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Learning From Others and Spontaneous Exploration: A Cross-Cultural Investigation

Laura Shneidman
University of Chicago

Hyowon Gweon
Stanford University

Laura E. Schulz
MIT

Amanda L. Woodward
University of Chicago

How does early social experience affect children's inferences and exploration? Following prior work on children's reasoning in pedagogical contexts, this study examined U.S. children with less experience in formal schooling and Yucatec Mayan children whose early social input is predominantly observational. In Experiment 1, U.S. 2-year-olds (n = 77) showed more restricted exploration of a toy following a pedagogical demonstration than an interrupted, accidental, or no demonstration (baseline). In Experiment 2, Yucatec Mayan and U.S. 2-year-olds (n = 66) showed more restricted exploration following a pedagogical than an observational demonstration, while only Mayan children showed more restriction with age. These results suggest that although schooling is not a necessary precursor for sensitivity to pedagogy, early social experience may influence children's inferences and exploration in pedagogical contexts.

Children grow up surrounded by others, and learn from others by observing and communicating with them. However, the nature of these early social interactions varies widely across contexts and across cultures. Some children grow up in environments where caregivers routinely engage in explicit teaching interactions with their young, while in other communities young children have little exposure to explicit pedagogical instruction. Because the majority of developmental research has been conducted in cultures where explicit child-directed teaching is prevalent, relatively little is known about how children's early social environment affects the way children learn from others. Here, we ask whether 2-year-old children draw appropriate inferences in pedagogical contexts, and to what extent these inferences are mediated by culturally specific experiences.

In addressing this question, we are motivated by formal models of pedagogical reasoning (Bonawitz et al., 2011; Shafto, Goodman, & Frank, 2012). These models provide normative accounts of how learners ought to update their beliefs in pedagogical contexts. With respect to these models, a pedagogical context is defined as one in which (a) one agent (the "teacher") knows the target hypothesis and selects evidence to increase the probability that a rational learner would infer the correct hypothesis from the sampled data, and (b) another agent (the "learner") is naïve to the target hypothesis but updates her beliefs under the assumption that the evidence she observes is being sampled by a knowledgeable, helpful teacher.

Within this framework, there are many contexts in which a child observes evidence generated by an adult that would not count as pedagogical with respect to the sampling assumptions involved. Consider a novel toy with many affordances, some of which have functionally interesting properties (e.g., squeaking, lighting up, etc.). We can imagine a case where an agent does not know which, if any, affordances are functional and simply acts on the toy (i.e., a *default* sampling process in which the affor-

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Correspondence concerning this article should be addressed to Laura Shneidman, Department of Psychology, University of Chicago, Chicago, IL 60615. Electronic mail may be sent to lauras@uchicago.edu.

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dances are tested at random), a case where the agent tries to teach the toy's functions but the demonstration is incomplete (i.e., an *interrupted* pedagogical sampling process), or a case where the agent selects and acts on the functional affordances, not to instruct a learner, but to serve her own interests (i.e., an *intentional* sampling process in which the affordances are tested with no concern for the learner). In these cases, observing that an affordance has a function provides strong evidence that the affordance does indeed have that function (e.g., that pulling a tube makes it squeak), but provides no information about additional functions of the toy. Thus, we treat these contexts as "nonpedagogical" even if they involve superficial cues to pedagogy, including ostensive cueing and intentional demonstration (e.g., Csibra & Gergely, 2009).

By contrast, when an agent engages in a *pedagogical* sampling process, it implies that his demonstration includes all the information necessary for the learner to draw a correct inference. Thus, observing that an affordance has a function in a pedagogical context (e.g., pulling the tube makes it squeak) provides information both about the observed function and about unobserved functions. If there were other important things to know about the toy, a knowledgeable and helpful teacher would have communicated those as well. Critically, this predicts that pedagogical instruction should limit spontaneous, self-guided exploration: Given the same evidence (e.g., that pulling a tube makes it squeak) children should explore less if the evidence is provided in a pedagogical context than in a nonpedagogical context, precisely because children should treat pedagogically sampled evidence as exhaustive.

Consistent with this account, research using this paradigm suggests that 4- to 6-year-olds selectively constrain their exploration and discover fewer additional functions of a toy following a pedagogical demonstration of one of its functions than following nonpedagogical demonstrations of the same function (Bonawitz et al., 2011). Note that although pedagogical sampling implies that the evidence is exhaustive, it does not specify the exact content communicated, and many different hypotheses may be consistent even with pedagogically sampled evidence. For instance, given a pedagogical demonstration of a single function of a toy, a child might infer that the toy has only one function (i.e., an inference about the true number of functions of the toy), she might infer that this is the best way to play with the toy (i.e., an inference about the most interesting or preferred properties of the toy), or she might infer that the demonstrated way is the only permissible way to play with the toy (i.e., an inference about cultural norms). The critical point, however, is that all of these inferences are consistent with there being only *one relevant aspect* of the toy the teacher intends to communicate to the learner: the one he demonstrated. By contrast, if the evidence is not sampled pedagogically, the child might infer that the demonstrated function represents only one of many properties of the toy, or only one of many (interesting or permissible) ways to play with it.

Some prior work suggests that children as young as 4 years of age treat pedagogically sampled evidence about a toy as evidence for what the toy actually does, rather than for how they ought to play with the toy. For instance, children rate a teacher higher when the teacher demonstrates one function of a toy and it has just one function (thus providing complete evidence) compared to when he demonstrates the same function and the toy actually has four functions (thus providing insufficient evidence). Moreover, if the same teacher then introduces a new toy and demonstrates one of its functions, children who previously saw the teacher provide complete evidence constrain their exploration of the new toy more than those who saw insufficient evidence (Gweon & Asaba, 2015; Gweon, Pelton, Konopka, & Shultz, 2014). For our purposes here, however, the critical question is not whether children infer properties of the world or social norms, it is whether children's tendency to treat pedagogically sampled evidence as exhaustive depends on extensive experience with child-directed teaching.

Instructional interactions or explicit teaching is common in the lives of children in the United States. Indeed, by the time children start formal schooling, they have typically had considerable experience in child-directed pedagogical contexts, often both through preschool education and via child-directed interactions with caregivers. Thus, children's responses to pedagogically delivered information could stem from this experience. Early childhood education may be particularly relevant for shaping children's responses to teaching, because children are not only taught, but also often rewarded for expressing what they were taught. Such interactions may reinforce the expectation that information delivered via explicit instruction is relevant, important, and worth attending to. The high frequency of explicit instruction could also lead children to notice that pedagogically marked information usually corresponds to what is true and correct about the world (e.g., what properties are true of a new object, or how to use a novel device), whereas information gleaned from noninstructive contexts varies more in this respect. Note that experience in child-directed teaching contexts could also help children understand when and how they should respond to others. Child-directed interactions often require a reciprocal response on the part of the child, and thus, in these contexts children may be restricting their actions to those of the actor as part of a familiar or conventionally appropriate routine.

Alternatively, however, children's reasoning about pedagogically delivered information might arise from an early developing ability to interpret others' actions in terms of their intentions and epistemic states (Gergely, Nadasdy, Csibra, & Biro, 1995; Hamlin, Ullman, Tenenbaum, Goodman, & Baker, 2013; O'Neill, 1996; Onishi & Baillargeon, 2005; Southgate, Chevallier, & Csibra, 2010; Southgate, Senju, & Csibra, 2007; Woodward, 1998; Sommerville, Woodward, & Needham, 2005). If so, children may be sensitive to the particular assumptions licensed by pedagogical sampling even in the absence of extensive experience in child-directed instruction. Across a range of cultural contexts, children might recognize when adults are knowledgeable about the world and when they are generating information to help the child arrive at true and correct beliefs about the world.

The prior empirical record cannot tell us whether children's sensitivity to pedagogically sampled evidence is learned through specific cultural experiences or whether it emerges as part of theory of mind quite broadly. To date, studies that have explored children's reasoning in pedagogical versus nonpedagogical contexts have come exclusively from populations where children regularly experience directed instruction (e.g., Bonawitz et al., 2011; Butler & Markman, 2012; Gweon et al., 2014). In this article we look at sensitivity to pedagogically and nonpedagogically demonstrated information in children who have much less experience in explicitly marked instructional contexts. We do this in two ways. In Experiment 1, we replicate the design previously used with 4- to 6-year-olds in the United States (Bonawitz et al., 2011) with a much younger population: 2-year-olds. Testing 2-year-olds allows us to ask if the amount of experience with direct instruction affects children's response to pedagogically framed information, and to validate the use of a toy appropriate to the motor skills of typical 2-year-old children. In Experiment 2, we take a more rigorous cross-cultural approach to study the effect of experience on pedagogical reasoning. We compare children in the United States (2- to 3.5-year-olds) to children of the same age growing up in a Yucatec Mayan community.

While instructional interactions are common in the lives of most children growing up in industrialized communities, explicit teaching occurs much less frequently in traditional Mayan communities (e.g., Correa-Chavez & Rogoff, 2009; de Leon, 1998; Gaskins, 1999; Gaskins & Paradise, 2010; Rogoff, 2003; Rogoff, Mistry, Göncü, & Mosier, 1993; Shneidman, Gaskins, & Woodward, 2015; Shneidman & Goldin-Meadow, 2012). Caregivers in these communities have a theory of learning that encourages children to pursue information in shared, noninstructional contexts (e.g., Gaskins, 1999; Gaskins & Paradise, 2010), and caregivers see development as a process that unfolds naturally, requiring little external help (e.g., Gaskins, 1999). Thus, children are expected to learn from observation of ongoing adult activities, instead of from formal one-on-one instruction (e.g., Rogoff, 2003).

Indeed, previous research quantifying the extent to which children are directly engaged by caregivers has found that, compared to children growing up in the United States, Mayan children receive relatively less language input in directed interaction (from both adults and other children), and relatively more language input from overhearing the conversations of others (Shneidman & Goldin-Meadow, 2012). Although directed talk to Mayan children increases over early childhood (Shneidman & Goldin-Meadow, 2012; see General Discussion), there are likely large cultural differences in the extent to which children experience explicit instruction in the first few years of life, especially because directed instruction is only a subset of the input children receive in directed speech.

These differences could relate to differences in children's interpretation of information received in pedagogical versus observational contexts. Indeed, children growing up in indigenous communities in the Americas display patterns of attention and learning that reflect their experience observing the actions of others (e.g., Chavajay & Rogoff, 1999; Childs & Greenfield, 1980; Correa-Chavez & Rogoff, 2009; Gaskins & Paradise, 2010; Paradise & Rogoff, 2009; Shneidman et al., 2015). For example, school-aged children growing up in a Guatemalan Mayan community, where observational learning is valued, are more likely to attend to and learn a new skill from observation than same-aged peers living in the United States (Correa-Chavez & Rogoff, 2009). Furthermore, while directed cues are informative for shaping U.S. children's imitation rates, they are irrelevant for informing imitation for Yucatec Mayan infants who rarely experience directed engagement (Shneidman et al., 2015). These findings suggest that cultural experience can shape the way that children learn from directed and observational contexts, and raise the possibility that children's interpretation of information received in these contexts similarly varies. Children with limited experience in directed teaching contexts could have little expectation that information presented with directed cues signals complete and accurate information about the affordances of objects, and might explore objects broadly following both pedagogical and nonpedagogical sampling of evidence. Conversely, children with ample experience observing the actions of others might reason that any action performed in a goal-directed way (whether they are accompanied by pedagogical cues) represents culturally relevant information about how that object should be used.

Note, however, that the information children need to process to distinguish pedagogical and nonpedagogically sampled evidence comprises a relatively small subset of all the information that might be communicated pragmatically through adult–child interactions. As discussed, for our purposes, an interaction is pedagogical insofar as it specifies that a knowledgeable agent selected data intended to help the learner arrive at the correct hypothesis. Thus, to the extent children's ability to represent the intentions and epistemic status of others is culturally universal, the ability to distinguish pedagogically and nonpedagogically sampled evidence might also be observed cross-culturally. Indeed, precisely because child-directed interactions are rare in Mayan culture, Mayan children might be as or more sensitive to adult demonstrations than U.S. children for whom this is a cultural norm (e.g., LeVine, LeVine, Schnell-Anzola, Rowe, & Dexter, 2012). Here, we investigate the hypothesis that young children selectively constrain their exploration given pedagogically sampled evidence in the absence of formal schooling (Experiment 1), and even in children whose youth and cultural context has allowed for very limited experience in direct instruction (Experiment 2).

Experiment 1

In Experiment 1, we ask whether 2-year-olds in the United States, who have little to no experience with formal schooling, are nonetheless sensitive to the different inferences licensed by pedagogical and nonpedagogical demonstrations. We compare their spontaneous exploration of a toy across four conditions—three in which an actor demonstrates one of its hidden functions, and a baseline condition—that closely replicate prior work (Bonawitz et al., 2011, Experiment 1). If children's ability to recognize and draw inferences in pedagogical and nonpedagogical contexts is independent of their experience with formal instruction, the results should mirror prior findings: Toddlers should be more likely to show restricted exploration following a pedagogical demonstration than no demonstration (baseline) or nonpedagogical demonstrations (interrupted or accidental).

Method

Participants

Fifty-nine children (M_{age} = 2.5 years, age range = 2.0–3.0 years) were recruited from an urban children's museum and were randomly assigned to one of three conditions: pedagogical (N = 20, 10 males, M_{age} = 2.5), interrupted (N = 20, 10 males, M_{age} = 2.5), and accidental (N = 19, 9 males, M_{age} = 2.6). Data collection took place in January 2010 and January–May 2012. In order to confirm that the pedagogical condition *reduces* exploration in this age group, we recruited a separate group of 18 children for a baseline condition (M_{age} = 2.4, age range = 2.0–2.9; April 2015). Although the baseline data were collected later, great care was taken to ensure consistency in testing environment, stimuli, and procedure. Critically, in order to maintain consistent coding criteria across conditions, we had a single well-trained individual blind code all children and used this data set for analysis. Although all children were primarily from middle-class families, a range of socioeconomic backgrounds of the local population was represented in our sample. There was no difference in average age across conditions, $F(3, 74) = 0.553$, $p = .65$. An additional 23 children were dropped and replaced due to parental or sibling interference (N = 11), showing no interest in the toy (N = 11), or toy malfunction (N = 1). One child (in the accidental condition) did not operate the beeping function during exploration or when asked to locate it following exploration. Removing this child did not alter the reported analyses so all analyses include this child.

Materials

A pyramid-shaped toy was constructed out of pieces of felt (see Supporting Information). As in Bonawitz et al. (2011), the toy was designed to have four nonobvious functional affordances. The toy and the functional affordances were designed to be appropriate for the motor skills and strength of typical 2-year-olds. Pressing a purple tab made a beeping sound, pressing a gray tab produced a buzzing sound, pulling down a flap on one side revealed a hidden mirror, and pulling down a flap on another side revealed a hidden embroidered duck.

Procedure

Demonstration phase. All children were tested individually in a quiet room. The experimenter sat across the table from the child and brought out the felt toy from under the table, facing the beeper part toward the child. In the pedagogical condition she said, "Look, I'll show you how my toy works, watch this!" and pressed the purple tab to produce a beep sound while looking between the toy and the child. She then said, "That's how my toy works, let's watch that again!" and repeated the demonstration. The interrupted condition was very similar to the pedagogical condition, except that after demonstrating the beeper twice, she said, "Oh no, I forgot to write down something over there!" In the accidental condition, the experimenter said as she brought out the toy, "I found this cool toy at the museum, and I don't know how it works!" and she pressed the purple tab to produce the beeping sound as if by accident as she was passing the toy to the child. She then said in a surprised tone, "Huh! Did you see that? Let me do that again!" and pressed the purple tab again. In the baseline condition, the experimenter did not demonstrate the beeper. She simply brought out the toy and said, "Wow, see this? Look at this!" repeatedly for a few seconds to match the other conditions for the duration of familiarization. Then in all conditions, the experimenter said, "Now I'm going to go write something down. Why don't you go ahead and play, and let me know when you're done?" and walked out of the child's line of sight.

Exploration phase. The child was allowed to explore the object until he said he was done or until he walked away from the toy or stopped interacting with it for more than 5 s. At this point the experimenter said, "Are you all done?" If the child did not reinitiate play with the toy the experimenter ended the trial. If the child began interacting with the toy again he was permitted to play until he stopped interacting with the toy for a second time.

Results and Discussion

Our main measure of interest was the proportion of time spent on the demonstrated function (beeping) relative to children's total playtime (defined as the duration of time from the beginning until the end of the exploration phase). Children also received a score based on the number of types of predefined unique actions they performed during exploration. These 15 predefined actions included interacting with the four main affordances of the toy (beep, buzzer, mirror, and duck), as well as other nonfunctional affordances on the toy (e.g., pulling the orange and blue tabs on the toy, lifting the bottom flap of the toy, pressing the black snaps holding the toy together, etc.). For functional actions, children were credited even if their exploration failed to reveal the hidden function (e.g., they touched the tab that activates the buzzer but failed to make it work).

Total playtime was highly variable across children and did not differ significantly across conditions (M_{sec} = 77, SD = 76; M_{sec} = 112, SD = 81; M_{sec} = 68, SD = 44; M_{sec} = 73, SD = 42 for pedagogical, accidental, interrupted, baseline conditions, respectively). To test our main hypothesis, we compared the proportion of time children spent on the demonstrated function (beeping). If children selectively restrict exploratory play in the pedagogical condition, they should spend a higher proportion of time playing with the beeping function relative to children in the interrupted and accidental conditions. The baseline condition was excluded from this analysis because the beep was never demonstrated; only two children spontaneously discovered the function. Planned linear contrast with weights [2-1-1] showed that children indeed spent more time playing with the demonstrated function in the pedagogical condition (M = 66%) than the interrupted (M = 48%) or accidental (M = 47%) conditions: linear contrast, $F(1, 57) = 7.48$, $p = .008$ (see Figure 2). Post hoc t tests showed that children in the pedagogical condition spent more time overall playing with the beeping function than children in the accidental, $t(38) = 2.31$, $p = .028$, or interrupted, $t(38) = 2.56$, $p = .015$ conditions. There was no difference between interrupted and accidental conditions. Children in the pedagogical condition also played more time on the demonstrated function in the 1st minute of play, $F(1, 57) = 4.36$, $p = .041$. Finally, children's age did not correlate with any of the exploration measures in any of the conditions ($p > .20$ in all conditions).

Although these results are consistent with the possibility that children in the pedagogical condition explore the toy less compared to those in nonpedagogical conditions, they are also consistent with the possibility that younger children show heightened exploration in nonpedagogical conditions. However, we confirmed that pedagogical demonstration *reduces* exploration by demonstrating that the unique number of actions following the pedagogical demonstration was less than the other three conditions (see Supporting Information).

These results replicate the main finding from Bonawitz et al. (2011), showing that pedagogical instruction limits exploratory play even in 2-year-old toddlers. Children in the pedagogical condition spent a greater proportion of their time playing with the demonstrated function than in the nonpedagogical conditions where the beeping function was demonstrated (the accidental and interrupted conditions). Furthermore, as compared both to the baseline and to the nonpedagogical demonstrations, the pedagogical demonstration of a toy's function reduced the number of unique actions children performed on the toy. These results suggest that children's sensitivity to pedagogical sampling does not directly depend on the amount of experience they have with formal schooling.

Two caveats are in order, however. First, we were unable to collect information about children's exposure to formal education settings or the degree to which children receive directed instruction outside their homes. Although given their age it is likely that these children had no formal schooling experience, we cannot rule out the possibility that children had some exposure to varying forms of directed instruction. We address this concern more directly in Experiment 2.

Second, the experimenter's action in the accidental and interrupted conditions may have encouraged children's exploratory play simply because it was more interesting or surprising, or because it implied that the experimenter was exploring the toy. Previous research suggests that children tend to explore more when they see an adult exploring (e.g., Engel, 2011) and that infants and preschoolers show heightened exploration of objects that they find surprising (Stahl & Feigenson, 2015; Schulz & Bonawitz, 2007). In the current study, however, the adult did not engage in exploration in either the accidental or interrupted condition, and indeed, the results suggest that children did not explore more in these conditions than they did at baseline. Collectively, therefore, the results suggest that the contrast between the pedagogical and nonpedagogical conditions is more likely to be due to children's relatively constrained exploration in the pedagogical condition than their relatively broad exploration in the nonpedagogical conditions.

In Experiment 1, we found that children restricted their exploration in the pedagogical condition relative to the other three conditions. Note, however, that these responses do not provide information about the precise content of children's inferences. It is possible that toddlers, like older children (Gweon et al., 2014), constrained their inferences about the functions the toy actually had. Alternatively, it is also possible that toddlers in the pedagogical condition constrained their inferences about the kinds of actions that were most desirable or interesting to perform ("This is the most fun way to play with the toy") or constrained their inferences about the kinds of behaviors that were normative or permissible ("This is how you ought to play with this toy"). These possibilities are not mutually exclusive and are consistent with formal models of pedagogical reasoning (see General Discussion). For our purposes, the critical point was that children selectively constrained their inferences given pedagogical sampling relative to nonpedagogical sampling and baseline. The results from Experiment 1 clearly show toddlers' sensitivity to pedagogically sampled information, and also validate the use of the novel toy with younger children for extending the research with toddlers cross-culturally.

Experiment 2

The results from Experiment 1 suggest that toddlers growing up in the United States draw appropriate inferences licensed by pedagogical and nonpedagogical demonstrations. However, a stronger test of this hypothesis might involve comparing toddlers' responses to evidence sampled pedagogically from evidence sampled intentionally but not pedagogically. Previous work has shown that 4- and 5-year-olds in the United States distinguish contexts in which others act on their instrumental goals (intending to activate the toy for themselves) and contexts in which they act on pedagogical goals (intending to teach). The results showed that children limited their exploratory play when they observed an actor pedagogically demonstrate a toy, but not when she activated the toy for herself (Bonawitz et al., 2011, Experiment 2).

As discussed, there are reasons to think that, relative to children growing up in the United States, Mayan children could treat pedagogical and observational contexts more similarly. Since observational learning is a more common means of learning cross-culturally, the relative infrequency of directed instruction might increase the importance of observational evidence (Chavajay & Rogoff, 1999; Childs & Greenfield, 1980; Correa-Chavez & Rogoff, 2009; Gaskins & Paradise, 2010; Paradise & Rogoff, 2009; Shneidman et al., 2015). Therefore, children may be less likely to infer that pedagogically framed information represents complete and correct information about the world. Conversely, given that Mayan children are often in a position to observe adults engaging in tasks of daily life, they could reason that any action performed in a goal-directed way provides culturally relevant information about how that object should be used. Alternatively, however, children might represent the intentions and epistemic status of others regardless of culture and use them to draw appropriate inferences licensed by the evidence they observe. If children distinguish contexts in which information is sampled for helping them converge on a correct hypothesis and contexts in which information is generated for the adults' own ends, then we might expect both U.S. and Mayan children to distinguish pedagogically and nonpedagogically sampled evidence. In particular, although children should learn the observed function in either context, they should be more likely to constrain their inferences to the observed function when evidence is presented pedagogically. We test this hypothesis in Experiment 2 by directly comparing the responses of U.S. children and children from Yucatec Mayan villages to information presented in pedagogical and nonpedagogical contexts.

Method

Participants

Sixty-six children participated (M_{age} = 2.6 years, age range = 2–3.4 years). Data collection took place in February–August 2014. Thirty-six children (22 males) were from five Yucatec Mayan villages in southeastern Mexico. Of these, 10 children were from Village A (population ~300), 7 from Village B (population ~200), 11 from Village C (population ~500), 3 from Village D (population ~900), and 5 from Village E (population ~100). The remaining 30 children (14 males) came from a large city in the United States (population ~2.7 million). U.S. children were primarily White and middle class although a range of socioeconomic backgrounds reflecting the local population were represented. Three additional Mayan children, and 6 additional U.S. children participated in the experimental procedure but were excluded from the final sample due to distress (1 Maya, 1 U.S.), because they failed to show interest in the target object (2 Maya, 4 U.S.), or because the session was not recorded due to technical error (1 U.S.). Six Mayan children (2 in the pedagogical condition and 4 in the observational condition) did not operate the demonstrated function at all during exploration. Removing these children did not alter the analyses, except as described below. The reported analyses included these children.

Across the two cultures, children had limited experience in formal schooling contexts. Three U.S. mothers and one Mayan mother reported their children had less than a year of preschool; the remaining children had no school experience. Because a cellular phone was used in the observational condition, all caregivers were asked if their child had experience viewing household members talking on a similar device. All subjects reported they had.

As expected, Mayan children differed from U.S. children in several ways that are likely to relate to variation in experience in pedagogical versus observational contexts. Mayan children came from larger households (M = 2.6 siblings) than the U.S. children (M = 0.5 siblings), $t(61) = 4.95$, $p < .001$, and mothers of Mayan subjects had fewer years of formal schooling (M = 5.6 years) as compared to U.S. mothers (M = 17.2 years), $t(59) = -14.3$, $p < .001$.

Thirty-two children (15 U.S. and 17 Maya) were assigned to the pedagogical condition and 34 children (15 U.S. and 19 Maya) to the observational condition such that the range and distribution of ages was roughly equal across condition and culture. Children's age did not significantly differ by condition, $F(1, 62) = 0.08$, $p = .78$, or by culture $F(1, 62) = 0.02$, $p = .90$.

Materials

The demonstration item was the same as felt toy described in Experiment 1.

Procedure

Mayan children were tested in a single-room house by a bilingual Mayan/Spanish speaker in either Yucatec Mayan (n = 32) or Spanish (n = 4) depending on which was reported to be the child's dominant language (per caregiver report). English glosses are provided here, but the experimenter spoke only in Maya or Spanish to the child. U.S. children were tested in English in a laboratory room at a university. Before testing, children played with the experimenter for a few minutes to familiarize them to the room and the experimenter. Once children seemed comfortable in the setting the experimenter said, "I'm going to get my toy," and retrieved the target object from the other side of the room.

Demonstration phase. In the pedagogical condition the experimenter sat with the child, made direct eye contact, and said in a child-directed speech register, "Look, this is what my toy does," and performed the beeping function. She repeated, "Here is what my toy does," and performed the action again while looking between the toy and the child. In the observational condition, the experimenter did not talk directly to, or make eye contact with, the child during the demonstration. Instead, while the experimenter was going to retrieve the toy, her cellular phone rang. She said, "Oh, I have a phone call," and answered the phone. Then, talking on the phone in adult-directed speech (as if she was having a conversation with a third party regarding an unrelated topic), she said, "Hi, yeah I think so." and performed the beeping function with the toy without looking up at the child. Continuing to talk on the phone she said, "What do you think?" and performed the function again before saying, "I have to go now," and hanging up the phone. Following the demonstration the child was asked, "Do you want to play now?" and handed the target object. The experimenter then said, "I'm going to read now, let me know when you're all done," and turned her attention to a book.

Exploration phase. The child was allowed to explore the object as described in Experiment 1.

Results and Discussion

Children's behavior during the exploration phase was coded offline as described in Experiment 1, except that if the child disengaged completely from the toy during the course of the trial this time was not included in the total playtime measure. This was to ensure that the cultural differences in children's willingness to interact with a novel toy did not differentially affect the total playtime. Total playtime did not differ across cultures or conditions (M = 86 s, SD = 68; M = 106 s, SD = 101; M = 57 s, SD = 31; M = 102 s, SD = 100 for Maya–pedagogical, Maya–observational, U.S.–pedagogical, U.S.–observational, respectively). There was no effect of culture, and no Culture × Condition interaction.

As in Experiment 1, we considered the proportion of time spent on the demonstrated part (the beeper) relative to the total play time as well as the number of unique actions performed. We ran analyses of variance on theses measures with culture and condition as fixed factors. Because of our large age range we included child age as a covariant in each of our analyses.

Our primary measure of interest was the proportion of playtime children spent on the demonstrated function (beeping). The results are displayed in Figure 1. There was a main effect of condition, $F(1, 61) = 11.98$, $p = .001$; culture, $F(1, 61) = 5.35$ $p = .024$; and age, $F(1, 61) = 9.05$, $p = .004$, indicating that children in the pedagogical condition, U.S. children, and older children spent a higher proportion of time on the demonstrated function compared to children in the observational condition, Mayan children, and younger children. (Note the effect of culture was not significant after eliminating the six Mayan children who did not interact with the beeping function.) There was no Culture × Condition interaction, $F(1, 61) = 0.078$, $p = .73$. Additionally, children in the pedagogical condition (Maya: M = 4.2, SD = 2.8; U.S.: M = 2.9, SD = 1.9) performed fewer unique actions than children in the observational condition (Maya: M = 5.4, SD = 2.3; U.S.: M = 5.5, SD = 3.3), $F(1, 61) = 7.88$, $p = .007$. There was no effect of culture, $F(1, 61) = 0.93$, $p = .338$; no effect of age, $F(1, 61) = 0.14$, $p = .708$; and no Culture × Condition interaction, $F(1, 61) = 1.26$, $p = .275$ (see Supporting Information). Thus, both U.S. and Mayan children

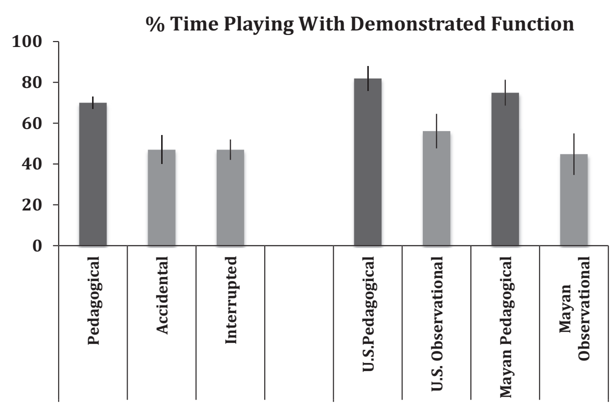

Figure 1. Percentage of time children spent on playing with the demonstrated function (beep) in Experiments 1 and 2.

selectively restricted play to the demonstrated function following pedagogical cuing, and U.S. children explored less overall than the Mayan children.

In sum, our results replicate and extend the findings of Bonawitz et al. (2011). In both cultures, children in the pedagogical condition performed fewer unique actions with the toy, and spent a larger proportion of their play time on the demonstrated function compared to children in the observational condition. Although we did not include a baseline measure in Experiment 2, and thus cannot be sure that these children, like those in Experiment 1, showed *restricted* exploration following pedagogical cuing (as opposed to heightened exportation following observation), given the findings from Experiment 1 with U.S. children, and the similarities in Mayan and U.S. responses, we believe that it is likely that children in both cultures were responding similarly. Thus, our results suggest that even children with little experience in formal schooling contexts, growing up in a cultural context where explicit teaching is relatively rare, are sensitive to pedagogical instruction.

Exploration and Age

Because our primary analysis revealed a significant effect of child age, and because previous research has demonstrated that there are increases in the extent to which Yucatec Mayan children are engaged in child-directed conversations across early childhood (Shneidman & Goldin-Meadow, 2012), we next considered the relation between age and proportion of play with the beeper in each condition. This allowed us to explore the hypothesis that Mayan children show a developmental change in how they respond to pedagogical instruction, in ways that correspond to their experience in directed conversations. Results revealed that in the pedagogical condition, there was not only main effect of child age, $F(1, 28) = 4.5$, $p = .04$, but also a significant interaction between age and cultural group, $F(1, 28) = 5.2$, $p = .03$, indicating that age and proportion of beep time was positively and significantly correlated in Mayan children ($r = .64$, $p = .006$), but not in U.S. children ($r = -.06$, $p = .86$; see Figure 2). A median split by child age revealed that older Mayan children in the pedagogical condition spent a higher proportion of their exploratory time on the beeper ($M = 85\%$) than younger children ($M = 49\%$), $t(15.6) = 2.3$, $p = .035$, and that younger children were more variable in this measure as compared to older children: Levene's test for equality variances, $F = 11.05$, $p = .005$. In the observational condition, there was a marginally significant effect of age, $F(1, 30) = 3.9$, $p = .06$, but, importantly, no Age × Culture interaction, $F(1, 30) = 0.13$, $p = .72$.

While these findings are based on a small number of subjects, and as such are necessarily preliminary, they open the possibility that there may be developmental differences in Mayan children's interpretation of pedagogically given information. Older but not younger Mayan 2-year-olds restrict exploratory play when given pedagogically framed information about the affordances or possible uses of an object.

General Discussion

The goal of this study was to see if children's tendency to restrict exploratory play following a pedagogical demonstration depends on extensive

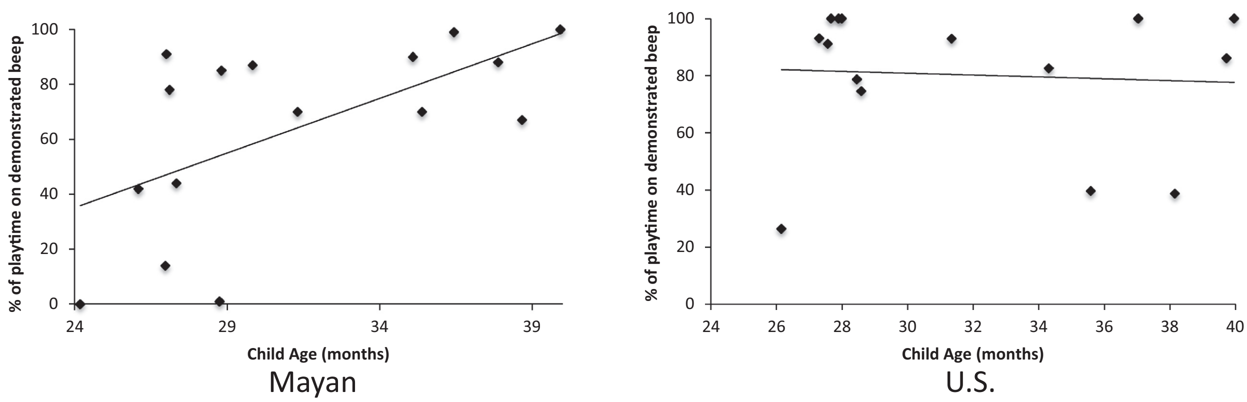

Figure 2. Relation between percentage of time spent on the demonstrated function (beeping) and child age for Mayan and U.S. children in the pedagogical condition.

experience in child-directed teaching contexts. Our findings suggest that it does not. We tested 2-year-old children, who had little to no experience with formal schooling, and Yucatec Mayan children, growing up in a community where explicit child-directed teaching in early childhood is limited. Overall, these children responded in very similar ways to older U.S. children in previous research (e.g., Bonawitz et al., 2011). Both Mayan and U.S. toddlers restricted exploration of an object to its demonstrated function, following pedagogical as compared to nonpedagogical experience (interrupted, accidental, and baseline conditions in Experiment 1, and observational condition in Experiment 2). These results rule out the possibility that experience in formal schooling contexts is a necessary precursor to this sensitivity. Toddlers from both cultural communities, despite having little to no formal schooling experience, restricted their exploratory play to the demonstrated part of the toy following pedagogical instruction.

Pedagogical framing could inform children's reasoning about socially communicated information in several ways. Children could infer that information presented in pedagogical contexts is usually about *what* is true about the world (e.g., "This is what the toy does"; see Bonawitz et al., 2011; Grice, 1975; Gweon et al., 2014; Shafto et al., 2012), or about *how* to interact with the world (e.g., "This is how you play with the toy"; see Butler & Markman, 2014; Casler & Kelemen, 2005; Nielsen, 2006; Nielsen & Tomaselli, 2010; Over & Carpenter, 2012; Shneidman & Woodward, 2015; Shneidman et al., 2015; Vredenburgh, Kushnir, & Casasola, 2014). Indeed, any demonstration likely serves as a "repository of cultural knowledge" (Harris, 2012, p. 60) and abundant research has shown that children are sensitive to information about social norms and conventions. For instance, when children do not have an alternative account of an adult's actions (see Gergely, Bekkering, & Király, 2002; Meltzoff, 1995, for contrasting cases), children imitate actions even when the actions are causally irrelevant to the outcome (Horner & Whiten, 2005; Kenward, Karlsson, & Persson, 2011; Lyons, Damrosch, Lin, Macris, & Keil, 2011; Lyons, Young, & Keil, 2007; McGuigan, Whiten, Flynn, & Horner, 2007) and children protest other's violations of socially established norms (e.g., Rakoczy, Warneken, & Tomasello, 2008; Schmidt, Rakoczy, & Tomasello, 2011). Thus, children in the pedagogical condition may have interpreted the demonstration as providing either information about what the toy did or about how they were supposed to interact with it.

We stress that these accounts are not mutually exclusive: Children presumably use information from adults to learn matters of fact about the world as well as norms, conventions, and broader social practices. In the formal analysis used in prior work (Bonawitz et al., 2011), the authors assume that the learner considers hypotheses regarding the possible number of toy's functions; however, the analysis is also consistent with hypotheses regarding the number of permissible or normative ways one could play with the toy. Furthermore, even though prior work suggests that older children in the United States interpret pedagogical demonstrations as information about the properties of an object rather than merely normative directions (Gweon et al., 2014), our results do not distinguish these possibilities in younger children. Indeed, there might be important and interesting developmental or cultural differences in the kinds of hypotheses children entertain from such demonstrations. In light of prior work documenting developmental shifts in children's reasoning in pedagogical contexts (e.g., Butler & Markman, 2012; Nielsen, 2006; Shneidman, Todd, & Woodward, 2014; see Shneidman & Woodward, 2015), we look forward to future research that might provide additional insight into the precise nature of children's inferences across early childhood. Critically, however, regardless of the specific content of the inferences, the current results suggest that pedagogical instruction leads children to learn not only that the communicated information is important, but also (by implication) that information that is *not* communicated is not true, relevant, or valuable.

Mayan children grow up in a cultural context where they have ample experience observing the actions of others, and prior research suggests they display patterns of attention and learning that reflect this experience (e.g., Chavajay & Rogoff, 1999; Childs & Greenfield, 1980; Correa-Chavez & Rogoff, 2009; Gaskins & Paradise, 2010; Paradise & Rogoff, 2009; Shneidman et al., 2015). Despite these cultural differences in pedagogical experience, we found that Mayan children, like children in the United States, explored an object less when directly taught as opposed to when they incidentally observed someone performing the same action.

Nonetheless, there are a number of respects in which children's cultural experiences may affect how they learn from others. In the United States, preschool-aged children who observe an adult teaching an action affordance to another child limit their exploration to that particular action, while children who observe a teaching interaction between two adults do not (Bonawitz et al., 2011). However, children growing up in industrialized Western communities, like the United States, are typically segregated from participation in adult activities (e.g., Rogoff et al., 1993) and thus may assume that actions taught to an adult are not relevant for informing their own learning. In contrast, children growing up in indigenous communities are allowed to monitor into the ongoing work and social activities of the adults around them (Gaskins, 1999; Gaskins & Paradise, 2010; Rogoff et al., 1993), and thus may have broader expectations about what information is appropriate or relevant for them.

Inferences that children draw from pedagogical and nonpedagogical contexts may also vary based on *within*-culture variations in social experience. For example, there are large increases, across early development, in the extent to which Mayan children are directly addressed in early childhood (Shneidman & Goldin-Meadow, 2012). Our results raise the possibility that these increases may correspond to developmental differences in children's pragmatic interpretation of pedagogically framed information. We found that older Mayan children spent an overall higher proportion of their play time on the demonstrated function following pedagogical cuing, while younger Mayan children were more variable in this measure. Future research with larger data sets might test the speculation that Mayan children have changing interpretations of pedagogically framed information corresponding to developmental changes in conversational input.

More generally, variations in caregiver behavior could relate to children's interpretation of pedagogically delivered information across development. For example, children growing up in indigenous communities in the Americas show variation in their propensity to attend to and learn from observed interactions based on caregivers' experience in formal schooling contexts (Correa-Chavez & Rogoff, 2009) and based on familial involvement in traditional cultural practices (Tsethlikiai & Rogoff, 2013). Similarly, within industrialized cultures, parent–child interactions vary greatly and have large effects on language and learning outcomes (e.g., Hart & Risley, 1995; Luce, Callanan, & Smilovic, 2013). Thus, although a basic sensitivity to the distinction between pedagogical and nonpedagogical contexts may emerge broadly in human development, individual differences in how children are integrated into adult life could well frame the kinds of contexts in which learning takes place.

In summary, the results of this study suggest that pedagogical contexts provide unique informational value for children, even when children have relatively limited experiences in formal and informal directed teaching contexts. However, our findings also open a number of avenues for future research. This work should consider ontogenetic and individual variation in Mayan children's experiences in child-directed and observed contexts, to ask if children's treatment of pedagogically framed information relates to variation in this social experience. Together, this work can provide a greater understanding of the mechanisms behind the relation between child-directed contexts and early learning, and can help inform questions about how children come to understand communicative intentions, how they interpret teaching situations, and what opportunities they use to learn from others.

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Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's website:

Appendix S1. Supplemental Analysis

Figure S1. Toy Used in Experiments 1 and 2. Pressing Tab (1) Activated Beeper, Tab (2) Activated Buzzer, Lifting Flap (3) Revealed Hidden Embroidered Duck, Lifting Back Flap (4) Revealed Hidden Mirror

Figure S2. Number of Unique Actions Performed by Children in Experiments 1 and 2