jcub.2007.08.032

Scardamalia, M., & Bereiter, C. (1989). Conceptions of teaching and approaches to core problems. In M. C. Reynolds (Ed.), *Knowledge base for the beginning teacher* (pp. 37–46). New York, NY: Pergamon Press.

Scheffler, I. (1965). Philosophical models of teaching. *Harvard Educational Review*, *35*(2), 131–143.

Seel, N. M. (2006). Mental models in learning situations. In C. Held, M. Knauff, & G. Vosgerau (Eds.), *Mental models and the mind: Current developments in cognitive psychology, neuroscience, and*

philosophy of mind (pp. 85–107). Amsterdam, The Netherlands: Elsevier.
Shultz, S., Nelson, E., & Dunbar, R. I. M. (2012). Hominin cognitive evolution: Identifying patterns and processes in the fossil and archeological record. *Philosophical Transactions of the Royal Society B*, *367*, 2130–2140. doi: 10.1098/rstb.2012.0115
Steiner, J. (2002). *English teachers' on-action mental models of their pupils' learning*. Ph.D. dissertation, School of Education, Tel Aviv University.
Strauss, S. (1993). Theories of learning and development for academics and educators. *Educational Psychologist*, *28*, 191–203. doi: 10.1207/s15326985ep803_1
Strauss, S. (2001). Folk psychology, folk pedagogy and their relations to subject matter knowledge. In B. Torff & R. S. Sternberg (Eds.), *Understanding and teaching the intuitive mind* (pp. 217–242). Mahwah, NJ: Erlbaum.
Strauss, S. (2005). Teaching as a natural cognitive ability: Implications for classroom practice and teacher education. In D. Pillemer & S. White (Eds.), *Developmental psychology and social change* (pp. 368–388). New York, NY: Cambridge University Press.
Strauss, S. (2011). Folk psychology about others' learning. In N. Seel (Ed.). *Encyclopedia of the sciences of learning* (Vol. 3, pp. 1310–1313). Heidelberg, Germany: Springer. doi: 10.1007/978-1-4419-1428-6
Strauss, S., Ravid, D., Magen, N., & Berliner, D. C. (1998). Relations between teachers' subject matter knowledge, teaching experience and their mental models of children's minds and learning. *Teaching and Teacher Education*, *14*, 579–595.
Strauss, S., Ravid, D., Zelcer, H., & Berliner, D. C. (1999). Teachers' subject matter knowledge and their belief systems about children's learning. In T. Nunes (Ed.), *Learning to read: An integrated view from research and practice* (pp. 259–282). London, UK: Kluwer.
Strauss, S., & Shilony, T. (1994). Teachers' models of children's minds and learning. In L. Hirschfeld & S. Gelman (Eds.), *Mapping the mind: Domain-specificity in cognition and culture* (pp. 455–473). Cambridge, UK: Cambridge University Press.
Strauss, S., & Ziv, M. (2011). What nonhuman animal teaching teaches us about teaching. In J. Ando (Ed.), *CARLS series of advanced studies of logic and sensibility* (Vol. 5, pp. 363–371). Tokyo, Japan: Keio University Press.
Strauss, S., & Ziv, M. (2012). Developmental milestones in human teaching: An essay in honor of Miriam Mevorach. Unpublished manuscript, School of Education, Tel Aviv University.
Strauss, S., Ziv, M., & Stein, A. (2002). Teaching as a natural cognition and its relations to preschoolers' developing theory of mind. *Cognitive Development*, *17*, 1473–1487. doi: 10.1016/s0885-2014(02)00128_4
Tennie, C., Call, J., & Tomasello, M. (2009). Ratcheting up the ratchet: On the evolution of cumulative culture. *Philosophical Transactions of the Royal Society B*, *364*(1528), 2405–2415. doi: 10.1098/rstb.2009.0052
Thornton, A., & Raihani, N. J. (2008). The evolution of teaching. *Animal Behaviour*, *75*, 1823–1836.
Thornton, A., & Raihani, N. J. (2010). Identifying teaching in wild animals. *Learning & Behavior*, *38*, 297–309.
Tomasello, M. (1999). *The cultural origins of human cognition*. Cambridge, MA: Harvard University Press.
Tomasello, M., Kruger, A., & Ratner, H. (1993). Cultural learning. *The Behavioral and Brain Sciences*, *16*, 495–552.
Whiten, A. (2000). Primate culture and social learning. *Cognitive Science*, *24*, 477–508.
Whiten, A. (2011). The scope of culture in chimpanzees, humans and ancestral apes. *Philosophical Transactions of the Royal Society B*, *366*, 99701997. doi: 10.1098/rstb.2010.0334
Whiten, A., Horner, V., & Marsall-Pescini, S. (2003). Cultural panthropology. *Evolutionary Anthropology*, *12*, 92–105. doi: 10.1002/even.10107
Wood, D., Wood, H., Ainsworth, S., & O'Malley, C. (1995). On becoming a tutor: Toward an ontogenetic model. *Cognition and Instruction*, *13*, 565–581.
Wood, D., Wood, H., & Middleton, D. (1978). An experimental evaluation of four face-to-face teaching strategies. *International Journal of Behavioral Development*, *1*, 131–147.
Ziv, M., & Frye, D. (2004). Children's understanding of teaching: The role of knowledge and belief. *Cognitive Development*, *19*, 457–477.
Ziv, M., Solomon, A., & Frye, D. (2008). Young children's recognition of the intentionality of teaching. *Child Development*, *79*, 1237–1256. doi: 10.111/j.1467-8624.2008.01186.x
Ziv, M., Solomon, A., & Strauss, S. (in press). Relations between the development of teaching in early childhood and theory of mind. *Megamot*. (In Hebrew).