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The Transformative Cultural Intelligence Hypothesis: Evidence from Young Children's Problem-Solving

Henrike Moll[1]

Abstract This study examined 4-year-olds' problem-solving under different social conditions. Children had to use water in order to extract a buoyant object from a narrow tube. When faced with the problem 'cold' without cues, nearly all children were unsuccessful (Experiment 1). But when a solution-suggesting video was pedagogically delivered prior to the task, most children (69% in Experiment 1, 75% in Experiment 2) succeeded. Showing children the same video in a non-pedagogical manner did not lift their performance above baseline (Experiment 1) and was less effective than framing it pedagogically (Experiments 1 and 2). The findings support ideas central to natural pedagogy (Csibra and Gergely *Trends in Cognitive Sciences*, 13(4), 148–153, 2009). They also challenge the Cultural Intelligence hypothesis, according to which only humans' social, but not their physical, cognition differs qualitatively from that of great apes. A more radical, transformative variant of the Cultural Intelligence hypothesis is suggested according to which humans' physical cognition is shaped by their social nature and must therefore be recognized as equally distinctive as their social cognition.

One of the most fundamental questions humans ask themselves is how their cognition differs from that of other animals. Philosophers, psychologists, and anthropologists have proposed various answers to this question. Tomasello and colleagues recently put forth the *Cultural Intelligence hypothesis*, according to which human rationality is not characterized by greater overall "cognitive horsepower" or intelligence but stands out solely in the area of social cognition (Herrmann et al. 2010). In response to selective pressures that favored collaborative foraging techniques, hominins are said to have

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✉ Henrike Moll
hmoll@usc.edu

[1] Department of Psychology, University of Southern California, 3620 S. McClintock Ave, Los Angeles, CA 99089, USA

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evolved unparalleled skills for mind-reading and cooperation. However, their reasoning about physical and causal matters is, on this account, comparable to that of the extant great apes. In the authors' own words: "Humans share many cognitive skills with nonhuman apes, especially for dealing with the physical world, but in addition have evolved special skills of social cognition" (Herrmann et al. 2010, p. 102).

At a first glance, research in comparative psychology appears to support this hypothesis because it suggests that apes and humans have distinct cognitive profiles—with that of humans being strongly tipped in favor of social cognition. Around the age of 1 year, humans engage in joint attention (Scaife and Bruner 1975), understand others' informative intentions (Behne et al. 2005), and even have an incipient grasp of others' epistemic attitudes such as beliefs (Sabbagh et al. 2013). Apes, by contrast, do not engage in joint attention (Carpenter and Call 2013; but see Leavens and Bard 2011), typically do not benefit from informative gestures (Bräuer et al. 2006), and fail to understand beliefs (Tomasello and Moll 2013). Yet, they appear to be as competent as 2- to 3-year-old children when it comes to understanding physical and causal relations. This is indicated by their similar performance on test batteries assessing object permanence, object rotation and tracking, and tool use (Herrmann et al. 2010, 2007; Wobber et al. 2014). In a seminal problem-solving task, apes even "outsmart" preschool children (Mendes et al. 2007). In an initial study using this task, orangutans were shown a peanut floating on a small amount of water inside a narrow tube. To be able to reach the peanut, the apes had to release water from a drinker into the tube so that the peanut would rise to the top. Impressively, all of five tested animals solved the problem. In a follow-up study with chimpanzees and human children (Hanus et al. 2011), the majority of the apes but only 17% of 4-year-olds passed the test. When the peanut lay on the bottom of a *dry* tube (Section 3), several chimpanzees still succeeded but none of the children did.

As mentioned, these and similar findings appear to confirm the Cultural Intelligence hypothesis because they suggest that from early on in their development, humans specifically excel in mind-reading and perspective-taking, but possess skills in instrumental reasoning that are on a par with those of apes and thus seem to "derive not from humans' unique forms of sociality, culture, and language but, rather from something like the individual problem-solving abilities of great apes" (Tomasello 2014, p. 2). In this paper, I will argue and provide evidence that this position fails to acknowledge the impact that children's sociality has on their physical cognition. Children's development of physical cognition affords cooperative forms of social learning, such as learning by demonstration, imitation, and teaching. In fact, most of what humans know they acquired testimonially from others who shared their knowledge with them (Anscombe 1979; McMyler 2011). Adults initiate children into the practices and knowledge shared by the community, including knowledge about physical causality and the proper use and functioning of objects. What an object is for and how it ought to be used is learned from others (Cimpian and Cadena 2010; Futó et al. 2010; Wood et al. 1976). As Vygotsky put it, "The path from object to child and from child to object passes through another person" (Vygotsky 1978, p. 30). On this view, children's ability to reason about the physical world is culturally mediated, and so cannot be said to develop in "direct continuation of corresponding processes in animals" (Vygotsky 1978, p. 20). The upshot is that it is incoherent to conceive of human physical cognition as an independent domain that is left untouched by humans' unique sociality and social cognition, as Tomasello and colleagues maintain. Inspired by these broadly Vygotskian ideas, I propose the *Transformative* Cultural Intelligence hypothesis, which differs from the classic Cultural Intelligence hypothesis in that it acknowledges that children's physical cognition is formed as part of humans' species-unique social development and thus cannot be seen as continuous with primate physical cognition. The claim is that children's reasoning about objects and causality must be recognized as equally unique as their social cognition, because the latter plays a constitutive role in how children come to grasp the physical world.

One way to provide support for this view is to show that children's reasoning about physical or causal events is affected by how the task is framed or socially presented to them. Natural pedagogy theory (Csibra and Gergely 2009, 2011) posits that humans evolved a communication system to pedagogically transmit knowledge that cannot, or not easily, be gleaned by simple inspection or observation. Humans are said to use a variety of behaviors to manifest their pedagogical intent and promote efficient learning: a personal address (calling child by name, eye contact), attentional imperatives ("Look!"), deictic gestures, and generic language ("Washers have holes in them"). (See Sage and Baldwin (2012), for partial confirmation that these behaviors are in fact deployed in educational parent-child interactions.) Faced with these markers, children take a pedagogical stance and tend to interpret what they learn as generic knowledge, i.e., as knowledge that holds true across instances, persons, and situations (e.g., Egyed et al. 2013; Topál et al. 2008). For example, when the magnetic property of a "blicket" is ostensively demonstrated to preschoolers, they expect other blickets to be magnetic too—but do not make this assumption when the blicket's magnetism is accidentally revealed (Butler and Markman 2010, 2012).

1 Current Study

In accord with natural pedagogy theory, it is argued that young children understand the generic nature of pedagogically transmitted knowledge and can benefit from this knowledge when faced with a novel problem. More specifically, this study addresses the question of whether young children's problem-solving can be shown to vary depending on how a problem is socially framed. In particular, it was asked if their ability to solve a problem can be enhanced by pedagogically introducing material that is relevant to its solution. If so, then it seems implausible to think that human physical reasoning can be divorced from their unique social abilities and be viewed as ape-like in quality.

To address this question, I compared the performance of 4-year-old children in the dry version of the aforementioned retrieval problem in different social conditions. Four-year-olds were selected because children at this age typically fail this task absent any cues (Hanus et al. 2011) but understand the generalizability that is suggested by generic statements (Butler and Markman 2012; Cimpian and Markman 2008)—which means that children this age might particularly benefit from a pedagogical introduction to the problem. In "Section 2", there were three conditions. In the *Baseline Condition*, which was modeled after Hanus et al.'s (2011) original task, children received no cues. In the *Incidental* and *Pedagogical* Conditions, children watched a video (see supplementary material) in which a puppet solved a similar problem by using water. This video was either shown incidentally, not as part of teaching, ("Is this a video? Let's watch it!") or pedagogically ("Look, *name of child*, I want to show you something!"). Table 1 shows the entire speech used to convey that the showing of the video is incidental or pedagogical, respectively. The prediction was that children's problem-solving would benefit more from a pedagogical compared to any other task presentation. No prediction was made regarding a potential difference between the Baseline and the Incidental Condition. In "Section 3", it was tested if the advantage of pedagogical over incidental knowledge transfer that was observed in "Section 2" persists when (episodic vs. generic) statements about the instrumental efficaciousness of water are better controlled. Such a finding would confirm that young children can identify educational interactions and apply what they learn in them to novel circumstances. More importantly given the purpose of this investigation, it would support the *Transformative Cultural Intelligence* hypothesis according to which children's physical cognition is shaped by their distinct sociality, of which pedagogical encounters form an integral part.

2 Experiment 1

2.1 Methods

2.1.1 Participants

Participants were 36 (18 females) 4-year-olds (M = 51.32 months for the Baseline Condition; M = 50.43 months for the Incidental Condition; M = 51.45 for the Pedagogical Condition; overall range = 46.48–56.25). They were recruited by phone calls from the university's subject list. Criteria for participation were that children spoke

Table 1 Overview of the language used by *E* in the Incidental and the Pedagogical Condition in the two experiments

Condition	Time relative to video demonstration		
	Before	During	After
Incidental Exp. 1	Someone must have left this here (*laptop*). Is this a video? Let's watch it!		
Incidental Exp. 2	Someone must have left this here (*laptop*). Is this a video? Let's watch it!	He's using water to get the ball out *(puppet pours water into channel).*	
Pedagogical Exp.1	Look, [*name of child*], I want to show you something!	It's stuck *(ball stuck in channel).* He's using water to get the ball out *(puppet pours water into channel).*	See, water can be used as tool
Pedagogical Exp.2	Look, [*name of child*], I want to show you something!		See, water can be used as tool – that's good to know.

English, were born full- or late preterm (> = 37 weeks gestation), and had no peanut allergy (all by parental report). Fifteen children were Caucasian, 15 'other', five Asian, and one African American. One additional child (Pedagogical Condition) was tested but excluded because she was uncooperative. Testing took place in a quiet room (3.55 × 5.80 m) at the university. Written consent was obtained from the participants' parents.

2.1.2 Materials and Design

Plant Watering and Drawing As in Hanus et al.'s (2011) study, children watered a plant in the test room just prior to receiving the retrieval task. The purpose of this was to familiarize children with the water and make them feel entitled to use it. In a pilot project prior to the study, some parents nonetheless suspected that their child refrained from using water at test because they were concerned about spillage. Children thus additionally drew with markers on the floor to further counteract any reluctance to use water out of fear of being untidy.

The plant that children watered (80 × 65 × 18.5 cm) stood on a table (45 × 55 × 55 cm) next to three transparent containers (12 cm in diameter, 18 cm high) filled with water. For the drawing activity, markers were used on a water-repellent section of the floor. Figure 1 depicts the experimental setup.

Retrieval Task and Video The retrieval task was administered at a second table (45 × 55 × 55 cm) 65 cm away from the table with the water. Three tubes (25.5 cm long, 4.5 cm diameter) made of acrylic glass were firmly attached to the table's legs at 19.5 cm above the ground. The table itself was mounted to the floor so that it could not be turned over. Each tube contained one of the objects shown in Fig. 2: an animal fig. (1 × 2 × 1 cm), an unshelled peanut, or a table tennis ball (3.8 cm diameter). The tubes were covered by a cloth.

The video (supplementary material) that children watched in the Incidental and Pedagogical Condition lasted 34 s and was shown on a laptop. It showed two puppets

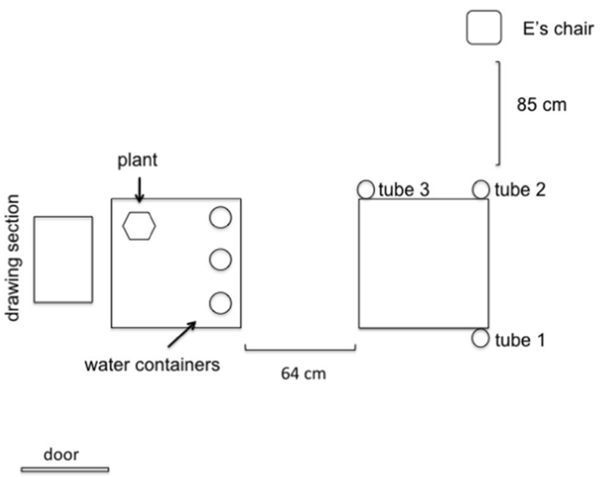

Fig. 1 Schematic view of the setup used in the two experiments

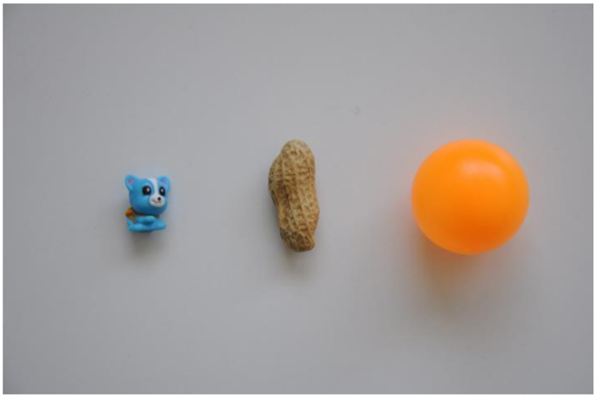

Fig. 2 The three objects used for the retrieval task in "Section 2"

rolling a ball back and forth through a channel, until the ball got stuck in the middle, out of their reach. One of the puppets then fetched water and poured it into the channel. The water released the ball, pushing it to the other end of the channel, where the other puppet retrieved it.

The room was void of any other objects (e.g., office utensils) to prevent children from getting sidetracked. Each child was randomly assigned to one condition. The order of tubes (1–3) was held constant; which object the tubes contained was balanced.

2.1.3 Procedure

E and the child entered the test room without a parent. *E* pointed at the plant and asked the child to water it using one of the containers. After the child watered the plant, they sat down and drew pictures on the floor for about 2–3 min. After this activity, *E* and the child turned to the cloth-covered table where the retrieval task was administered. What happened next varied by condition.

In the *Baseline Condition*, *E* lifted the cloth above the first tube. Pointing at the tube, she stated "Now here's a problem for you. There's a [*name of object, e.g., peanut*] in here! If you get it out, you'll get a surprise later. You can use anything you see in this room, but you have to figure it out all by yourself!" *E* claimed that she had to do some work. She sat down in a nearby chair, pretending to be busy. If the child did not succeed after 2 min, *E* said: "Keep trying! You can use anything you like!" This prompt was repeated after another 2 min. If the child did not succeed after a total of 6 min, the trial was ended. *E* then showed the child the next tube and repeated the instructions. The procedure was repeated for the third tube. This condition was modeled on Hanus et al.'s (2011) presentation of the task in their study.

In the *Incidental* and *Pedagogical Conditions*, a laptop stood on the table with the screen open. It showed the first frame of the video. In the *Incidental Condition*, *E* remarked "Someone must have left this here! Is this a video? Let's watch it!" She started the video, which the child and *E* then attentively watched. When the video was finished, *E* removed the laptop, lifted the cloth above the first tube and stated "Now here's a problem for you!" From hereon, the procedure was identical to the Baseline

Condition. The same procedure was repeated on subsequent trials. In the *Pedagogical Condition,* when *E* and the child reached the laptop, *E* stated "So, [*name of child*], look here, I want to show you something!" *E* started the video. When the ball in the video got stuck in the channel, *E* exclaimed "It's stuck!" followed by "He's using water to get the ball out." When the video was finished, *E* looked at the child and stated "See, water can be used as a tool!" *E* removed the laptop, lifted the cloth over the first tube, pointed at it and declared: "Now here's a problem for you!" The procedure continued as in the Incidental and the Baseline Condition.

2.1.4 Scoring and Reliability

E scored the responses during the session. For every trial, she judged if the object was successfully retrieved. Successes were scored as '1', failures as '0'. To assess inter-observer reliability, an independent observer, who was unaware of condition, coded a random sample of 25% of children in each condition based on the recordings. There were no disagreements (Cohen's $K = 1$). For descriptive purposes, the independent observer furthermore noted if i) a child used water ineffectively by pouring an insufficient amount into the tube (a behavior that (Hanus et al. 2011) occasionally observed in apes), ii) attempted to retrieve the object manually, and iii) addressed *E* for advice. Six trials had to be disregarded because the child became too upset over not solving the task (four), retrieved the object by hand (one), or because a parent—having failed to report an allergy—requested that the trial with the peanut be omitted (one). Percentage scores (number of successful trials divided by completed trials × 100) are therefore reported.

2.2 Results and Discussion

There were no effects of gender, trial, or object, *p*s > .47 (all two-sided), so these factors were removed from the final analyses. Table 2 shows for each condition how many children achieved a certain percentage of successful retrievals, with the mean performance in the final column. On average, children in the Baseline Condition retrieved the object 8% ($SE = .08$) of the time, compared to 25% ($SE = .13$) in the Incidental, and 67% ($SE = .13$) in the Pedagogical Condition. An analysis of variance (ANOVA) yielded a strong effect of condition, $F(2, 33) = 6.63$, $p = < .01$, partial $\eta^2 = .29$. Pairwise comparisons with the Tukey-test were conducted to determine which group differences caused the effect. Children's performance in the Baseline and the Incidental Condition

Table 2 "Section 2": Number of children (out of 12 per condition) with a given percentage of successful trials in each condition

Condition	N children (out of 12) % success				Mean % correct
	0%	33%	67%	100%	
Baseline	11	–	–	1	08 (.29)
Incidental	9	–	–	3	25 (.45)
Pedagogical	3	1	1	7	67 (.45)

Means (with standard errors in parantheses) are displayed in the far right column did not differ, $p = .58$. However, children in the Pedagogical Condition were more successful than children in the Baseline, $p = .003$, and than those in the Incidental Condition, $p = .043$.

One child (Pedagogical Condition) used water ineffectively by pouring an insufficient amount into the tube. All others used the water successfully or not at all. Except for three children (who solved the problem early in the trial), all tried to access the object by reaching into the tube. Manual attempts to reach the objects thus predominated, although children were reminded that they could “use anything”. Despite having been instructed to solve the problem by themselves, 25% addressed *E* at least once for advice (with *E* ignoring this request).

In this experiment, 4-year-olds had to use water to make a buoyant object float within reach. As in a previous study (Hanus et al. 2011) children were, with one exception, unsuccessful in the absence of cues, which confirms that children this age do not spontaneously think of water as an agent of mechanical force. But most children solved the problem when solution-suggesting material was pedagogically framed. The same material, when shown incidentally, i.e., intentionally but with no teaching motive, did not facilitate success. As predicted by natural pedagogy theory (Csibra and Gergely 2009), introducing the video pedagogically led children to conceive of it as relevant beyond the learning episode and enabled them to see its connection to the retrieval problem. By contrast, without any signs of pedagogical motivation, children failed to recognize the material’s relevance for the problem at hand.

A point of criticism might be that children were successful in the Pedagogical Condition not because they recognized the video as portraying general knowledge, but simply because they paid better attention to the video than children in the Incidental Condition. Skeptics of natural pedagogy have argued that the benefits of ostensive communication can be reduced to children paying more attention (Szufnarowska et al. 2014). To address this possibility, a research assistant, who was unaware of condition, coded for how long children (25% per condition) visually fixated the video. All children, regardless of condition, focused on the video throughout its duration of 34 s. Along with other data (Sage and Baldwin 2011), this finding refutes the idea that the advantages of pedagogical task presentations can be adequately explained by children attending more keenly to what they are shown.

There are many ways in which pedagogical situations can be contrasted with non-pedagogical ones. In the Pedagogical Condition of this experiment, the adult not only made a generic statement about water being instrumentally useful (“Water can be used as a tool”) but also episodically narrated the video while it was shown (“It’s stuck” when the ball got trapped, followed by “He’s using water to get the ball out!” when the puppet poured the water in the channel). This was done in recognition of the fact that observational statements have their place in teaching alongside generic locutions (e.g., “She is placing a washer between the nut and the surface. Washers enhance the nut’s grip and protect surfaces.”) None of this language was used in the Incidental Condition, however, which leaves open the possibility that children in the Incidental Condition failed the task not because they were not taught about the usefulness of water but simply because the crucial part of the video was not narrated to them.

In “Section 3”, it was therefore tested if the advantage of pedagogical compared to incidental knowledge transmission holds up when the adult’s speech is more balanced. In the Incidental Condition, the adult episodically narrated the video by stating “He’s using water to get the ball out" as the puppet used water to release the ball. In the Pedagogical Condition, the adult generically asserted that "Water can be used as a tool—that's good to know" without episodically narrating the video. The adult's speech was thus more balanced between conditions, with an act of *telling* (of a particular instance of an agent's instrumental use of water) in the Incidental Condition versus an act of *teaching* (about the instrumental effectiveness of water) in the Pedagogical Condition.

3 Experiment 2

3.1 Methods

3.1.1 Participants

Participants were 48 (24 females) 4-year-olds (M = 51.74 months for the Incidental Condition; M = 52.33 for the Pedagogical Condition; overall range = 47.96–58.22). Children were recruited from the same subject list and according to the same criteria, with the exception that a peanut allergy was no reason for exclusion because the peanut was replaced with a small toy (see Section 3.1.2). Twenty children were Caucasian, 23 'other', one Asian, and four African American. Testing took place in the same room as "Section 2". Five additional children (three Pedagogical, two Incidental Condition) were tested but excluded due to uncooperativeness.

3.1.2 Materials and Design

Two minor changes were made to the materials to improve test conditions. First, narrower tubes (3.5 instead of 4.5 cm in diameter) were used to avoid manual retrievals (observed once in "Section 2") and "near-hit" misses in reaching down the tube, which could lead children to perseverate on this ill-advised strategy. Second, two objects were exchanged: The peanut was replaced with a red jack (2 × 1 × 1.5 cm) to avoid allergy-related exclusions, and the table tennis ball, which was too large for the new tubes, was replaced with a smaller rubber ball (2.5 cm circumference). The other materials and the design were kept the same.

3.1.3 Procedure

The procedure was identical to "Section 2" and identical across conditions until *E* and the child reached the table with the laptop. The *Incidental* Condition was identical to that of "Section 2" until the puppet in the video poured water into the channel to release the ball. At this point, *E* stated "He's using water to get the ball out." From hereon, the procedure continued as in "Section 2". In the *Pedagogical* Condition, everything was as in "Section 2" until the video was shown. This time, the adult did not narrate the content of the video, but silently watched it with the child. After it ended, *E* declared "See, [*name of child*], water can be used as a tool—that's good to know". Hereafter, the procedure continued as in "Section 2".

3.1.4 Scoring and Reliability

Scoring and the measurement of reliability followed the same procedures as in "Section 2". Inter-rater reliability was perfect (Cohen's $K = 1$). Out of 72 trials total, four could not be completed because the child became too frustrated with the problem. Percentages (successful over valid trials × 100) are therefore reported.

3.2 Results and Discussion

There were no effects of gender, trial, or object, *p*s > .41 (all two-sided), so these factors were disregarded. Table 3 shows how many children in each condition achieved a given success rate, with the final column showing the mean performance (with *SE*s in parentheses). On average, children in the Incidental Condition retrieved the object 38% of the time compared to 67% in the Pedagogical Condition. A t-test for independent samples was conducted to compare performances between conditions. It revealed that children in the Pedagogical Condition were significantly more successful than children in the Incidental Condition, $t(46) = -2.11$, $p = .04$; Cohen's $d = .610$.

One child (Incidental Condition) used water ineffectively by pouring a small amount into the tube. Sixty-nine percent of the children reached into the tube at least once, so manual attempts remained a prevalent strategy despite the narrower tubes. Thirty-five percent addressed *E* at least once for advice, again confirming young children's natural inclination to turn to others for guidance when they are faced with a novel problem.

In this experiment, the advantageous effects of pedagogically compared to incidentally conveyed knowledge on children's problem-solving were replicated. Compared to "Section 2", the Incidental Condition was enhanced by not only showing children a solution-suggesting video, but additionally narrating its content in episodic terms ("He's using water to get the ball out"). No such episodic narration was used in the Pedagogical Condition. The fact that children were again more proficient in the Pedagogical Condition suggests that verbally referring to a particular act of problem-solving is neither necessary nor sufficient for children to learn in a way that leads to knowledge transfer to a new problem. Young children clearly differentiate between being *taught* (general facts) and being *told* particular events (see Small 2014, on teaching and telling), and it is knowledge acquired by teaching, not telling, that significantly informs their problem-solving.

Table 3 "Section 3": Number of children (out of 24 per condition) who received a given percentage score of successful retrievals in each condition

Condition	N children (out of 24) % success				Mean % correct
	0%	33%	67%	100%	
Incidental	15	–	–	9	38 (.10)
Pedagogical	7	1	1	15	67 (.09)

Means (with standard errors in parentheses) are displayed in the far right column

4 General Discussion

In two experiments, 4-year-olds were given a task that affords the use of water to retrieve an object. When faced with the problem 'cold' without cues, almost no child succeeded (Section 2). Under these circumstances, chimpanzees can be said to outstrip children (Hanus et al. 2011). But when a solution-suggesting video was pedagogically introduced to children, the majority (69% in "Section 2", 75% in "Section 3") succeeded. The same video presented in an incidental manner did not lift children above baseline (Section 2) and did not yield the same success as its pedagogical presentation (Sections 2 and 3). An examination of children's visual attention in "Section 2" ruled out that children in the Pedagogical Condition simply paid more attention to the video, which debunks reductive explanations that try to account for the benefits of pedagogy in terms of heightened attention (Szufnarowska et al. 2014).

The results underscore children's responsiveness to others' attempts to convey knowledge (Csibra and Gergely 2009, 2011). Along with prior studies on children's learning about artefacts and natural kinds (Brandone et al. 2012; Butler and Markman 2010; Sutherland et al. 2015), the findings confirm that young children can identify educational encounters and acknowledge the trans-situational validity of knowledge that is transmitted in them. Crucially, the children in this study *transferred* what they learned to a situation that differed from the scene portrayed in the teaching episode. In the video, a puppet used water to flush out a ball stuck in a channel. The children, on the other hand, had to use water to make an object float upward in a tube. Transferability is a major ambition of teaching. The teacher invites the learner to take the shared knowledge with her and see for herself where it "fits" and how it might be expanded—what Small (2014, p. 382) refers to as the "inspirational dimension" of teaching. Even though children in this study did not refine or expand the knowledge they acquired, they found a creative way to apply it to a novel situation. Being taught thus gave them insight into a problem's solution that they in all likelihood would not otherwise have had.

In this respect, the findings transcend what has been shown by imitation and tool-use studies. These studies have revealed that children faithfully copy the action performed by an adult to accomplish some goal, such as extracting an object from an apparatus. Action steps that are marked as intentional (though not necessarily pedagogical; see Hoehl et al. 2014) are usually imitated by children, even when it seems obvious that they are causally ineffective (Gardiner et al. 2011; Lyons et al. 2007). But in these experiments, children were directly shown the problem's solution. They just needed to re-enact what they were shown. In the present study, by contrast, the solution was not modeled, but embedded in material from which it needed to be extracted. Children had to "see" the solution in the material, which they presumably accomplished by recognizing the material *as a demonstration* for the purpose of instruction or as an exemplary manifestation of generic knowledge (see also Bonawitz et al. 2011; Csibra and Gergely 2011). This study is thus a first step in the direction of tracing the effects of pedagogy on young children's transfer of knowledge to new situations that differ markedly from the teaching episode. Further research is needed not only to explore the extent of this transfer, but also to investigate the relation between pedagogical exchange and young children's spontaneous effort to expand or further their own knowledge, which teaching hopes to achieve.

Another difference between this and prior studies concerns the stringency of the control condition. In previous controls of imitation and problem-solving studies, an adult marked her behavior as unintentional or accidental (which children do not deem worthy of being copied; Carpenter et al. 1998). What children witnessed in these controls was thus not action, but mere behavior. By contrast, the control condition of the present experiments showed an agent deliberately engaging in causally efficacious action. Nothing about the displayed act was accidental. The difference between conditions was thus not in the teleology or success of the action but only in how the action was introduced: either as a demonstration of general knowledge (Pedagogical Conditon) or as a particular occurrence of successful problem-solving (Incidental Condition). Despite this difference being rather small, it notably impacted children's problem-solving, which benefitted distinctly from a pedagogical presentation of the action.

A limitation of the present study is that the single contribution of elements that were bundled together to create a teaching episode cannot be determined. In keeping with natural pedagogy theory, ostensive-communicative signals (eye contact, calling child's name, "Look", "I want to show you something") were combined with generic language ("Water can be used as a tool!"). These cues are commonly clustered in pedagogically-minded adult-child interactions (Sage and Baldwin 2012) and were conjoined in this study to unambiguously convey the educational purport of the situation. However, one consequence of this is that it cannot be teased apart which particular component or complex of components was effective in leading children to adopt a pedagogical stance. Also, the generic statement in the Pedagogical Condition was changed from "Water can be used as a tool" (Section 2) to "Water can be used as a tool—that's good to know!" (Section 3). The aim of the added phrase was to underscore the educational character of the statement, without thereby altering the propositional content or leading children directly to the solution. In any case, the fact that multiple changes were made from "Section 2" to "Section 3" (excluding the episodic language and intensifying the generic statement by adding "that's good to know!") prevents us from pinpointing the effect of each single change.

Natural pedagogy theory has been challenged on various levels. Among those things that have been called into question are the role of ostensive signals for learning and exploration (Bonawitz et al. 2011; Correa-Chavez and Rogoff 2009), the universality of these signals, as well as the evolutionary story about the emergence of pedagogy (Nakao and Andrews 2014). I concur with parts of the criticism and see a problem with the portrayal of the infant or young child as a "sponge" that is evolutionarily designed for optimal information uptake, which is primed by ostensive signaling. My agreement with natural pedagogy theory mainly lies in recognizing the importance of intergenerational knowledge transmission for children's acquisition of what would otherwise remain opaque and inaccessible (Gergely and Csibra 2013). Just how much children rely on other persons in epistemic matters was confirmed not only by the pedagogical effects observed in this study but also by children's tendency to address the adult for advice despite having been instructed to solve the problem individually.

Above all, the present findings challenge the Cultural Intelligence hypothesis, which states that "cognitive development in the physical domain is still basically equivalent to that of the common ancestor of humans and chimpanzees some 6 million years ago" (Herrmann et al. 2007, p. 1365). While it is true that shared intentionality and cooperation are what first and foremost set humans apart from other animals, this hypothesis underestimates the pervasive impact that humans' unique sociality—which is characterized by shared intentionality and cooperation—has on children's cognitive development, including their emerging understanding of the physical.

Children do not discover how the world works as individuals. This is impossible in a world replete with artefacts (e.g., tools), symbols, rules, and conventions, which children learn to use and understand through participation, imitation, and by being taught. The current study offers one example of the extent to which children rely on others in their understanding of the world. But if children's physical cognition is formed as part of their social development, as I suggest, then it is incoherent to think of the former as evolutionarily continuous and essentially "ape-like". The *Transformative* Cultural Intelligence account stresses that humans' physical cognition, because it develops in epistemic exchanges with others, cannot be completely divorced from their social cognition or traced back to ape instrumental rationality in a straight line. Importantly, it is not denied that primate physical cognition is immune to variations in the social environment. Social enhancement and observational learning influence apes' tool use (Call and Carpenter 2002; Whiten et al. 2004), and long-term factors such as rearing circumstances (Russell et al. 2011) or population membership (Whiten et al. 1999) leave their mark on how apes interact with the local environment. But the case of humans is different: Their physical cognition is not just responsive to an ecology that includes social factors, but is formed in necessary epistemic exchanges with others that reflect the cooperative and interdependent nature of the species to which they belong.

Finally, the present findings urge reflections about the methodology of studies in comparative cognition. A major maxim of this field, at least for *pan-homo* comparisons, has been to construct test conditions that are as similar as possible across genera for the sake of comparability (Mulcahy and Hedge 2012). But if human children were presented with the retrieval task in a way that closely resembles the apes' version, then they would neither know the task objective (which has to be made explicit to them) nor the rules (they need reassurance that using water is permitted); in short, they would be set up for failure. At the same time, imposing the interactive test format that children require on apes would be equally inept. Paradoxically then, identical conditions spoil, rather than guarantee, comparable test results. So how to strike the balance between similarity across tests on the one hand and adaptations that tether the test to the species' different natures on the other? There does not seem to be a simple answer, but acknowledging this dilemma might instigate a redefinition of the purpose of comparative studies—for example as trying to identify the different approaches that animals and humans take toward a situation or determining the conditions under which a species is most likely to solve a problem of a certain kind. The adaptations necessary to yield this success might reveal more about the cognitive make-up of the species than the test result itself. The field has begun to move in this direction, with productive debates revolving around the idea that ape cognition might be most fruitfully tapped in opportunistic, dog cognition in imperative, and child cognition in cooperative settings. This is not to say that apes never engage in cooperative activities (see Melis et al. 2006) or that human children do not know how to compete (e.g., Greenberg 1932)—they do. But these behaviors take on different forms and play different roles in the lives of animals versus humans (Kern and Moll 2017). Instead of viewing these circumstances as factors that undermine comparability, we might be well-advised to recognize their potential in unlocking key differences in animal and human cognition.

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