CHILD DEVELOPMENT

Child Development, November/December 2012, Volume 83, Number 6, Pages 2057–2072

# Learning About Tool Categories via Eavesdropping

Brenda Phillips
*Harvard University*

Rebecca Seston and Deborah Kelemen
*Boston University*

Prior research has found that toddlers will form enduring artifact categories after direct exposure to an adult using a novel tool. Four studies explored whether 2- ($N$ = 48) and 3-year-olds ($N$ = 32) demonstrate this same capacity when learning by eavesdropping. After surreptitiously observing an adult use 1 of 2 artifacts to operate a bell via a monitor, 3-year-olds returned to the demonstrated kind of tool as ''for'' the task and avoided it for an alternative task over 2 days. Two-year-olds performed similarly after eavesdropping on someone with more discriminable artifacts via the method of a window rather than a monitor. These results demonstrate that toddlers can acquire enduring artifact categories after less than 40 s of surreptitious observation.

Artifacts are a central and universal feature of human cultural environments. They are integral to almost every human activity, influencing the way that we forage, feed, fight, furnish, clothe, and entertain ourselves. In technologically-rich cultures, the array of physical artifacts that a young child is likely to encounter in the course of a single day is vast. Yet, despite this barrage of input, from early on children show a remarkable capacity to parse the artifact world into discrete and stable functional categories. Between 2 and 3 years of age, children's behavior actively demonstrates their knowledge of the conventional use of many household objects (e.g., Williams, Kendall-Scott, & Costall, 2005). They use spoons for feeding, cups for drinking, chairs for sitting, and even, to the despair of many a parent, television remotes to turn on the television.

The competence reflected in this kind of early artifact categorization behavior, in which tools are both recognized and treated as being ''for'' a particular task, is far from trivial. Human ecological success is, in significant part, a consequence of behavioral efficiencies resulting from the ability to create, maintain, consult, and act upon a stable mental inventory of function-based artifact categories (Casler & Kelemen, 2005; Gergely & Csibra, 2006). When solving an everyday problem (e.g., cutting fruit), humans do not spend time computing what object might physically achieve the goal (''what object is sharp enough?''). Instead, they easily bring to mind the category of tool for the task (i.e., a knife), find one, use it, and then—apparently unlike other primate species—store it for later reuse should the need rearise (see McGrew, 1996). When consultation of tool category knowledge suggests a functional need is unmet within an existing repertoire of tools, recognition of this fact provokes people to innovate new tool categories that are designed to fulfill that specific purpose. Children's early capacity to categorize tools as ''for'' particular functions is then a reflection of an evolutionarily significant skill that not only underpins active tool use but also promotes artifact innovation and design. So, how do children achieve this skill?

One possibility is that artifact function information is so adaptively significant that adults go out of their way to teach it to children either via very explicit kinds of child-directed tutoring (e.g., ''it's raining so use your umbrella'') or salient but more subtle child-directed demonstrations intended to foster children's imitative learning (Rogoff, 1993; see also Csibra & Gergely, 2009). Indeed, it may be noncoincidental that studies providing successful demonstrations of children's capacity to

This research was supported by NSF 0529599 and NSF 1007984 to Deborah Kelemen (PI). Additional support was provided by the SURE Program at the University of Sheffield and the AHRC Culture and the Mind Project. We thank the following undergraduate and graduate students for their research assistance: Reza Hadisi, Holly Jacobs, Maiya Jordan, Tasha Ramanayake, Laure St. Georges, and Carina Wind. Thanks also to Michael Carollo, Elisa Jarnefelt, Amy Needham, Joshua Rottman, and Carina Wind for comments on earlier drafts of this manuscript.

Correspondence concerning this article should be addressed to Brenda Phillips, Harvard University, Maxwell Dworkin 136, 33 Oxford Street, Cambridge, MA 02138. Electronic mail may be sent to phillips@seas.harvard.edu.

[Correction added on 9/26/2012, after first online publication 8/7/2012: A post-submission editing error in Table 2 has been corrected.]

 0009-3920/2012/8306-0017
DOI: 10.1111/j.1467-8624.2012.01827.x

functionally categorize artifacts in ways that directly influence their own actions have almost exclusively adopted some version of these child-directed approaches.

For example, Kemler Nelson and colleagues found that young children lexically categorize unfamiliar artifacts based on functional similarity after seeing them used to perform functions (in a child-directed demonstration) that are tightly supported by the structure of the objects (Kemler Nelson, Frankenfield, Morris, & Blair, 2000; Kemler Nelson, Russell, Duke, & Jones, 2000). In research adopting a more behaviorally active paradigm, Elsner and Pauen (2007) found that after seeing an adult use (in a child-directed demonstration) an effective and an ineffective kind of tool for a task, 15-month-olds imitated adults' effective tool use and showed tendencies to generalize to a novel exemplar. Finally, in the behaviorally active categorization paradigm that provides the methodological basis to this article, Casler and Kelemen (2005) found that after very briefly witnessing (in a child-directed demonstration) one of two perceptually distinct novel artifacts being used to perform the novel function of activating a light box, 2- to 4-year-old children enduringly categorized the demonstrated tool as being for that function. That is, they selectively returned to that kind of tool when repeatedly asked to perform the task over the course of 2 days. Indeed, by 2.5 years of age (although not 2 years; see Casler & Kelemen, 2007), the mappings created on the basis of this brief display were so specified that children avoided using the demonstrated tool for an alternative task. The mappings were also highly conventionalized (e.g., Diesendruck & Markson, 2001); children explicitly viewed their own tool categorization decisions as extending to absent individuals in a novel context (Casler & Kelemen, 2005, Study 2; see also Casler, Terziyan, & Greene, 2009).

The involvement of overt demonstration in all of these methodologies raises questions about the conditions under which children's competence at functionally categorizing artifacts emerges. Do children depend on having direct social exchanges with agents who actively solicit their attention to information about how an artifact could be used, or do they learn equally well from more self-involved individuals? The issue of whether children can learn artifact categories surreptitiously by observing others engaged in self-directed purposeful behavior is relevant for a number of reasons. First, as cultural psychologists and anthropologists have noted, not all children are likely to be the recipients of directive teaching acts that seem to be a particular feature of Western cultures (Henrich, 2004; Rogoff, Paradise, Mejía Arauz, Correa-Chávez, & Angelillo, 2003). Second, there is evidence from other conventional domains of knowledge that children can learn generalizable information without direct social exchanges with others (for learning words: Akhtar, 2005; Akhtar, Jipson, & Callanan, 2001; Floor & Akhtar, 2006; O'Doherty et al., 2011; for learning arbitrary rules to games: Schmidt, Rakoczy, & Tomasello, 2010; for learning novel object-directed actions: Herold & Akhtar, 2008).

It remains unknown, however, whether category learning in the very tangible domain of physical artifacts is similarly amenable to such nonexperiential, indirect learning by eavesdropping. Prior research has focused on learning in domains that reflect highly arbitrary conventional stimuli (e.g., words, game rules) that children cannot learn except by gleaning information from others—a fact that may perhaps heighten children's attention to, and ability to learn from, ambient social input. By contrast, the design history of artifacts renders them a less arbitrary domain. Information about an artifact's intended, conventional use is often embodied in its physical structure and can frequently be inferred from it. In consequence, children may be generally less oriented to ambient social cues when learning about artifacts, even as they may be receptive to explicit demonstrations of functional information when an adult offers them, or in search of such explicit guidance when structural ambiguities about what an artifact is "for" actually arise. Consistent with this suggestion of lower reliance on ambient social cues, DiYanni and Kelemen (2008) found that, even in a social exchange context, 2- and 4-year-olds tended to ignore an adult's incidental social cues that she preferred a physically suboptimal rather than an optimal artifact for a particular task; when presented with a choice, children selected the optimal artifact to perform the task for themselves.

Given these questions about the social context of children's artifact category learning, in the present studies, we investigated young children's capacity to learn function-based artifact categories by eavesdropping. Specifically, we adapted Casler and Kelemen's (2005) selective return method, which, as noted, has previously shown that at 2.5 years of age, toddlers rapidly and enduringly map specific functions to novel artifacts in a behaviorally productive way after witnessing a child-directed demonstration. In the current four studies, we stripped away the social, child-directed experiential context of this method to examine whether young children can rapidly learn novel artifact categories via surreptitious observation of a solitary, physically remote individual's tool use actions.

Study 1 initiated the sequence of studies as an important precursor to any experiments involving eavesdropping. It was conducted to explore the age at which young children can rapidly form enduring artifact categories in a direct social exchange context but with only brief observational exposure, that is, absent any initial personal hands-on learning experience. This first step was necessary because in our eavesdropping studies, we intended to not only strip away children's social interaction with a model but, in a departure from prior eavesdropping research (e.g., Schmidt et al., 2010), also their physical proximity to her; children were placed in a remote location because we wanted to deprive the model of visual access to the child so she could not inadvertently interact with them. As a result, at the time of first exposure, children were not going to have any option for immediate manual access to the novel artifacts—a methodological feature present in prior research using the selective return method (e.g., Casler & Kelemen, 2005, 2007).

Consistent with prior studies using the selective return method (e.g., Casler & Kelemen, 2005), in Study 1, children saw the adult experimenter demonstrate use of a tool to ring a bell in a transparent box. They were also introduced (in counterbalanced order) to an alternative object that was physically distinct but functionally equivalent although, importantly, never used for any purpose. Following this introduction, children were offered both objects and, over multiple trials, asked which object they needed to ring the bell and which object they would need to perform the previously undemonstrated task of crushing crackers. However, in a departure from prior work (Casler & Kelemen, 2005), in the current ''hands-off'' method, the experimenter did not offer children the chance to use the tool for the demonstrated purpose after briefly modeling it, and she did not hand them the nonfunctional alternative object after talking to them about it.

Prior theoretical and empirical research suggested that depriving young children of hands-on experience in this way could have a significant detrimental impact on their ability to form stable, artifact categories (e.g., Berthenthal & Clifton, 1998; Bourgeois, Khawar, Neal, & Lockman, 2005; Gibson & Pick, 2000; Lockman, 2000). This underscored our sense that this preparatory study was required, especially as we were also making the initial familiarization period extremely short to account for the fact that our young but mobile participants were unlikely to watch the model for long under later socially noninteractive eavesdropping conditions. The question of the age when children can rapidly learn artifact categories in a direct social exchange context but absent initial ''hands-on'' experience is one that we revisited in Study 3. In consequence, the sequence of four studies was as follows: Study 1 explored 2- and 3-year-old children's rapid ''hands-off'' observational learning of novel artifact categories in a direct social exchange context; Study 2 stripped away direct social exchange with the model and explored 3-year-old children's learning by surreptitious observation of a model from another room via a monitor; Study 3 revisited 2-year-olds' capacities to rapidly learn novel artifact categories with direct social exchange but absent hands-on experience; Study 4—the culminating eavesdropping study—explored 2-year-olds capacities to surreptitiously observe a model in another room via the direct method of a peeking hole created in a laboratory observation window.

Notably, the eavesdropping studies in this article depart from previous overhearing studies on word and game learning insofar as children were neither third parties to a social exchange in which the socially relevant information was being explicitly communicated to someone (Akhtar, 2005; O'Doherty et al., 2011) nor were they sitting in close proximity to a saliently gesturing experimenter (Schmidt et al., 2010). In this sense, the current experiments explore children's capacity to learn by eavesdropping under conditions that are in many ways more degraded than those in prior studies.

## Study 1

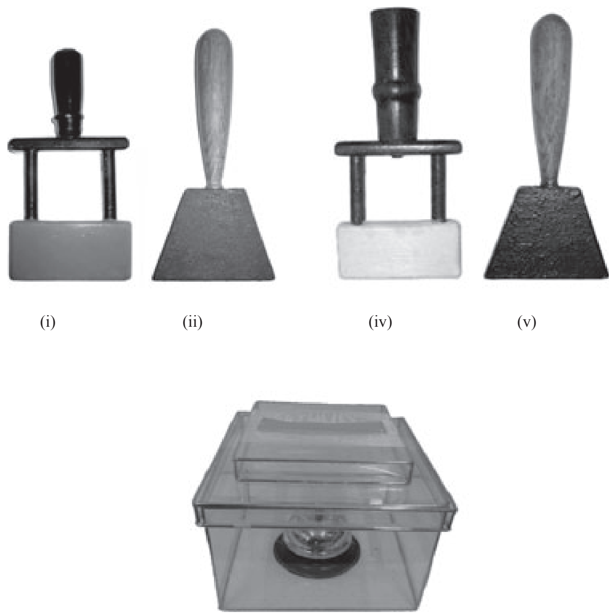
### *Method*

#### *Participants*

Participants were sixteen 2.5-year-olds ($M$ = 30 months, $SD$ = 2 months; 3 females) and sixteen 3.5-year-olds ($M$ = 43 months, $SD$ = 2 months; 9 females). Participants were primarily from middle-class homes in all studies. Among the 2.5-year-olds, 81% were Caucasian, 13% were Asian, and 6% were Hispanic. Among the 3.5-year-olds, 69% were Caucasian, 19% were Asian, 6% were African American, and 6% were Hispanic. Children were tested individually, in a laboratory, preschool, or home setting. All sessions in all studies were video recorded.

*Procedure*

Children were sequentially presented with two physically dissimilar artifacts in counterbalanced order for 30 s (approximately 15 s per artifact). Both artifacts were red with black and brown handles (Figure 1). The experimenter introduced the child to one of the artifacts (‘‘a blicket’’) and immediately provided him with an intentional demonstration of how it could be used to operate a transparent bell box (‘‘Now watch!’’) without making an explicit statement about the relation between the function and the tool (‘‘Wow! That’s really neat!’’). We used a transparent bell box that we planned to use in subsequent eavesdropping studies because the goal state was easy to perceive at a distance, and it offered children visual access to the fact that the demonstrated tool had caused the goal. The experimenter inserted the blicket in the box and rang the bell twice rapidly. She then paused briefly, stating, ‘‘Oh, I think I will give it another go!’’ before ringing the bell twice again. The child was not offered the option to handle or use the tool himself following her demonstration. If the child asked to ring the bell, the experimenter proceeded with her actions as planned, passing over the request in her apparent enthusiasm to keep exploring things.



(i) (ii) (iv) (v)

(iii)

*Figure 1.* In Study 1 and Study 2, the experimenter demonstrated how to insert artifact (i) or (ii) into a transparent box to ring a bell (iii). In Study 3 and Study 4, the experimenter performed the same actions with artifact (iv) or (v). The artifacts in Studies 1 and 2 were painted red, whereas the artifacts in Studies 3 and 4 were painted two different colors (e.g., white vs. gray).

During familiarization, the child was also introduced to the other object (‘‘a dax’’), which arrived wrapped in brightly colored gift paper. The only property or identity information that the child received about this artifact was nonfunctional in content: It pertained to its status as an object that had been misplaced (‘‘A dax! I wondered where it was and here it was all wrapped up!’’). After unwrapping this artifact, the experimenter pointed out its distinctive features (e.g., ‘‘It’s [texture is] bumpy’’) to make its physical attributes as salient as those of the blicket (e.g., ‘‘It’s really neat!’’). The experimenter allowed the child to visually inspect it, but as with the blicket, the child was prevented from handling it. The artifact serving as the functionally demonstrated blicket was counterbalanced (i.e., rectangle vs. triangle artifact) as was the order of familiarization (i.e., blicket first vs. dax first).

After both artifacts had been introduced, they were presented to the child again, at which time the experimenter explicitly pointed out their similar features and consequent functional equivalence (‘‘Look! These are really different, but on the bottom they are exactly the same size!’’). The experimenter then gave the child implicit manipulative information about the artifacts’ functional equivalence: She asked the child to help her put them away by inserting both artifacts into a holder that did not contain a bell but had two slots that were identical in size and shape to the slotted portion of the bell box. To be clear, the child did not have the opportunity to use either artifact to ring the bell during familiarization.

*Test trials.* After familiarization, the child received four sets of test trials, each set consisting of a generalization trial and then a dissociation trial (see Table 1 for test trial descriptions). Children therefore received eight trials in total. On the four generalization trials, the child was offered the blicket and dax and asked to make a choice as to which one was needed to ring the bell. On the four dissociation trials, the child was presented with the blicket and dax and asked which one was needed to crush a cracker. Our dependent measure was the number of times children chose the object that the experimenter had used to ring the bell (the blicket). On generalization trials, we predicted that children would consistently return to the blicket for ringing the bell despite the ready availability of the equally good alternative object. On dissociation trials, we predicted they would avoid use of the blicket for the alternative function of

Table 1
*Description and Order of Test Trials*

| Trial set | Trial type | Artifact set | Question |
|---|---|---|---|
| 1: Day 1 | Generalization | New | If you want to ring the bell, which one do you need? |
| 1: Day 1 | Dissociation | New | If you want to crush a cracker, which one do you need? |
| 2: Day 1 | Generalization | New | If you want to show your mommy [present adult] how to ring the bell, which one do you need? |
| 2: Day 1 | Dissociation | New | If you want to show your mommy [present adult] how to crush a cracker, which one do you need? |
| 3: Day 2 | Generalization | Same as in familiarization | If I [Day 1 or novel experimenter] want to ring the bell, which one do I need? |
| 3: Day 2 | Dissociation | Same as in familiarization | If I [Day 1 or novel experimenter] want to crush a cracker, which one do I need? |
| 4: Day 2 | Generalization | Same as in familiarization | If your daddy was here [absent adult] and he wanted to ring the bell, which one would he need? |
| 4: Day 2 | Dissociation | Same as in familiarization | If your daddy was here [absent adult] and he wanted to crush a cracker, which one would he need? |

cracker-crushing, selecting the alternative object (the dax) instead.

To explore enduring learning, the four sets of test trials were split across two testing sessions. The first two trial sets were conducted on Day 1 immediately following familiarization. The second two trial sets were conducted on Day 2, which was 1–3 days later. To explore the categorical nature of children's knowledge, all the trials on Day 1 were conducted with novel yellow variants of the red familiarization objects. On Day 2, all trials were conducted with the red artifacts that the experimenter introduced during familiarization on Day 1.

We were also interested in the conventional nature of children's tool–function categorizations. To explore whether children viewed the tool's function as an intrinsic object property with relevance to *all* users not just the particular tool user who was physically present during the testing session, we took two steps during the 2nd day of testing. First, the Day 2 test trials queried children's choices for a currently present (Set 3) versus currently absent (Set 4) adult. That is, in Set 3 the child was asked which object the experimenter would need to ring the bell and then crush the cracker and in Set 4 the child were asked which one an absent family member would need. Second, half of the children in each age group were tested by a novel experimenter on Day 2 rather than the familiar experimenter whom they had observed on Day 1. This allowed us to evaluate if children's object preferences were context and person specific thus limited to the presence of the experimenter who originally introduced the objects. Our method for assessing conventionality therefore departs from that adopted by others (e.g., Diesendruck, 2005; Diesendruck & Markson, 2001, 2011; Henderson & Graham, 2005) insofar as we did not ask children whether an absent individual would know the functions of the blicket or dax and therefore did not therefore explicitly assess whether they construed the functions as common knowledge. Nevertheless, our approach did allow us to examine children's assumptions about the existence of a common practical standard of usage that is relevant to novel and absent others—individuals whose opinions might very well differ from their own given that the artifacts were explicitly identified as equally affordant and physically interchangeable.

*Control trials*. Children were presented with four control tasks between Set 1 and Set 2 of the test trials on Day 1: novelty, memory, and two imitation tasks. If, as predicted, children repeatedly and enduringly returned to a familiar tool for a familiar task on the multiple generalization trials, this would represent a violation of a typical preference for novelty (e.g., Fantz, 1964). To establish the tool-specific nature of this behavior, we therefore explored whether children displayed normal novelty preferences on a non-tool-use task involving the same verbal request. On the novelty control task, children were shown a novel toy, and the experimenter pointed out its features. After this presentation, the toy was removed. The child was then presented with a choice to look at that toy again or another novel toy (''Which one do you need?''). A child with a preference for novelty would choose to look at the new toy.

The main test trials rest on children's ability to remember nonobvious functional information about artifacts after brief exposure and over a delay. Given this, we included a memory task to measure children's general ability to recall the hidden properties of two briefly demonstrated novel objects after a delay. On Day 1, following Set 1 of the test trials, the experimenter demonstrated the nonobvious hidden property of a tube-shaped toy (''It rattles when you touch it!'') and cloth toy (''It squeaks when you touch it.''). Following completion of all test trials on Day 1, and between test trial sets on Day 2, the child was asked to recall the properties of the toys without further demonstration (e.g., ''Which one rattles when you touch it?''). For consistency with the artifact testing procedure, the child did not have any hands-on experience immediately following the experimenter's brief toy demonstration.

The test trials also explored children's imitation of an adult's tool preference. As such, two imitation control tasks were included to examine whether children would have a tendency to indiscriminately imitate adults' object choices even in a nontool use context. In the first task, the child observed the socially interactive experimenter intentionally select one of two crayon colors (brown or black) to color in a printed triangle. The child was then offered a choice of the crayons for coloring using exactly the same phrasing as in test trials (''Which one do you need?''). In the second task, the child observed an experimenter intentionally choose one of two differently colored and shaped rocks and then place it onto a bull's-eye-type goal location platform. Following the experimenter's demonstration, the child was asked to perform the task (''Which one do you need?''). These imitation tasks served to show us whether a socially interactive adult's intentionally displayed object preferences, as well as the phrasing used in test trials, induces indiscriminate imitation of object choices.

Table 2
*Description and Results of Control Tasks by Study and Age*

| Control task | Study | Frequency of object choice |
|---|---|---|
| Novelty: Preference for novel toy | Study 1 | 2.5: 75%, $\chi^2$ = 4.0, $p$ = .05* |
| | | 3.5: 100% |
| | Study 2 | 3.5: 81%, $\chi^2$ = 6.25, $p$ = .01*** |
| | Study 3 | 2.5: 79%, $\chi^2$ = 4.57, $p$ = .03* |
| | Study 4 | 2.5: 88%, $\chi^2$ = 9.00, $p$ = .00*** |
| Memory: Recall hidden property on day 1 | Study 1 | 2.5: 87%, $\chi^2$ = 9.00, $p$ = .00*** |
| | | 3.5: 94%, $\chi^2$ = 12.25, $p$ = .00*** |
| | Study 2 | 3.5: 94%, $\chi^2$ = 12.25, $p$ = .00*** |
| | Study 3 | 2.5: 88%, $\chi^2$ = 9.00, $p$ = .00*** |
| | Study 4 | 2.5: 100% |
| Memory: Recall hidden property on day 2 | Study 1 | 2.5: 100%; 3.5: 100% |
| | Study 2 | 3.5: 94%, $\chi^2$ = 12.25, $p$ = .00*** |
| | Study 3 | 2.5: 94%, $\chi^2$ = 12.25, $p$ = .00*** |
| | Study 4 | 2.5: 100% |
| Imitation: Preference for same color crayon | Study 1 | 2.5: 31%, $\chi^2$ = 2.25, $p$ = .13 |
| | | 3.5: 56%, $\chi^2$ = 0.25, $p$ = .62 |
| | Study 2 | 3.5: 25%, $\chi^2$ = 4.00, $p$ = .05* |
| | Study 3 | 2.5: 44%, $\chi^2$ = 0.25, $p$ = .62 |
| | Study 4 | 2.5: 25%, $\chi^2$ = 4.00, $p$ = .05* |
| Imitation: Preference for same rock | Study 1 | 2.5: 50%, $\chi^2$ = 0.00, $p$ = 1.00 |
| | | 3.5: 56%, $\chi^2$ = 0.25, $p$ = .62 |
| | Study 2 | 3.5: 31%, $\chi^2$ = 2.25, $p$ = .13 |
| | Study 3 | 2.5: 44%, $\chi^2$ = 0.25, $p$ = .62 |
| | Study 4 | 2.5: 31%, $\chi^2$ = 2.25, $p$ = .13 |

*$p < .05$, two-tailed. ***$p < .001$, two-tailed.

## Results

### *Control Trials*

As Table 2 shows, on nontool tasks, children displayed normal preferences for novelty, orienting toward a novel rather than familiar toy. They also had no difficulty with delayed recall of two novel toys' hidden properties even after brief exposure. Finally, and importantly, children showed no bias to indiscriminately imitate an adult experimenter's intentional choice of object in either the crayon or rock imitation task. Children's lack of tendency to imitate object choice on nontool use control trials replicates Casler and Kelemen (2005, 2007) and was essentially the same in all studies in this article (although rejection of the experimenter's choice sometimes reached above chance levels). Given this consistency, for reasons of space, we do not consider this pattern in detail again until the general discussion of results. Children's orientation to novelty and strong memory control trial performance was also the same in all four studies and is not considered further.

### *Test Trials*

Children's tendency to form stable artifact categories was examined in a 2 (age: 2.5-year-olds vs. 3.5-year-olds) × 2 (blicket object: triangle vs. rectangle) × 2 (presentation order: blicket first vs. dax first) × 2 (trial type: generalization vs. dissociation) × 2 (test day: Day 1 vs. Day 2) analysis of variance (ANOVA) on the number of times children chose the demonstrated tool (the blicket) across eight test trials. Analyses revealed a main effect of trial type, $F(1, 24) = 8.82$, $p < .01$, subsumed by a Age × Trial Type interaction, $F(1, 24) = 11.74$, $p < .01$. An Age × Blicket Object × Test Day interaction also occurred, $F(1, 24) = 7.25$, $p < .01$.

*T* tests were conducted on each age group to explore the Age × Trial Type interaction. Results indicated a significant effect for 3.5-year-olds only, $t(15) = 4.13$, $p < .001$. As shown in Table 3, 3.5-year-olds were significantly more likely to select the blicket when asked to ring the bell on generalization trials than when asked to crush the cracker on dissociation trials, with their tool preference differing from chance in each case, $t(15) = 5.84$, $p < .001$ for generalization trials, $t(15) = -1.83$, $p < .05$ (one-tailed) for dissociation trials. In contrast to 3.5-year-olds, 2.5-year-olds used any tool for any task: They did not selectively return to the blicket on generalization trials or the alternative tool on the alternative task.

Additional *t* tests revealed that the Age × Blicket Object × Day interaction occurred because, on Day 2 only, 2.5-year-olds preferred the triangle artifact for both bell ringing and cracker crushing whether it had been the demonstrated tool on Day 1 or not. Thus, having functionally categorized neither the blicket nor dax on Day 1, 2.5-year-olds chose according to a physical preference when retested on Day 2.

To test the conventionalized, context-general nature of 3-year-olds' tool–function categorizations, we explored their responses to questions on the 2nd day of testing (Sets 3 and 4). To recap, a novel experimenter tested half of the children on Day 2. A 2 (experimenter: familiar vs. novel) × 2 (trial type: generalization vs. dissociation) repeated measures ANOVA on the tendency to select the blicket across the four test trials on Day 2 revealed no significant effects involving experimenter: main effect, $F(1, 14) = 1.34$, *ns*; interaction, $F(1, 14) = .66$, *ns*. Rather than being context and person specific, children's tool–function mappings were therefore intrinsic to the tools, holding constant whether the social context was familiar or novel.

Second, we explored whether children conventionalized their tool judgments extending them not only to an adult who was present with them but to an absent adult as well. Collapsing together groups in the familiar versus novel Day 2 experimenter conditions, children's Day 2 tool choices for the present adult (Set 3) were therefore compared with their choices for an absent adult (Set 4). Results of McNemar tests revealed no differences: Children selected the blicket to the same extent for both agents whether considering bell ringing, $p > .05$ (88% present; 63% absent), or cracker crushing, $p > .05$ (25% present vs. 44% absent).

### *Discussion*

The current results provide evidence that by 3.5 years of age, children can rapidly form stable, enduring artifact categories on the basis of brief ''hands-off'' familiarization. After brief observation of a child-directed demonstration, 3.5-year-olds, tested across 2 days, selectively returned to the demonstrated object, the blicket, as the kind of tool for ringing the bell and preferred the alternative kind of object, the dax, for crushing the cracker. Furthermore, children's tool mappings were conventionalized: 3.5-year-olds responded no differently whether they were tested by a familiar or previously absent novel experimenter or whether asked about the tool use of a party who was currently present or absent.

In contrast, 2.5-year-olds' chance responding on test trials revealed that young children did not make stable, enduring conventionalized mappings under the observational learning conditions of Study 1. Thus, interestingly, neither the context of direct social exchange nor, importantly, linguistic

Table 3

*Mean Percentage of Times Children Chose the Demonstrated Tool (the Blicket) on Generalization (Gen) and Dissociation (Dis) Trials Across 2 Days of Testing*

| Study | Age group | Gen total | Dis total | Gen Day 1 | Dis Day 1 | Gen Day 2 | Dis Day 2 |
|---|---|---|---|---|---|---|---|
| Study 1 | 3.5-year-olds | 81[c] | 38[b] | 88[c] | 41 | 75[c] | 34[b] |
| Study 1 | 2.5-year-olds | 50 | 53 | 41 | 47 | 59 | 59 |
| Study 2 | 3.5-year-olds | 80[c] | 45 | 88[c] | 47 | 72[a] | 44 |
| Study 3 | 2.5-year-olds | 74[a] | 42 | 78[c] | 31[a] | 69[a] | 53 |
| Study 4 | 2.5-year-olds | 69[a] | 34[b] | 69[a] | 41 | 69[a] | 28[a] |

[a]Different from chance at $p < .05$, two-tailed; [b]Different from chance at $p < .05$, one-tailed; [c]Different from chance at $p < .001$, two-tailed.

cues like the experimenter's referential use of the count nouns *blicket* and *dax* were sufficient to induce rapid novel artifact categorization despite reasons to suspect that both might be effective (e.g., Waxman & Markow, 1995; Xu, 2002).

So, why did 2.5-year-olds' response patterns occur? Consistent with a theoretical view that action conception depends on action experience, one possibility was that the absence of hands-on experience during familiarization undermined young children's ability to interpret the experimenter's actions and to form a motor-based representation of the tool's function (e.g., Meltzoff & Brooks, 2008; Sommerville & Decety, 2006; Sommerville, Hildebrand, & Crane, 2008; see also Piaget, 1929). An alternative interpretation from a more general information processing perspective (e.g., Wilson & Knoblich, 2005) is that hands-on experience is just one avenue by which information gains salience. By reducing the general salience of 2.5-year-olds' experience, in a context of brief exposure, children's memory for the differently shaped but identically colored artifacts may have been impacted, diminishing their ability to categorize them. Because these issues are interesting and important, we return to them in Study 3.

Given 3.5-year-olds' unambiguous Study 1 performance, however, we moved to test this age group in the eavesdropping method of Study 2. In this study, we stripped away the direct social exchange with the model during the artifact familiarization procedure to see if children could acquire function-based tool categories via surreptitious observation alone. In consequence, children were taken to an observation room with a highly visible television monitor where they could, if willing, observe an adult familiarize herself with the artifacts.

## Study 2

### *Method*

#### *Participants*

The final sample included sixteen 3.5-year-old children ($M$ = 43 months, $SD$ = 2 months; 12 females). Participants were 43% Caucasian, 25% Indian, 13% African American, 13% Hispanic, and 6% Asian. Four additional children were excluded and replaced due to parental interference (2), experimenter error (1), and failure of a control object-retrieval task (1). All testing occurred in a laboratory setting.

#### *Procedure*

To ensure that the child was oriented to the space and the first experimenter (E1), whom they would later surreptitiously observe, the child first engaged in a warm-up block play session in the study room with the first experimenter (E1) and second experimenter (E2). During the familiar activities of this warm-up session, while E1 was distracted, E2 covertly and confidentially informed the child that she had a fun secret to share. In a whisper, she invited the child—and any parent present—to follow her to a ''special TV room.'' After the child and E2 left the study room, E1, who was seated at the study room table, began to play with a teddy bear and building blocks, speaking aloud to herself as she explored.

As Figure 2 shows, after exiting the study room, the child briefly passed through two other rooms en route to the spying room. Upon finally entering it, the child saw the salient viewing apparatus, an 11.5-in. × 8-in. television monitor (with 14-in. screen) that provided a live feed to the study room where E1 was exploring. Importantly, the monitor projected a rotated birds-eye spatial view of the study room making it essential that E2 orient them to the viewing powers of the monitor as well as the location of several familiar objects in the room. Despite the increased cognitive load created by this altered view, results of the test trials and an

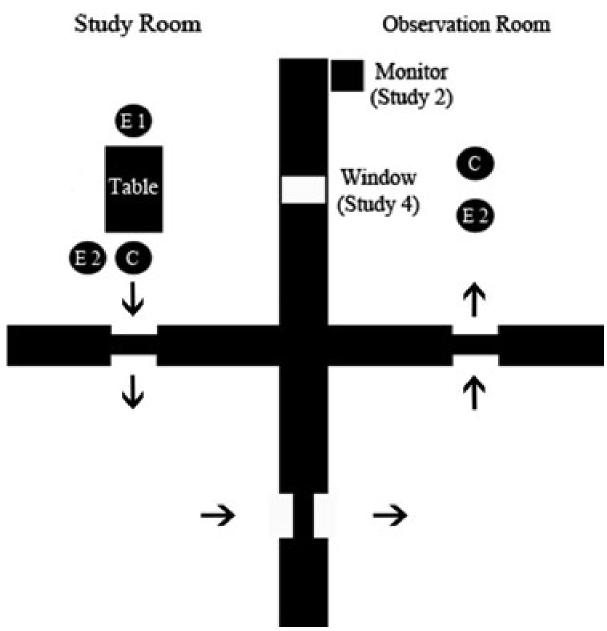



*Figure 2.* Layout of experimental rooms used in Studies 2 and 4.

additional ''object-retrieval'' task indicate that children dealt well with it.

On entrance to the observation room, the child was directed to a chair that was situated in front of the monitor. As the child climbed onto the chair, E2 excitedly pointed out that the television meant that he could see E1 and various objects in the room they had just left, highlighting in the process E1's ignorance about being spied upon and her lack of contingent interactivity: ''We can see her [E1] but she *can't* see us. And we can hear her [E1] but she *can't* hear us!! Look, there's the couch that mommy was sitting on and there are the blocks that you were playing with. What's she [E1] doing? She's playing with the bear. I'll push you in (on the chair) so you can see better.''

This introduction served to orient the child to the projected view of the room. Importantly, however, it should be clarified that lack of visual access meant E1 did not, in fact, know the child's whereabouts in the observation room or whether he was actually attending to her actions at any point. Furthermore, the ''birds eye'' camera angle—rather than a face-on view—ensured that child could never feel that the experimenter was observing or conscious of him. The model could therefore not inadvertently socially cue the child.

As E2 pushed in the chair, she simultaneously ''accidentally'' bumped against the wall. This served as the covert signal to E1 that the child's orientation to how the monitor reflected the viewing room was now complete. E2 then positioned herself behind the child—and out the child's line of vision—so that she would not inadvertently provide any cues to the child to attend to anything about E1's behavior next door. Furthermore, E2 never intervened if the child chose to ignore E1's actions. Interactions in the observation room were video recorded.

After receiving the covert signal, E1 began puting away the teddy bear and building blocks and then focused her attention on the contents of a toy box where the test artifacts and several other objects were housed. This procedure ensured that the child witnessed several object-directed actions in addition to those focused on the nonfunctional dax and the functional blicket while they were seated at the monitor. It is important to note that, on average, E1 spent more time engaging in nonfunctional object-directed activities (e.g., playing with bear, unwrapping the ambiguous nonfunctional dax) than exploring the functional blicket (44 s vs. 17 s, respectively) while she was being observed.

Given that she was by herself, E1 did not engage in conversation with anyone, and never looked at the camera, but instead spoke quietly to herself in a stream of consciousness as if she had stumbled upon the discovery of a secret set of unfamiliar objects hidden inside a toy box: For example, ''Oh my goodness, look at this! I wonder what's in here!'' She then began exploring the box contents, discovering and unwrapping the nonfunctional dax object first for half the participants: ''Wow, a dax! I wondered where it was and here it was all wrapped up! That's really neat!'' She also took out the blicket tool, which was discovered first for half the participants: ''Oh a blicket. Let me see what I could do with this.'' She then used the blicket to ring the bell two times in rapid succession (''That's really neat!''). Equal time was spent unwrapping and describing the physical features of the nonfunctional dax and using the blicket. The purpose of E1's self-talk was to provide children, should they attend, to the same information as in Study 1 without providing these cues in the context of an interactive child-directed demonstration. The child had to attend to at least 50% of the dax and blicket familiarization to be included in the final sample; all children did so.

The child followed E2 back to the study room after this brief surreptitious observation. At this point, E1 was standing with her back toward the door as she looked through another box of objects. On entering the study room, E2 prompted the child to tell E1 what they had been doing ''We were watching you!'' In return, E1 stated playfully, ''I don't believe you! If you were watching me then tell me what was I playing with?'' E1 then presented the child with a box of objects that included the familiarization artifacts, two other unfamiliar artifacts, and two stuffed animals. This recall task was included to verify that the child had attended to E1's actions. Children were not excluded for answering incorrectly. As in Study 1, E1 then pointed out that the artifacts looked different but had similar ends and also asked the child to insert the artifacts into a two-slotted, bell-box shaped holder. Importantly, E1 did not reference her prior tool use actions during this task.

*Test trials.* As in Study 1, the child then received four test trial sets, each consisting of a generalization and a dissociation trial. Two sets occurred on Day 1 and two occurred on Day 2, 1–3 days later. E1 conducted the test trials on Day 1. These trials were conducted with novel yellow tool variants (an unfamiliar artifact set) as in Study 1. Also as in Study 1, half the children were tested by a novel experimenter on Day 2 and half the Day 2 trials for all children involved questioning about an absent person's tool choice.

*Control trials*. As in Study 1, the child was presented with four control tasks between Set 1 and Set 2 test trials on Day 1: novelty, memory, and the crayon and rock object choice imitation tasks. The memory test was completed after all test trials on Day 1 and between test trial sets on Day 2.

An additional ''object-retrieval'' trial was included to examine whether the child had made the mapping from the symbolic medium of the monitor to the actual study room. Although it was a live feed and the child were oriented to how the image on the monitor allowed them to spy directly on the room next door, the child nevertheless viewed the experimenter via a televised image rather than viewing her actions directly. Therefore, after completion of all test trials on Day 2, the child performed an object-retrieval task modeled on Troseth, Saylor, and Archer (2006): He was told that E1 was going to hide a teddy bear in the study room and that it was his job to find it. At this time, the child followed E2 to the observation room and observed E1 hiding the bear via the live television feed. E1 did not communicate with the child as she hid the toy. Following this observation period, the child went back into the study room to ''find the bear.'' Consistent with Troseth et al.'s prior findings, most 3.5-year-olds retrieved the bear without issue. All children included in the final sample did so.

### *Results*

Results of the control measures were consistent with those in Study 1 (see Table 2). Data from the test trials were entered into a 2 (blicket object: triangle vs. rectangle) × 2 (presentation order: blicket first vs. dax first) × 2 (trial type: generalization vs. dissociation) × 2 (test day: Day 1 vs. Day 2) ANOVA on children's choice of the blicket tool. The results revealed a main effect of trial type, $F(1, 12) = 6.10$, $p < .05$, and a main effect of day, $F(1, 12) = 7.71$, $p < .05$. As Table 3 shows, children selectively returned to the blicket for the purpose of ringing a bell at above chance levels across 2 days of testing, $t(15) = 4.84$, $p < .001$, and were significantly less likely to select it for the purpose of crushing crackers, although their preference for the dax on dissociation trials did not reach above chance levels. The main effect of day occurred because regardless of trial type, children were more likely to use the demonstrated tool, the blicket, on Day 1 than Day 2.

To test the conventionalized nature of 3-year-olds' tool–function categorizations, a 2 (experimenter: familiar vs. novel) × 2 (trial type: generalization vs. dissociation) repeated measures ANOVA on the tendency to select the blicket across Day 2 test trials was conducted. Results revealed no significant effects involving experimenter: main effect, $F(1, 14) = 1.84$, *ns*; interaction, $F(1, 14) = .37$, *ns*. Second, collapsing across experimenter condition, we compared children's tool choices for the currently present adult (Set 3) with their choices for an absent adult (Set 4). McNemar tests revealed that children's tendency to select the blicket did not differ between agents for either bell ringing, $p > .05$ (75% present; 69% absent), or cracker crushing, $p > .05$ (38% present vs. 50% absent).

A further 2 (study: Study 1 vs. Study 2) × 2 (trial type: generalization vs. dissociation) repeated measures ANOVA was conducted to see if children's performance differed between the socially interactive context of Study 1 and the eavesdropping context of Study 2. The analysis revealed no effects of study: main effect, $F(1, 30) = .25$, *ns*; interaction, $F(1, 30) = .28$, *ns*. Thus, children rapidly categorized the novel artifacts to the same degree whether they gained information by directly interacting with the experimenter or by spying on her.

### *Discussion*

The current results provide evidence that 3.5-year-olds can form stable function-based categories by surreptitiously observing a solitary individual in another room absent a social exchange context. These conditions depart from those used in prior eavesdropping studies in which there was either close proximity to an experimenter engaging in salient gestures and actions (Schmidt et al., 2010) or the relevant material was the focus of a communicative exchange between others (Akhtar, 2005; O'Doherty et al., 2011). Despite the nonsocial, physically nonproximal context of the current study and the involvement of a symbolic medium (i.e., a television) that generally impedes rather than facilitates young children's learning (e.g., Deocampo & Hudson, 2005; Krcmar, Grela, & Lin, 2007; Singer & Singer, 1998; Strouse & Troseth, 2008; Troseth et al., 2006), children rapidly and enduringly acquired conventionalized function-based artifact categories from the experimenter. This was the case despite the lack of any contingent interactivity and regardless of whether children saw the experimenter unwrap the nonfunctional dax or use the blicket first as they eavesdropped on her removing items from a box. Importantly, children were as likely to rapidly form these categories as 3.5-year-olds in Study 1, who received a child-directed tool use demonstration.

In summary, results to this point suggest that 3.5-year-olds can learn function-based artifact categories from brief exposure to information in a non-experiential ''hands-off'' learning context whether socially interacting with a child-directed model or not. Yet, the results of Study 1 suggest that category learning is limited to experiential ''hands-on'' learning conditions for 2.5-year-olds. As noted earlier, there are several ways to interpret this developmental difference. One interpretation is that young children learn through doing. It is thus unsurprising that their ability to construct conceptual knowledge was inhibited when they were prevented from physically acting on the world in Study 1. Another interpretation, however, is that experience enhances children's learning not because conceptual representations have their origin in motor behavior alone, but rather because hands-on activity increases the salience of information, giving it a memorial advantage over unexperienced information. This latter position suggests that 2.5-year-olds would have been able to rapidly acquire novel artifact categories, even without hands-on experience, if the features of each object had been more physically salient.

In Study 3, we tested this latter idea. Specifically, 2.5-year-olds were presented with exactly the same ''hands-off'' socially interactive procedure as Study 1 except for two simple changes: The artifacts were made more visually discriminable by being painted two different colors—where previously they had both been painted the same color—and the handle of the rectangle object was enlarged.

## Study 3

### *Method*

#### *Participants*

The sample included sixteen 2.5-year-old children ($M$ = 31 months, $SD$ = 2 months, 8 females). Participants were 80% Caucasian, 13% Indian, and 13% Middle Eastern. Children were tested in a laboratory, preschool, or home setting.

#### *Procedure*

The procedure was exactly the same child-directed demonstration procedure as in Study 1 except that the blicket and dax now differed from each other in color (white vs. gray) to increase the physical distinctiveness of each object (see Figure 1). The functional ends of the artifacts were the same shape and size as in the previous two studies, but the handles were more equally and easily graspable for little hands. In Day 1 test trials, the child was presented with an artifact set that was painted in different colors (green vs. brown) than the initial familiarization set, and on Day 2 test trials, he was presented with the original familiarization artifact set (white vs. gray) again.

### *Results*

Results of the control measures were consistent with Study 1 (see Table 2). Test trial responses were entered into a 2 (blicket object: triangle vs. rectangle) × 2 (presentation order: blicket first vs. dax first) × 2 (trial type: generalization vs. dissociation) × 2 (test day: Day 1 vs. Day 2) ANOVA on children's choice of the blicket tool. Results revealed a main effect of trial type, $F(1, 12) = 9.75$, $p < .01$. As Table 3 indicates, children were significantly more likely to use the demonstrated tool, the blicket, for bell ringing than for cracker crushing, selecting the blicket as the bell ringer at above chance levels, $t(15) = 3.76$, $p < .005$.

Consistent with results of Studies 1 and 2, conventionality analyses yielded no significant effects of experimenter (familiar vs. novel) on the Day 2 test trials; main effect, $F(1, 14) = .04$, *ns*; interaction, $F(1, 14) = .07$, *ns*. Also consistent with the earlier studies, McNemar tests comparing children's responses for a present adult (Set 3) and absent adult (Set 4) revealed that children's tendency to select the blicket did not differ between agents for either bell-ringing, $p > .05$ (82% present; 56% absent), or cracker-crushing, $p > .05$ (56% present vs. 50% absent).

### *Discussion*

When 2.5-year-olds were presented with a brief ''hands-off'' familiarization procedure, but with highly discriminable artifacts, their mappings were enduring with the function being treated as an intrinsic property of the tool that generalized across people and contexts. As a result, we tested 2.5-year-olds in a surreptitious observation study with the same highly discriminable artifacts.

## Study 4

### *Method*

#### *Participants*

The final sample of participants included sixteen 2.5-year-old-children ($M$ = 31 months, $SD$ = 3 months, 11 females). Participants were 75% Caucasian, 13% Asian, 6% African American, and 6% Hispanic. Eight additional children were excluded and replaced due to failure to attend to familiarization (7) and parental interference (1). All testing occurred in a laboratory setting.

### *Procedure*

We used the same surreptitious observation method as in Study 2 with two changes: First, children saw the highly discriminable artifacts of Study 3. Second, children no longer eavesdropped by watching a television monitor but by kneeling on a chair and watching through a 14-in. aperture in an otherwise occluded one-way observation window. This switch to direct observation was required because prior research has found that children in this age range have significant difficulties with learning via a televised medium (Singer & Singer, 1998; Troseth et al., 2006) and piloting of the object-retrieval control trial in the current study confirmed this.

In consequence, when the child entered the observation room with E2, they were invited to climb up on a chair in front of the window as E2 pulled up the blinds. As in Study 2, E2 excitedly pointed out that the window meant that they could see E1 and various objects in the room they had just left. ''We can see her [E1] but she *can't* see us. And we can hear her [E1] but she *can't* hear us!! Look, there's the couch that mommy was sitting on. What's she [E1] doing? She's playing with the bear.'' This orientation to the viewing powers of the window was required because, to reach our observation room, the child passed through two other rooms and ended up being rotated 180° from their original position in E1's room when viewing it (see Figure 2). Moreover, given toddlers' limited concentration and tendencies to wander off, it was also highly unlikely that they would have discovered and explored the viewing powers of the window for themselves if simply deposited in the room. Importantly, however, E1 could not see the child at any time because the window glass on her side was mirrored. She therefore unfalteringly engaged in her actions according to her script, ignorant of whether the child was actually attending to her or not. Furthermore, because E1 sat parallel to the observation window rather than facing it, the child had a good view of her actions but was prevented from developing the sense that E1 was looking at or engaging with him. The procedure and sequence of events otherwise proceeded as in Study 2: Overall, E1 spent more time engaged in nonfunctional acts with the other objects than with the functional blicket tool (34 s vs. 21 s, respectively). Children were included in the final sample if they looked through the window for at least 50% of the blicket and dax familiarization period. As in Study 3, the test and control trials were conducted in the study room after familiarization on Day 1.

## *Results*

Findings from control trials paralleled those of previous studies (see Table 2). Test trial responses were entered into a 2 (blicket object: triangle vs. rectangle) × 2 (presentation order: blicket first vs. dax first) × 2 (trial type: generalization vs. dissociation) × 2 (test day: Day 1 vs. Day 2) ANOVA on children's choice of the blicket tool. Results revealed a main effect of trial type, $F(1, 12) = 9.77$, $p < .01$. As Table 3 indicates, children selectively returned to the blicket for bell ringing at above chance levels, $t(15) = 2.54$, $p < .05$, and tended to avoid it for cracker crushing, $t(15) = -1.91$, $p < .05$, one-tailed.

Consistent with results of all the studies reported here, conventionality analyses yielded no significant effects of experimenter (familiar vs. novel) on the Day 2 test trials: main effect, $F(1, 14) = .55$, *ns*; interaction, $F(1, 14) = 1.47$, *ns*. McNemar tests comparing children's responses for a present adult (Set 3) and an absent adult (Set 4) also revealed no differences between agents: Children selected the blicket to the same extent for both the present and absent party for both bell ringing, $p > .05$ (63% present; 75% absent), and cracker crushing, $p > .05$ (31% present vs. 25% absent).

A further 2 (study: Study 3 vs. Study 4) × 2 (trial type: generalization vs. dissociation) repeated measures ANOVA was conducted to see if children's performance differed between the socially interactive context and the eavesdropping context. The analysis revealed no effects of study: main effect, $F(1, 30) = .77$, *ns*; interaction, $F(1, 30) = .05$, *ns*.

## *Discussion*

After briefly surreptitiously observing an adult use one of two equally affordant but highly discriminable artifacts for a task, 2.5-year-old children rapidly categorized the blicket as the tool ''for'' that task, avoiding it for an alternative task. Their mappings were both stable and conventional, enduring over multiple trials across 2 days and generalizing across people and question contexts.

## General Discussion

The current studies sought to examine whether toddlers are capable of rapidly acquiring function-based artifact categories via eavesdropping rather than via the ''hands-on'' triadic child-directed social exchanges that are more typical in studies of artifact categorization (e.g., Casler & Kelemen, 2005; Elsner & Pauen, 2007; Kemler Nelson, Frankenfield, et al., 2000). The cumulative results of four studies indicate that they can. As long as the artifacts are easily visually discriminated, from at least 2.5 years of age, children can form stable, enduring, conventionalized function-based artifact categories by briefly surreptitiously observing a solitary individual in another room. That is, on seeing a non-socially interactive adult's intentional use of a tool to achieve a goal, toddlers rapidly map that goal as being the tool's intrinsic function and identify it as the category of tool that should be used for the task in other contexts and by other people.

The capacities revealed by toddlers in the current studies are notable for several reasons. It has long been reported that in some small-scale societies, it is unusual for adults to directly address children and engage in the kinds of child-directed interactions typical of white middle-class parents (e.g., Schieffelin & Ochs, 1986). Observational learning is therefore proposed as the primary means by which children in such societies acquire the arbitrary conventions of their culture (e.g., Ochs, 1982; Rogoff et al., 2003). However, as noted earlier, an artifact's function is rooted in and constrained by its physical structure. As a result, artifact functions are not only less socially arbitrary than many other cultural conventions (e.g., labels, rituals, etiquette), but their representation as intrinsic features of action-relevant object categories is potentially also more dependent on children having first-hand motor experience at the time of initial learning. In consequence, it was an open question how amenable artifact categories would be to the observational learning context in the current studies.

What the present results demonstrate, however, is that young children are not only able to acquire behaviorally stable and action-relevant artifact categories on the basis of hands-off observation but they are able to do so extremely rapidly under learning conditions involving no social exchange with, and no bodily proximity to, a model. In the case of 3.5-year-olds, children learned via the symbolic medium of a television screen—a medium that often hinders rather than facilitates learning (Singer & Singer, 1998; Troseth et al., 2006). In other words, children were able to acquire this categorical, conventional knowledge under conditions that are in many ways more socially degraded than even those described in naturalistic cross-cultural studies of learning by overhearing (e.g., Ochs, 1982).

Findings of this kind of competence in young children raise questions not only about the potentially privileged nature of artifact category acquisition but also about the prerequisites for the kind of rapid categorical learning found here. For example, in context of the theory of natural pedagogy (Csibra & Gergely, 2009; Gergely & Csibra, 2006), it has recently been argued that children may depend on a model's ostensive-referential communicative cues that she is performing an object-directed action for their benefit (e.g., alternating referential eye gaze, infant-directed speech). These cues trigger an object-centered interpretation that the knowledge conveyed generalizes beyond the specific referent to the kind to which it belongs and beyond the specific user to the community of users to whom there is an agreed on convention. Various findings provide support for different aspects of this proposal. For example, Király, Csibra, and Gergely (2004) found 14-month-old children were unlikely to reproduce an experimenter's novel means-end action of turning on a light box with her head unless her demonstration was first ostensively communicatively cued. More recently, in a looking time paradigm, Futó, Téglás, Csibra, and Gergely (2010) found that simply exposing 10-month-olds to an ostensively communicatively cued demonstration of one artifact performing two functional effects induced infants to believe that they had seen two different kinds of functional artifacts. This result is made striking in context of Futó et al.'s (2010) other finding that without an ostensively cued function demonstration, infants were unable to even individuate two artifacts that were perceptually distinct.

At first blush then, it may seem inconsistent with prior work on natural pedagogy theory that, in these surreptitious observational learning studies, children demonstrated the kind of rapid, stable, and conventionalized artifact categorization behavior that they displayed. While the pragmatics of working with young, mobile children required that these 2- and 3-year-old participants had the general spying capacities of the monitor (Study 2) or window (Study 4) pointed out to them, there was a complete lack of contingent interaction between the experimenter and child, and children were never instructed to attend to E1's tool use behavior: Use of the blicket just happened to be one action sequence of several—including unwrapping and exploration of the nonfunctional dax—that they observed as they engaged in spying. In other words, children did not receive any of the kinds of social-communicative cues or cues of relevance that studies on natural pedagogy theory have often focused upon as necessary to induce children to a kind-based interpretation of a model's tool use actions.

One way to reconcile this possible discrepancy between natural pedagogy theory and the present findings, however, is to assume a developmental view of children's reliance on ostensive-communicative cues. Studies suggesting the importance of ostension to children's object-centered genericity assumptions have primarily been conducted with infants (Csibra & Gergely, 2009; but see Butler & Markman, in press, for older preschoolers). In contrast, the present research was conducted with 2- and 3-year-olds. It seems reasonable to presume that as children mature and become more explicitly knowledgeable about artifacts and agents, the strategies that they use when deciding whether object-centered actions are idiosyncratic to an individual or generic information about an artifact kind change over time. For example, older children may become more attentive to person-specific cues about the model. That is, they may be more likely to treat tool use actions as categorical if they see them performed by someone whom they evaluate as a rational tool user—insofar as their actions are consistent with the functional, physical properties of the tool—or whom they appraise as generally knowledgeable—insofar as their actions seem confident (see DiYanni & Kelemen, 2008, for evidence). In addition, toddlers and older children may also be highly attentive to pragmatic cues (e.g., facial expression, naming) that the objects are familiar to the model and by implication likely to be known by others (see Schmidt et al., 2010, for evidence). Many of these conditions held in the present studies and might help to explain children's competence.

An alternative way to reconcile natural pedagogy theory with the present findings is, however, to instead argue that pedagogical cues were still present in our eavesdropping procedure: To avoid any subtle social cuing between E1 and the child, our studies were designed such that the child spied from a remote location—an experimental step that required E2 to orient children to the fact that they could spy via either the monitor or the peeping window. This was particularly necessary given the rotated view provided by the monitor and the peeping window (Studies 2 and 4) and the erratic, wandering nature of toddler participants who were unlikely to notice the eavesdropping window by themselves (Study 4). Perhaps, however, children's rapid categorization can be explained by this orientation. Maybe, in some way, it cued children to attend to E1's later use of the blicket for the bell box despite the fact that the blicket was not what children saw when they were oriented to the monitor or window; half the children saw the nonfunctional dax unwrapped first when the unfamiliar box was discovered and pedagogical cues presumably have some limitations on their scope. That is, instructing children about special windows or monitors should lead to generalization of information about special windows or monitors not every single entity and action associated with them at some point in time.

Nevertheless, the concern about the eavesdropping orientation is important. Fortunately, results from a recent sequence of studies exploring the influence of affiliative cues on children's learning help to address it. In one of these affiliation studies (Kelemen, 2012a), 2.5-year-old children performed exactly the eavesdropping procedure of Study 4. The only difference was that we stripped away children's friendly, affiliative interaction with E1, prior to any eavesdropping. Specifically, while E1 was present in the room during the initial warm-up period—and E2 drew attention to her, identifying her by name—E1 did not get involved in any socially affiliative interaction with the child before the child left the room to spy. Results revealed that under these conditions—with the window orientation fully intact—children did not learn any artifact categories from E1. During test trials conducted by E1 (as in the current study), participants neither selectively returned to the blicket tool that they had seen her use to ring the bell box (generalization, $M$ = 58%) nor avoided the blicket when asked to crush crackers (dissociation, $M$ = 59%). In short, these findings suggest that while explicit orientation to the peeping powers of a window does not play a causal role in children's rapid artifact categorization, person-specific information derived from socially affiliative interactions with others might. This makes sense when it is considered that an agreeable, affiliative person is more likely to be socially integrated and, thus, a better source of conventional knowledge—or perhaps any kind of generic knowledge—than someone who displays socially odd propensities such as ignoring others in close proximity (see Király et al., 2004; Gergely, 2007, for cases where this factor may have influenced results).

It is also worth noting that these affiliation results, combined with the findings of Study 1, also help rule out the possibility that the current categorization effects are attributable to the use of the count nouns *dax* and *blicket* in the procedure. Specifically, while labels have been found to induce categorization (e.g., Waxman & Markow, 1995; Xu, Carey, & Quint, 2004), artifact labels were not sufficient to successfully invite category formation by 2.5-year-old children in Study 1. They have also not been found effective in studies exploring children's rapid functional categorization of natural kinds (Kelemen, 2012b; Kelemen, Phillips, & Seston, 2012). It therefore remains for future research to further clarify why young children have such facility as rapid artifact category learners, enduringly acquiring them in less than 40 s even under highly socially degraded learning conditions. Understanding this capacity will not only help shed light on the developmental emergence of our capacities as the most proficient of tool using and tool creating species but also into the suite of potentially human-specific social and cognitive abilities underpinning children's striking accomplishments as cultural learners more generally.

## References


Akhtar, N. (2005). The robustness of learning through overhearing. *Developmental Science*, *8*, 199–209.

Akhtar, N., Jipson, J., & Callanan, M. A. (2001). Learning words by overhearing. *Child Development*, *72*, 416–430.

Berthenthal, B. I., & Clifton, R. K. (1998). Perception and action. In W. Damon (Series Ed.) & D. Kuhn & R. Siegler (Vol. Eds.), *Handbook of child psychology: Vol. 2. Cognition, perception, and language* (pp. 51–102). New York: Wiley.

Bourgeois, K. S., Khawar, A. W., Neal, S. A., & Lockman, J. J. (2005). Infant manual exploration of objects, surfaces, and their interrelations. *Infancy*, *8*, 233–252.

Butler, L. P., & Markman, E. M. (in press). Preschoolers use intentional and pedagogical cues to guide inductive inferences and exploration. *Child Development*. doi:10.1111/j.1467-8624.2012.01775.x

Casler, K., & Kelemen, D. (2005). Young children's rapid learning about artifacts. *Developmental Science*, *8*, 472–480.

Casler, K., & Kelemen, D. (2007). Reasoning about artifacts at 24 months: The developing teleo-functional stance. *Cognition*, *103*, 120–130.

Casler, K., Terziyan, T., & Greene, K. (2009). Toddlers view artifact function normatively. *Cognitive Development*, *24*, 240–247.

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

Deocampo, J. A., & Hudson, J. A. (2005). When seeing is not believing: Two-year-olds' use of video representations to find a hidden toy. *Journal of Cognition and Development*, *6*, 229–258.

Diesendruck, G. (2005). The principles of conventionality and contrast in word learning: An empirical examination. *Developmental Psychology*, *41*, 451–463.

Diesendruck, G., & Markson, L. (2001). Children's avoidance of lexical overlap: A pragmatic account. *Developmental Psychology*, *37*, 630–641.

Diesendruck, G., & Markson, L. (2011). Children's assumption of the conventionality of culture. *Child Development Perspectives*, *5*, 189–195.

DiYanni, C., & Kelemen, D. (2008). Using a bad tool with good intention: Young children's imitation of adults' questionable choices. *Journal of Experimental Child Psychology*, *101*, 241–261.

Elsner, B., & Pauen, S. (2007). Social learning of artefact function in 12- and 15-month-olds. *European Journal of Developmental Psychology*, *4*, 80–99.

Fantz, R. L. (1964). Visual experience in infants: Decreased attention to familiar patterns relative to novel ones. *Science*, *146*, 668–670.

Floor, P., & Akhtar, N. (2006). Can 18-month-old infants learn words by listening in on a conversation? *Infancy*, *9*, 327–339.

Futó, J., Téglás, E., Csibra, G., & Gergely, G. (2010). Artefact representation in preverbal infants: Function overrides visual properties. *Cognition*, *117*, 1–8.

Gergely, G. (2007). Learning *about* versus learning *from* other minds: Human pedagogy and its implications. In P. Carruthers (Ed.), *The innate mind: Foundations and the future*. Oxford, England: Oxford University Press.

Gergely, G., & Csibra, G. (2006). Sylvia's recipe: The role of imitation and pedagogy in the transmission of cultural knowledge. In N. J. Enfield & S. C. Levenson (Eds.), *Roots of human sociality: Culture, cognition, and human interaction* (pp. 229–255). Oxford, England: Berg.

Gibson, E. J., & Pick, A. D. (2000). *An ecological approach to learning and development*. New York: Oxford University Press.

Henderson, A. M. E., & Graham, S. A. (2005). Two-year-olds' appreciation of the shared nature of novel object labels. *Journal of Cognition and Development*, *6*, 381–402.

Henrich, J. (2004). Cultural group selection, coevolutionary processes and large-scale cooperation. *Journal of Economic Behavior and Organization*, *53*, 127–143.

Herold, K. H., & Akhtar, N. (2008). Imitative learning from a third-party interaction: Relations with self-recognition and perspective-taking. *Journal of Experimental Child Psychology*, *101*, 114–123.

Kelemen, D. (2012a). *Be nice: The role of affiliative cues in children's cultural knowledge acquisition*. Unpublished manuscript.

Kelemen, D. (2012b). Teleological minds: How natural intuitions about agency and purpose influence learning about evolution. In K. Rosengren & E. M. Evans (Eds.), *Evolution challenges: Integrating research and practice in teaching and learning about evolution* (pp. 66–92). Oxford, England: Oxford University Press.

Kelemen, D., Phillips, B., & Seston, R. (2012). *Children's functional categorization of natural and unnatural things: The role of intentional cues*. Unpublished manuscript.

Kemler Nelson, D. G., Frankenfield, A., Morris, C., & Blair, E. (2000). Young children's use of functional information to categorize artifacts: Three factors that matter. *Cognition*, *77*, 133–168.

Kemler Nelson, D. G., Russell, R., Duke, N., & Jones, K. (2000). Two-year-olds will name artifacts by their functions. *Child Development*, *71*, 1271–1288.

Király, I., Csibra, G., & Gergely, G. (2004). *The role of communicative-referential cues in observational learning during the second year*. Poster presented at the 14th Biennial International Conference on Infant Studies, Chicago.

Krcmar, M., Grela, B., & Lin, K. (2007). Can toddlers learn vocabulary from television? An experimental approach. *Media Psychology*, *10*, 41–63.

Lockman, J. L. (2000). A perception-action perceptive on tool use development. *Child Development*, *71*, 137–144.

McGrew, W. (1996). *Chimpanzee material culture: Implications for human evolution*. New York: Cambridge University Press.

Meltzoff, A. N., & Brooks, R. (2008). Self-experience as a mechanism for learning about others: A training study in social cognition. *Developmental Psychology*, *44*, 1257–1265.

Ochs, E. (1982). Talking to children in Western Samoa. *Language in Society*, *11*, 77–104.

O'Doherty, K., Troseth, G. L., Shimpi, P. M., Goldenberg, E., Akhtar, N., & Saylor, M. M. (2011). Third-party social interaction and word learning from video. *Child Development*, *82*, 902–915.

Piaget, J. (1929). *The child's conception of the world*. New York: Harcourt, Brace Jovanovich.

Rogoff, B. (1993). Children's guided participation and participatory appropriation in sociocultural activity. In R. H. Wozniak & K. W. Fischer (Eds.), *Development in context: Acting and thinking in specific environments* (pp. 121–153). Hillsdale, NJ: Erlbaum.

Rogoff, B., Paradise, R., Mejía Arauz, R., Correa-Chávez, M., & Angelillo, C. (2003). Firsthand learning through intent participation. *Annual Review of Psychology*, *54*, 175–203.

Schieffelin, B., & Ochs, E. (1986). *Language socialization across cultures*. Cambridge, England: Cambridge University Press.

Schmidt, M., Rakoczy, H., & Tomasello, M. (2010). Young children attribute normativity to novel actions without pedagogy or normative language. *Developmental Science*, *14*, 530–539.

Singer, J. L., & Singer, D. G. (1998). Barney and Friends as entertainment and education: valuating the quality and effectiveness of a television series for preschool children. In J. K. Asamen & G. L. Berry (Eds.), *Research paradigms, television, and social behavior* (pp. 305–367). Thousand Oaks, CA: Sage.

Sommerville, J. A., & Decety, J. (2006). Weaving the fabric of social interaction: Articulating developmental psychology and cognitive neuroscience in the domain of motor cognition. *Psychonomic Bulletin and Review*, *13*, 179–200.

Sommerville, J. A., Hildebrand, E., & Crane, C. C. (2008). Experience matters: The impact of doing versus watching on infants' subsequent perception of tool use events. *Developmental Psychology*, *44*, 1249–1256.

Strouse, G. A., & Troseth, G. L. (2008). ''Don't try this at home'': Toddler's imitation of new skills from people on video. *Journal of Experimental Psychology*, *101*, 262–280.

Troseth, G. L., Saylor, M. M., & Archer, A. H. (2006). Young children's use of video as a source of socially relevant information. *Child Development*, *77*, 786–799.

Waxman, S., & Markow, D. B. (1995). Words as invitations to form categories: Evidence from 12- to 13-month-old infants. *Cognitive Psychology*, *29*, 257–302.

Williams, E., Kendall-Scott, L., & Costall, A. (2005). Parents' experiences of introducing everyday object use to their children with autism. *Autism: International Journal of Research and Practice*, *9*, 521–540.

Wilson, M., & Knoblich, G. (2005). The case for motor involvement in perceiving conspecifics. *Psychological Bulletin*, *131*, 460–473.

Xu, F. (2002). The role of language in acquiring object kind concepts in infancy. *Cognition*, *85*, 223–250.

Xu, F., Carey, S., & Quint, N. (2004). The emergence of kind-based object individuation in infancy. *Cognitive Psychology*, *49*, 155–190.