

Pedagogical Cues Influence Children’s Inductive Inference and Exploratory Play

Lucas P. Butler (lpbutler@stanford.edu)

Department of Psychology, Stanford University
Building 420, 450 Serra Mall, Stanford, CA 94305

Ellen M. Markman (markman@stanford.edu)

Department of Psychology, Stanford University
Building 420, 450 Serra Mall, Stanford, CA 94305

Abstract

A hallmark of human cognition is the ability to learn from others—both via language and via non-linguistic cues. Children are sensitive to actions done for their benefit, treating pedagogical acts as conveying important information (Csibra & Gergely, 2009). The current research tapped children’s exploration to investigate whether seeing a causal property either demonstrated pedagogically or produced accidentally influences children’s expectations about that property’s extension to other kind members. Experiment 1 found striking differences in 3- and 4-year-olds’ exploration when a property was demonstrated intentionally rather than accidentally. Experiment 2 replicated this effect while also investigating possible influences of the emotional valence of causal events and the salience of property information. These experiments reveal that preschoolers use pedagogical cues to make inferences about generalizability and guide their exploration.

Keywords: Pedagogy; Exploratory Play; Inductive Inference; Causal Learning.

Introduction

One fundamental aspect of human cognition is our ability to learn from and teach others. Our abilities to read others’ intentions and engage in collaborative learning may provide the necessary foundation for human culture, from law and government to industry and education (Gergely & Csibra, 2005; Tomasello, 1999). Children’s understanding of intentions is inherent to many domains, including word learning (Baldwin, 1991, 1993a, 1993b) and imitation (Carpenter, Akhtar, & Tomasello, 1998; Meltzoff, 1995). Recent work has elaborated on the importance of explicit teaching and demonstration, which fundamentally rely on children’s ability to read intentions. Tomasello and Carpenter (2007) argue that “instructed learning” is key to acquiring cultural knowledge, such as what we call objects and how we use them, and Csibra and Gergely (2006, 2009) suggest that humans have adapted a faculty for “natural pedagogy,” enabling efficient social learning. On this account, children should treat pedagogical cues (e.g., eye gaze, pointing) as signaling that information is not only important, but that it is culturally agreed-upon and generalizable.

Indeed, pedagogical cues appear to influence processing of information even in infancy. For example, 8-month-olds

expect eye gaze to be directed at referent objects when accompanied by pedagogical cues (Csibra & Volein, 2008). Further, pointing leads 9-month-olds to privilege a novel objects’ identity over current location in memory (Yoon, Johnson, & Csibra, 2008). And when 14-month-olds see a person pedagogically convey affective information (e.g., disgust) about an object, they treat it as a stable property of the object (Gergely, Egyed, & Király, 2007), and expect others to react similarly towards it (Egyed, Király, Krekó, Kupán, & Gergely, 2007).

Thus, even infants treat pedagogy as communicating important information about novel objects. However, it is as yet unclear whether children take such information as generalizable to a kind, rather than merely to a particular object. Assessing whether novel information should be generalized to a kind is critical in category and concept formation, where children rely on others to impart often otherwise unknowable information (Gelman, 2009; Harris, 2002; Harris & Koenig, 2006). Such knowledge transmission is often linguistic, using language that refers to kinds and categories, and children make a variety of inductive inferences on the basis of kind-referring language. For example, children take labels as referring to kinds that share nonobvious properties, and generalize novel properties on the basis of shared labels—which signal shared category membership—rather than perceptual similarity (e.g., Booth & Waxman, 2002; Gelman & Coley, 1990; Gelman & Markman, 1986, 1987). Moreover, recent work has demonstrated that preschoolers expect novel objects that share a label to share a novel causal property, and selectively explore those objects more when that property fails to extend to additional kind members (Schulz, Standing, & Bonawitz, 2008). Children also understand that information conveyed in a generic statement (e.g., “dogs bark”) has greater inductive potential than information conveyed non-generically (e.g., “this dog barks”) (Cimpian & Markman, 2008; Gelman, Star, & Flukes, 2002; Hollander, Gelman, & Raman, 2009), and information conveyed generically becomes more central to their kind representations (Cimpian & Markman, 2009).

However, it is important to note that while linguistic cues such as kind labels are powerful in driving generalization, they are not always used pedagogically. One can use object or kind labels without having any intention of pedagogically conveying information, and certainly without intending such information to be taken as generalizable. Thus it might be

important for children to make use of non-linguistic cues when assessing the generalizability of novel information.

Indeed, Gergely and Csibra (2009) suggest that at the core of generic knowledge transmission is pedagogical intent—an intent to explicitly impart new information to a recipient—and that children are sensitive to whether or not information is communicated for the purpose of teaching them something important. Similar to a Gricean view of communication (cf. Clark, 1996; Sperber and Wilson, 1986), in which we expect speakers to be clear and informative, children may infer that when an adult intentionally communicates information for their benefit, it is because the adult intends to teach them something relevant and important, and thus children may use pedagogical cues to gauge generalizability. Given this, we hypothesize that, even given a shared label, children may make stronger inferences about the whether a property is generalizable when it is demonstrated pedagogically, treating it as more conceptually central and inferring that other kind members should share that property.

To test this, our methodology builds on prior research which has established that exploratory play is a window onto children's implicit inductive processes. Having learned that an exemplar of a kind has a causal property, young children, even infants, explore more upon encountering exemplars that share a kind label, but which lack that property (Baldwin, Markman, & Melartin, 1993; Schulz et al., 2008). In the current research, we tapped children's natural exploration to investigate whether, even given objects that share a kind label, they would form different expectations about generalizability depending on whether a novel property was demonstrated intentionally or produced accidentally. If so, then when a property is intentionally demonstrated for them, but fails to obtain for other kind members, children should explore more than when that same property is produced accidentally.

Experiment 1

In Experiment 1 we taught children a name for a novel object, and either intentionally demonstrated or accidentally produced a novel causal property (magnetically picking up paperclips). We then presented children with an identical set of exemplars with the same label but which lacked the property (they were not magnetic), and let them play.

Methods

Participants Thirty-two three-year-olds (16 girls; $M = 42$ months; range = 36-46 months) and 32 four-year-olds (16 girls; $M = 54$ months; range = 48-61 months) from a university preschool participated. Children came from predominantly middle- and upper-middle-class families, representing a variety of ethnic groups. Children were randomly assigned to condition, equating for gender and age.

Materials The novel objects were small wooden blocks. The active block had magnetic tape on one end, while the inert blocks had non-magnetic tape. All were covered with black tape, with green tape covering the magnetic/non-magnetic end.

Procedure All children were tested in a private room in their preschool by a trained experimenter. Children first learned a novel label (blicket) for the active block. When asked for the blicket, all children successfully selected it from 4 distracters on two trials, without error.

After learning the word, children did a short distracter task (making paper houses). This served two goals. First, it distanced the word-learning, which was necessarily pedagogical, from the demonstration. Otherwise, children may have remained in a pedagogical "mindset." Second, it provided a plausible excuse for placing a pile of paperclips on the table.

The experimenter then started to clean up the toys. He put away each the distracters saying, "Let's put this away. He then picked up the active block, and again said "Let's put this away," which served as an implicit invitation to attend to the blicket. In the intentional condition, he said, "Look, watch this!" He deliberately placed the it on the paperclips, picked it up (with paperclips attached), and looked at it, saying "Hmmm" in a neutral tone. He then placed it next to the paperclips. Next, he placed 10 inert blocks on the table, saying, "here are some blickets." The accidental condition was *identical*, except that the experimenter appeared to "accidentally" drop the block on the paperclips as he was putting it away, exclaiming "Oops!" As in the intentional condition, he picked it up with paperclips attached, looked at it, said, "Hmmm," and placed it next to the paperclips.

The experimenter then told the child to "go ahead and play" while he left the table and sat facing away from the child for 60 seconds. Upon returning, the experimenter introduced a puppet and asked the child, "Can you tell Mr. Monkey about blickets?"

Results

None of the 3-year-olds explored the blickets in the accidental condition (leading to zero variance in that cell of the design), precluding parametric analyses. We analyzed 3- and 4-year-olds' responses separately, using non-parametric Mann-Whitney U and χ^2 tests.

4-year-olds Although there were no differences across conditions in whether or not 4-year-old children explored the blickets, they showed striking differences across conditions in the nature of that exploration, specifically the amount of time they spent exploring and the number of times they tried to elicit the property from the inert blickets. When 4-year-olds saw the property demonstrated intentionally, they spent more time trying to pick up paperclips with the blickets ($M = 46.94$ s, $SD = 21.38$) than when they saw it produced accidentally ($M = 24.69$ s, $SD = 25.02$), $U = 66.0$, $N = 32$, $p = 0.019$.

Four-year-olds also made more attempts to pick up paperclips with the blickets ($M = 9.25$, $SD = 7.62$) in the intentional condition than the accidental condition ($M = 2.94$, $SD = 3.45$), $U = 61.5$, $N = 32$, $p = 0.011$.

3-year-olds Three-year-olds showed an analogous effect of condition, which was even starker than for the 4-year-olds. In the accidental condition, zero out of 16 children explored at all, compared with 8 out of 16 in the intentional condition, $\chi^2(1, N = 32) = 10.67$, $p = 0.001$. Thus, despite lower overall levels of exploration, 3-year-olds were sensitive to how the property was produced, and this guided their inferences and exploration

Discussion

These results provide compelling evidence that children use pedagogical cues to guide their inductive inference and exploration. When 4-year-old children were deliberately shown a causal property of a novel object in a pedagogical manner, they explored more upon discovering that the property did not obtain for additional kind members, indicating that they expected the property to generalize. Furthermore, 3-year-olds explored only in the Intentional condition, suggesting a sensitivity to intentional demonstration even at a younger age.

Two additional factors beyond the pedagogical cues may have influenced children's exploration. First, to convey that it was accidental the experimenter said "Oops!" after producing the property in the accidental condition. But this may have also marked the property as negative, potentially inhibiting exploration. Additionally, the conditions may have produced slightly different evidence—more paperclips may have stuck to the block in the intentional condition, making the property potentially more salient. Experiment 2 explored the possible effect of these factors on children's exploration. We added an enthusiastic exclamation ("Wow!") in both conditions to mitigate any influence of negative affect, and also equated the number of paperclips picked up across conditions.

Experiment 2

The results of Experiment 1 make clear that, even when objects share a kind label, whether or not a property is demonstrated in an intentional, pedagogical manner has a powerful effect on children's inferences about the generalizability of that property and their exploration of novel kind members. Further, as mentioned above, there are other potentially interesting factors that could also be influencing children's exploration—specifically the inherent negativity of accidental events and the varying salience of the property information. If children are sensitive to the affective valence of causal events and attuned to the saliency of particular properties in making inferences and guiding exploration of novel kinds, then we might expect that equating these factors across conditions could dampen

the effect of the manner of demonstration. However, if children's sensitivity to pedagogical cues is singularly important in guiding inference and exploration, equating for other facets of the event might have little impact on the effect of intentional demonstration.

Methods

Participants The participants were an additional 32 3-year-olds (16 girls; $M = 41$ months; range: 39-46 months) and 32 4-year-olds (16 girls; $M = 52$ months; range: 48-57 months), with comparable backgrounds to children in Experiment 1.

Procedure The procedure was identical to Experiment 1 with several modifications. First, while maintaining the manipulation of saying either "Look, watch this" or "Oops!" the experimenter also exclaimed, "Wow!" after producing the property in both conditions, rather than simply saying, "Hmm." This should mitigate any inhibitory effect that exclaiming "Oops!" in the accidental condition might have had on children's exploration. Second, we controlled for the number of paperclips picked up across conditions. The experimenter always picked up 2 paperclips in the intentional condition, while in the accidental condition the mean was 2.41 paperclips.

Results

Unlike Experiment 1, in which not one 3-year-old in the accidental condition explored, some 3-year-olds in both conditions of Experiment 2 did explore. However, violations of assumptions of normality and homoscedasticity precluded parametric comparisons across age groups. Instead, we used non-parametric ordinal logistic regressions (see Cimpian, 2009), with condition and age as predictors, to compare exploration across the two age groups and two conditions.

These analyses revealed a main effect of condition on children's exploration, with children in the intentional condition spending more time exploring (Wald $\chi^2 = 10.05$, $df = 1$, $p = 0.002$) and making more attempts to elicit the property (Wald $\chi^2 = 18.29$, $df = 1$, $p < 0.001$) than children in the accidental condition. The analyses also revealed a main effect of age, with 4-year-olds spending marginally more time exploring (Wald $\chi^2 = 3.21$, $df = 1$, $p = 0.073$) and making significantly more attempts to elicit the property (Wald $\chi^2 = 6.82$, $p = 0.009$) than 3-year-olds. To explore these effects further, we followed up these analyses by conducting Mann-Whitney U tests within each age group.

4-year-olds As in Experiment 1, 4-year-olds spent more time exploring in the intentional condition ($M = 40.63$ s, $SD = 19.57$) than in the accidental condition, ($M = 20.75$ s, $SD = 22.27$), $U = 70.5$, $N = 32$, $p = 0.029$. They also made more attempts to elicit the property in the intentional condition ($M = 7.63$, $SD = 4.53$) than in the accidental condition ($M = 2.81$, $SD = 2.46$), $U = 44.5$, $N = 32$, $p = 0.001$.

3-year-olds As in Experiment 1, significantly more 3-year-olds explored in the intentional condition (12 children; 75%) than in the accidental condition (5 children; 31%), $\chi^2(1, N = 32) = 6.15, p = 0.013$. Additionally, 3-year-olds spent more time exploring in the intentional condition ($M = 32.38$ s, $SD = 23.48$) than the accidental condition ($M = 11.56$ s, $SD = 21.09$), $U = 68, N = 32, p = 0.023$, and made more attempts to elicit the property in the intentional condition ($M = 5.63$, $SD = 6.29$) than the accidental condition ($M = 1.00$, $SD = 2.76$), $U = 59.5, N = 32, p = 0.008$. Thus, as with the older children, 3-year-olds used pedagogical cues to assess the generalizability of new information and guide their exploration.

Discussion

Even when controlling for the emotional valence of the event and the salience of the property, children showed different patterns of inductive inference and exploration on the basis of whether a property was demonstrated intentionally. Having seen a property intentionally demonstrated rather than produced accidentally, 3- and 4-year-olds showed increased exploration when that property failed to obtain for other kind members.

General Discussion

These experiments provide initial purchase on the question of how intentional demonstration influences children's inductive inferences. While previous research has documented an early sensitivity to pedagogy (Csibra & Volein, 2008; Egyed et al., 2007; Gergely et al., 2007; Yoon et al., 2008), the current work directly investigates the role of pedagogical cues in the process of theory-based categorization and concept formation in young children. As early as age 3, children take intentionally demonstrated information as more kind-relevant and generalizable than identical evidence produced accidentally.

Recent work has suggested that pedagogy might be a "double-edged sword," potentially dampening children's natural curiosity and constraining learning to only what is being taught (Bonawitz et al., 2009). However, our data indicate that children do not merely learn exactly what is taught (in our case, that a particular novel object is magnetic), but rather infer from pedagogical cues that this is an important and generalizable property of the novel kind. Upon encountering evidence conflicting with this inference, having seen the property demonstrated pedagogically increased curiosity and exploration. Thus, pedagogy may facilitate deeper learning of socially or culturally important information. Particularly to the extent that children are intuitively geared towards to learning not simply everything one can do with an object, but rather what we as a group or society use such artifacts for (Kelemen, 1999; Kelemen & Carey, 2007), selective use of pedagogical cues in this manner may be particularly important.

It is important to note that in the current research, we have not directly addressed the distinction between *pedagogical* as opposed to simply *intentional* action. In the current studies, the intentional condition was both intentional and pedagogical, while the accidental condition was neither. It is possible that simply seeing an artifact used in an intentional manner is enough to lead children to infer that other objects of the same kind can be used in the same way. However, children may remain particularly attuned to whether or not that action was done with *pedagogical* intent—that is, with the purpose of teaching them something new—or merely with the intent of carrying out a particular function. This is an important question, and one which we are addressing in further research.

Another open question what children are learning from, on one hand, information conveyed by the demonstration, and on the other hand, evidence produced by their own exploration. It is precisely this conflict between inferences about generalizability made on the basis of pedagogical cues and evidence that the property in fact fails to generalize which appears to drive continued exploration. But of course this conflict remains even after exploration, and how children resolve this conflict is as yet unclear.

More broadly, these results support the idea that, as generic language conveys information about the generalizability and conceptual importance of new information (Cimpian & Markman, 2009; Gelman et al., 2002; Hollander et al., 2009), so too does intentional, pedagogical action. When presented with the same novel causal property in a pedagogical manner rather than an accidental one, children make appear to make generic, kind-based inferences that drive their exploration. Furthermore, this obtains even when objects in both conditions share a label. Kind labels are known to license category-based inductive inferences, (e.g., Gelman & Markman, 1986), and having shared versus distinct kind labels does influence exploratory play (Schulz et al., 2008). Our research demonstrates that pedagogical cues play an important role above and beyond that of the kind label.

When facing inductive problems in generalization, children have many sources of information available to them, both non-social (e.g., observation, exploration, and prior knowledge) and social (e.g., labels, generic language, intentional and pedagogical cues). Children's ability to integrate sources of information—especially when they conflict—is an important skill. The current research suggests that this ability is developing during the preschool years, and that by as young as 3 children are particularly sensitive to intentionally communicated information as they form and test hypotheses about the world.

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