Controlling the message: Preschoolers' use of evidence to teach and deceive others

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Abstract

Effective communication entails the strategic presentation of evidence; good communicators present *representative* evidence to their listeners—evidence that is both consistent with the concept being communicated and also unlikely to support another concept a listener might consider. The present study examined whether preschool-age children effectively select evidence to manipulate others' semantic knowledge, by testing how children choose evidence in a teaching or deception task. Results indicate that preschoolers indeed effectively select evidence to meet specific communicative goals. When asked to teach others, children selected evidence that effectively spanned the concept of interest and avoided overly restrictive evidence; when asked to deceive others into believing a narrower concept, they selected evidence consistent with the overly restricted belief. Thus, results support the idea that preschool children possess remarkable abilities to select the best evidence to manipulate what others believe.

Keywords: Cognitive development; evidential reasoning; teaching and deception; psychological reasoning

Effective communication often entails the strategic presentation of evidence: Politicians describe uncontroversial portions of their proposals and leave out less palatable details; storytellers present the components of their narratives slowly to build anticipation of major events; teachers present unambiguous examples to help learners obtain new concepts, leaving aside exceptions and qualifications until the basic ideas are in place. In each case, effective communicators consider the evidence relevant to the beliefs they wish to communicate, reason about how particular evidence will shape the mental states of listeners, and present specific evidence accordingly.

Any idea can be conveyed with infinite data, but practical constraints limit the amount of evidence a communicator can provide to impart a particular idea. Given these limits, there may be ambiguity in a message; the evidence may support inference to multiple possible intended concepts. Thus, good communicators must select representative evidence—evidence that is both consistent with the concept being communicated and also unlikely to support another concept a listener might consider (Griffiths & Tenenbaum, 2001).

There is a long literature supporting the claim that the number of possible meanings in a message is constrained by a set of assumptions shared between listeners and communicators (e.g. Clark, 1996; Grice, 1975; Sperber & Wilson, 1986). Recent models also show the importance of reciprocally reasoning about both the goals of the communicator and the inferences of listener in communicative contexts (Frank & Goodman, 2012; Shafto, Goodman, & Frank, 2012). The norms are similarly important in the specific case of pedagogy – where a learner must infer the intended concept being conveyed by a teacher (Shafto & Goodman, 2008).

These communicative norms are helpful for effective teaching, but one can also take advantage of these communicative norms to deceive another. For example, consider learning a rule about what makes machines activate. If repeated examples of red objects activating the machine are given and objects of other colors are never chosen, one might infer that *only* red objects activate the machine, even though the evidence is also perfectly consistent with the broader rule that *all* objects activate the machine. An effective deceiver, like an effective teacher, must be able to simultaneously consider the beliefs of another (e.g. pragmatic assumptions) and the implications of different choices of evidence for a concept given these beliefs.

Here we examine whether preschool-age children make effective use of evidence to manipulate others' beliefs. We ask children to either teach or deceive their listeners about a concept. We test whether children strategically select evidence in a concept rule-learning game. In what follows, we first briefly review the development of reasoning about another's mental states, in the context of providing information for another. Next we present our empirical studies of children's evidence selection in teaching and deceptive conditions. We conclude with a discussion of our results and implications for future work.

Developing understanding of evidence and the role of another's mental state

Before formal schooling, children can make accurate guesses about the concepts being communicated from representative evidence (Gopnik & Wellman, 2013; Tenenbaum & Xu, 2007). Children's evidential reasoning distinguishes between different types of communicative contexts (Bonawitz, Shafto et al 2012; Buschbaum et al, 2012), and children can use data to infer communicative intent such as whether evidence was generated purposefully with the goal of teaching, or accidentally (Gweon & Schulz, 2011; Gweon, Tenenbaum, & Schulz, 2010). Less is known, however, about children's ability to select evidence in the service of communicating a concept to another.

Mental state reasoning when providing information

By quite early in development, children systematically consider their social partners' mental states when providing information. For example, in the second year of life (ages 18-24 months), infants track whether other people hold true or false beliefs about the locations of objects and intervene by pointing to communicate true locations only when necessary (i.e., only to prevent a person holding a false belief from making a mistake; Knudsen and Liszkowski, 2012a, 2012b; see also Buttelmann, Carpentar, & Tomasello, 2009). Furthermore, two-year-olds are more likely to add verbal cues for a partner when pointing alone may produce ambiguity in the referent (O'Neill & Topolovec, 2001), and three- and four-year-olds produce more informative speech when their partner does not have visual access to a scene (Matthews, Lieven, Theakston, & Tomasello, 2006).

In addition to tracking the mental states of others when providing information, children's early deceptive behaviors can also reflect attempts to instill specific mental states in other people. Simple deceptive behaviors, such as denying having performed an action (Lewis, Stanger, & Sullivan, 1989), withholding information (Peskin, 1992), or marking an incorrect location (Carlson, Moses, & Hix, 1998; Chandler, Fritz, & Halla, 1989; Russell, Mauthner, Sharpe, & Tidswell, 1991; Sodian, Taylor, Harris, & Perner, 1991) emerge in the preschool years and are linked to false-belief and inhibitory control (e.g. Talwar & Lee, 2008). These tests of early deceptive behaviors have focused on fairly simple manipulations of episodic knowledge—children deceptively communicating that previous events either did or did not occur. Even in these straightforward contexts, preschool-age children often undermine their own intentions to deceive by accidentally "leaking" information that reveals the truth (Talwar & Lee, 2002). Thus, although prior work has shown that young children attempt to manipulate others' mental states through deception, based on this work, children's understanding of the relation between the information they provide and their partners' mental states appears somewhat precarious.

Here we examine whether late preschool-age children can strategically select evidence to instill particular semantic knowledge in other people. Success on such a task would require selecting the most effective evidence between multiple sets of true information—unlike the tasks described above, which involved a simpler decision of whether to provide information or not.

Preschooler's understanding of evidence

Previous work examining children's ability to evaluate the effectiveness of multiple sets of evidence comes primarily from the literature on scientific reasoning, and suggests that metacognitive reasoning about evidence often develops fairly late in childhood (Bindra, Clarke, & Schultz, 1980; Chen & Klahr, 1999; Fay & Klahr, 1996; Klahr & Chen, 2003; Koslowski, 1996; Masnick & Klahr, 2003). For example, preschool-age children often have difficulty deciding whether particular sets of evidence provide good support for new hypotheses (Rhodes, Gelman, & Brickman, 2008). Indeed, even older children and adults struggle with designing informative interventions in order to generate meaningful evidence (Kuhn, 1989; Kuhn, Amsel, & O'Laughlin, 1988).

Contexts that involve the communication of simpler concepts might reveal earlier, nascent forms of evidence-selection abilities, however. For example, Rhodes and colleagues (2010) found that six-year-olds select evidence more strategically when asked to communicate a concept to someone else than when asked to discover a concept for themselves. Thus, communicative contexts may elicit particularly sophisticated use of evidence. We return to a discussion of this potential benefit of leveraging social situations to reason about evidence in the discussion.

Experiment: Preschoolers select evidence to teach or deceive another

In the present study, we asked four- and five-year-olds to choose a representative sample of evidence to teach or deceive another about a concept, providing a test of whether preschoolers can effectively select evidence to manipulate the semantic knowledge of other people. Previous research has demonstrated that younger preschoolers may have a developing understanding of the relationship between communicative content and another's beliefs (e.g. Talwar & Lee, 2008, 2002), so we focus on children just at (and above) this potential transitional stage. Furthermore, we focus on children at this age, as this is just before the time that children begin formal schooling, and we are interested in children's intuitive beliefs about, and approaches to, evidence selection in teaching and deception.

Methods

Participants. Participants (N = 32, 15 female; M age = 4.8 years, range = 4.0-6.1 years) were randomly assigned to one of two conditions (Teaching, N = 16; Deception, N = 16; an additional 3 participants were excluded for experimenter error). Half the children in each condition first participated in another study (participating in the other study did not affect the present results; $\chi 2$ (4) = 6.12, p = .2). There were no differences in age between children by condition and prior study exposure (F(28) = 1, p = .407).

Procedure. Children were introduced to a novel toy and a transparent container containing blocks. The blocks included four demonstration blocks and four blocks to be used as evidence (see Figure 1), though at the beginning of the experiment, all of the blocks were intermixed in the transparent container. In a seemingly random fashion, the experimenter drew the set of four demonstration blocks from the container and laid them on the table in front of the child in one of two orders. To familiarize children with the blocks, they were asked to point to each one (e.g., "Can you point to the red triangle? Now, can you point to the yellow star?").

Next, children were taught that placing any of the blocks on the machine would "make it go" (i.e. cause an attached propeller to spin). They were told, "'Now we're going to play a game with my special toy. This toy is special because my blocks make it go. *All* of my blocks make it go! Let me show you how it works." The experimenter proceeded to place each of the blocks on top of the machine and each time the propeller activated and the experimenter said, "'Oh look! Did you see the toy go? This [block] made my toy go." After all four demonstrations, the experimenter picked up each block one at a time and asked, "So did this [block] make the toy go?" All of the participants answered correctly. The experimenter reiterated that all of the blocks activated the machine, including the rest of the blocks (the evidence set) in the transparent bucket, by saying, "All of the blocks make it go! All of the blocks we have laid out here, and all of the blocks in the bucket too!" The experimenter then put the demonstration blocks back in the transparent container.

Children were then introduced to a puppet, "Daisy," and told that she did not know which blocks would activate the toy. The puppet was then removed from sight. In the Teaching condition, children were told, "A little while ago, I had a different toy that looked just like this toy, but for my old toy, only red blocks made it go." They were reminded that for the current toy all the blocks make it go and told that their goal was to help Daisy learn that all blocks make it go. In the Deception condition, children were told, "Let's play a fun trick on Daisy and make her think that only red blocks make it go." They were then reminded that in reality, all the blocks make it go, but that their goal was to trick Daisy to make her think that only red blocks make it go. The phrases "red blocks" and "all blocks" were used equal numbers of times across conditions.

Children were then presented with four new blocks (Figure 1c)—the set of possible evidence—and were asked to select two of the four blocks to communicate the intended concept to Daisy (e.g. "Let's pick the best two blocks to show her" [Teaching: "so she will learn that all blocks make it go"; Deception: "to trick her into thinking that only red blocks make it go"]). In both conditions, the experimenter asked, "So remind me one more time. How many blocks are we going to show Daisy?" Corrective feedback was given when necessary. Daisy was then brought back into view, and the experimenter said, "Remember, you can pick any of these four blocks to show Daisy to help her think about how the toy works. Which one do you want to show her first?" The child then put the chosen block on the platform and Daisy witnessed the toy activating. Before they selected their second clue, the experimenter gestured to the evidence set and said, "Remember you can pick any of these four blocks to show Daisy. You showed her this one. Which one do you want to show her next?"

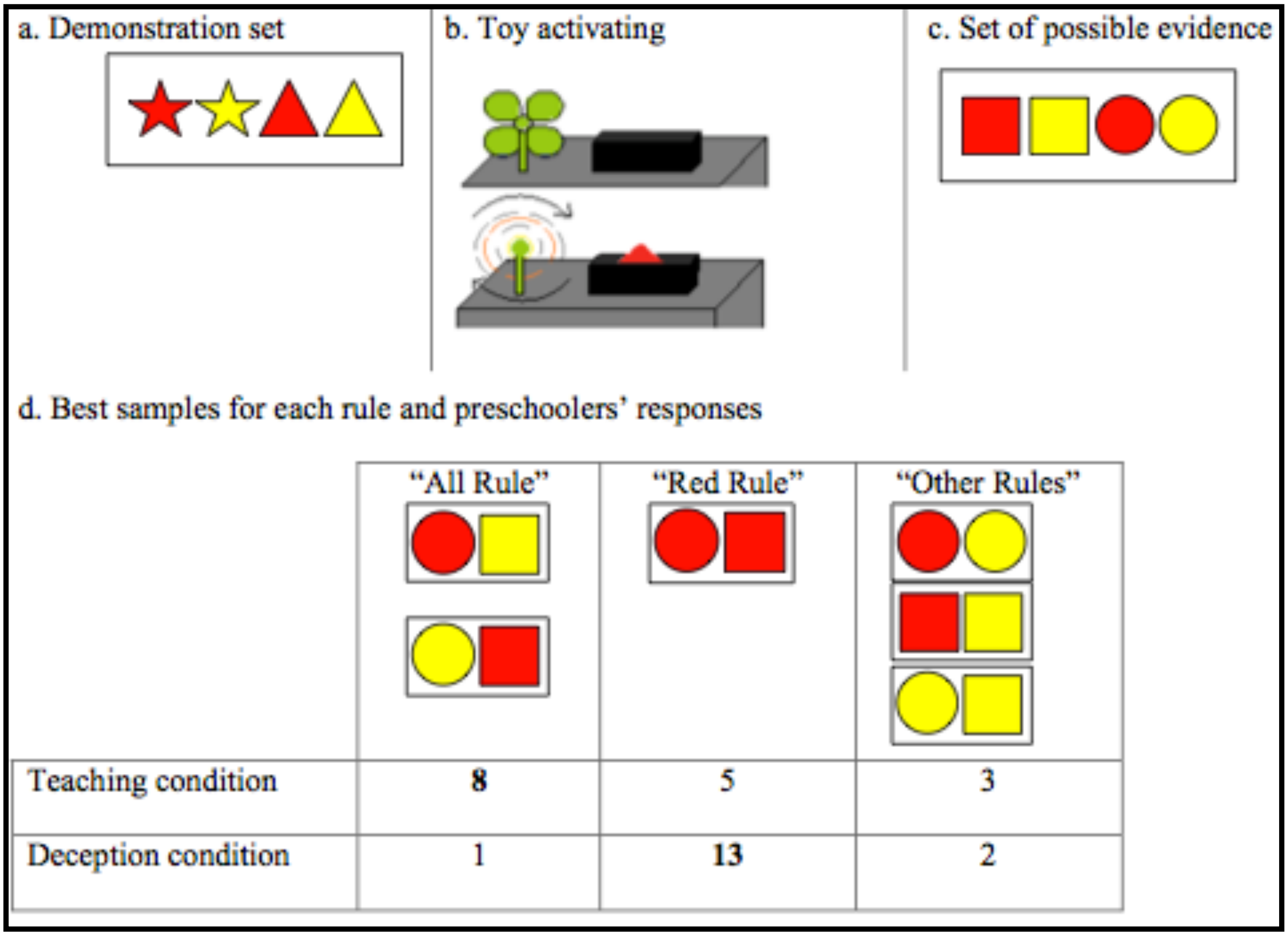
After the child selected the second block, Daisy was then put away and the experimenter asked to be reminded what actually makes the machine go by asking, "What really makes the machine go?" The majority of children in both conditions correctly generated the response that all blocks activate the machine (Teaching, 12/16; Deception, 13/16).

Results

Children's evidence selections uniquely and unambiguously fell into one of three categories: teaching target, deception target, other (Figure 1d). Children effectively selected evidence to communicate the belief specified by their condition; their selections differed depending on whether they were given a teaching goal or a deceptive goal, Fisher exact, p = .008, see Figure 1d. (These results are also significant when examining only the children who generated the correct rule at the very end of the experiment: Fisher exact, p = .01).

We also compared the distribution of children's responses in each condition to the distribution of responses expected in each of the three categories if children were responding at chance[1]. Within each condition, children's selections reliably differed from chance (Deception, $\chi^2(2) = 46.06$, $p <$ .001; Teaching, $\chi^2(2) = 6.50$, p = .039). In the Deception condition, children most often selected evidence that communicated that only red blocks activate the toy, whereas in the Teaching condition, children selected evidence that best communicated that all blocks turn on the toy.

[1] The possible pairs of blocks are not equally distributed across each rule. For example, only one pairing of blocks supports the "Only Red" rule, two pairs best support the "All Blocks" rule, and three different possible pairs support the "Other Rules". Thus, the Probability of randomly selecting objects consistent with each rule differs by rule, so a Chi-square Goodness of Fit test was used to compare the response pattern of each condition to chance.



	"All Rule"	"Red Rule"	"Other Rules"
Teaching condition	**8**	5	3
Deception condition	1	**13**	2

Figure 1. (a) Set of four blocks used to demonstrate that all blocks make the toy go. (b) The novel toy pictured in the off position and the on position. (c) Participants were asked to select two blocks, from this set of four possible evidence blocks, to show Daisy so that she can infer the rule specified by the child's condition. (d) Number of children choosing each pair of samples in the Teaching and Deception conditions (Probability of randomly selecting objects consistent with "All Rule"=2/6, "Red Rule"=1/6, "Other Rules"=3/6).

Discussion

These data show that preschoolers effectively select evidence when prompted to teach or deceive other people. Both conditions require a level of strategic evidence selection that goes beyond what has been previously demonstrated in preschoolers. In the Teaching condition, all of the evidence that children could choose was consistent with the truth (i.e. that all blocks turn on the toy), yet children strategically chose to select evidence that spanned the concept and thus avoided communicating an overly restricted rule (e.g., that only squares or yellow blocks turn on the machine). In the Deception condition, children inhibited their knowledge of the true rule (that all blocks would activate the machine) and effectively selected evidence that would communicate a false, overly restricted rule (that only red blocks would activate the machine).

In this study, the design required that the Deception condition entail a more "restrictive" rule than the Teaching condition. In particular, if the actual rule was that "only red things activate the machine" and the Deception condition required communicating the broader rule that "all things activate the machine," there would be no effective way to generate evidence, because selecting a broader sample (e.g. yellow objects) would belie the deceiver: the machine would not activate when a yellow object was set on top. That is, a key feature of our design was that all of the samples of evidence could be displayed truthfully—in each case, the child had to choose among the possible sets of truthful evidence to communicate the intended concept most effectively. Although we do not believe that always presenting the more restrictive rule in the Deception condition can account for our results, it would be interesting to control for this in future studies by exploring preschoolers' abilities for teaching and deceiving in probabilistic contexts – where one might be able to generate an unlikely or unrepresentative (and thus potentially deceptive) observation for a learner.

There is a growing tension in the literature on children's early evidential reasoning. Studies like these suggest precocious evidential reasoning in communicative contexts (e.g. see also Bonawitz et al, 2012; Bonawitz & Lombrozo, 2012; Cook, Goodman, & Schulz, 2011; Schulz & Bonawitz, 2007). In contrast, there is formidable evidence that children have significant trouble reasoning about, and effectively using evidence in tests of their scientific reasoning (Bindra, Clarke, & Schultz, 1980; Chen & Klahr, 1999; Fay & Klahr, 1996; Klahr & Chen, 2003; Koslowski, 1996; Masnick & Klahr, 2003). In future work, it will be important to examine these apparent conflicting findings.

One possibility for the differences found by these literatures is that different reasoning mechanisms support information communication vs. information discovery (Rhodes et al., 2010). In particular, although children may use the composition of a sample of evidence to infer a communicator's intent (or the belief that a learner will form), they may not attend to the same features of the evidence for discovering new information. When it comes to information discovery, children might rely more strongly on their prior hypotheses about the structure of their environment, and thus give less attention to the composition of new samples of evidence.

A second, but related possibility is that the same mechanism supports learning in both contexts, but that communicative contexts bolster children's performance for other reasons. For example, truly effective teaching and deceiving requires reasoning about another's beliefs. Reasoning about another person's beliefs might help children consider alternative hypotheses to their own, which in turn helps children consider the best set of evidence to select given these alternatives. Ongoing work is also exploring this possibility.

Yet, another possibility is that children succeeded in the present task because it involved simpler concepts than have been tested in prior work. Indeed, in other on-going work, we have found that even in instances of concept communication, preschool-age children show less systematic evidence selection when the number of dimensions that varies across the sets of evidence increases (and thus children have to consider a much larger hypothesis space). Systematically comparing children's evidence selection across different types of learning contexts for tasks equated for these stimulus features is thus necessary to determine the boundaries and developmental timescale of children's abilities.

The present study extends prior work on the development of theory of mind (Knudsen and Liszkowski, 2012a, 2012b) and deception. Our results suggest that not only can children consider their social partner's current and intended mental states to provide information about whether a prior event occurred, they can strategically select between multiple sets of truthful evidence to instill specific semantic knowledge in other people. However, children may have been able to succeed at our task, without explicitly reasoning about the learner's potential for false beliefs. Future work may investigate the degree to which this aspect of theory of mind is required for effective teaching and deception. Nonetheless, these results contribute to a growing body of evidence that, from an early age, children exhibit surprising, seemingly sophisticated abilities to learn in and reason about social and communicative contexts.

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