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Brief article

Reasoning about artifacts at 24 months: The developing teleo-functional stance ☆

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Abstract

From the age of 2.5, children use social information to rapidly form enduring function-based artifact categories. The present study asked whether even younger children likewise constrain their use of objects according to teleo-functional beliefs that artifacts are "for" particular purposes, or whether they use objects as means to any desired end. Twenty-four-month-old toddlers learned about two novel tools that were physically equivalent but perceptually distinct; one tool was assigned implicit function information through a short demonstration. At test, toddlers returned to the demonstrated tool when asked to repeat the task, but, unlike older children, also used it for another task. Results imply that at 24 months, toddlers expect artifacts to have functions and proficiently use a model's intentional use to inform tool choices, suggesting cognition that differs from that of tool-using monkeys. However, their artifact representations are not yet specified enough to support exclusive patterns of tool use.

Keywords: Tool use; Function; Teleology; Artifacts; Intentionality; Design stance

One of the most surprising characteristics of preschoolers' tool use is how adultlike it is. Like adults, when children see a new tool or unfamiliar device, they assume it is "for" some purpose and they monitor others' intentional use of the object in order to learn

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that purpose (Casler & Kelemen, 2005). In adults, this behavior is argued to stem from an explanatory tendency referred to as the design stance. The design stance biases adults to classify, name, and use objects according intended function—what the object was designed for (Bloom, 1996; Gutheil, Bloom, Valderrama, & Freedman, 2004; Kelemen, 1999; Matan & Carey, 2001; Rips, 1989; for alternative views, however, see Malt & Johnson, 1992, 1998; Siegal & Callanan, 2005).

Children do not appear sensitive to design information until late preschool age (Gelman & Bloom, 2000; Kelemen, 1999; Matan & Carey, 2001), with some estimates putting the understanding even later, around the age of 6 or 7 (Defeyter & German, 2003). Nevertheless, recent research shows that prior to appreciating the notion of intended design, children teleo-functionally view artifacts in terms of functions (Kelemen & Carey, in press). Kemler Nelson and others (Kemler Nelson, 1999; Kemler Nelson, Frankenfield, Morris, & Blair, 2000; Kemler Nelson, Russell, Duke, & Jones, 2000) have found, for example, that young preschoolers extend names to objects according to shared use rather than overall similarity as was previously assumed (Gentner, 1978; Landau, Smith, & Jones, 1998). Moreover, in a recent move away from lexical categorization methods, sensitivity to function has been shown to support children's real-world action upon objects too. When children as young as 2.5 years old very briefly observed a model intentionally using an object to achieve a goal, and were given a single opportunity to try out the object themselves, most children immediately viewed the object as exclusively "for" that demonstrated function and avoided using it for an alternative, feasible purpose (Casler & Kelemen, 2005). Preschoolers' tool learning was rapid (one-trial learning), their tool-function mappings were enduring (they lasted across several days), and the functions were viewed as intrinsic to the tools themselves (children judged that all people would need the same objects for the same functions).

As teleo-functional reasoners, preschoolers can rapidly create stable, function-based object categories. This has significant implications for cognitive efficiency because, as a result, children do not need to "reinvent the wheel" each time they choose to achieve a particular goal. Instead, they can simply call to mind the object that is "for" that purpose and use it accordingly. Their teleo-functional stance makes them proficient tool users well before their third birthdays, providing an early foundation to the mature, design-based construal of artifacts. However, preschoolers' relatively adultlike competence begs a question: when does teleo-functional reasoning begin to influence children's object understanding and use?

To help answer this question, the present investigation probes the tool use of 24-month-old toddlers, using a streamlined version of methodology previously employed with older children (Casler & Kelemen, 2005). The key issue is whether toddlers will form stable artifact categories based on observing an intentional use, like their older counterparts, or whether they will treat tools opportunistically, as simple means to ends. There is reason to suspect both possibilities. On one hand, the latter possibility would be in keeping with recent proposals that children and non-human primates initially accrue object knowledge similarly (Fragaszy, Takeshita, Matsuzawa, & Mizuno, 2004; Lockman, 2000). Like tamarin and capuchin monkeys, which have not been found to reliably prefer certain tools as "for" certain tasks even after lengthy training (Cummins-Sebree & Fragaszy, 2005; Hauser, 1997; Hauser, Pearson, & Seelig, 2002), perhaps toddlers too see tools as merely useful means to currently desired ends. On the other hand, toddlers may already show distinctly human patterns of tool use because of their competence in understanding intentions and goal-directed action (Gergely, 2002; Meltzoff, 2002; Tomasello, 1999; Woodward, 2003). These early-appearing social abilities arguably pave the way for a teleo-functional stance by focusing children's attention on the specialized, socially mediated roles of artifacts (Bloom, 1996; Kelemen, 2006; Kelemen & Carey, in press; Tomasello, 1999).

To help disentangle these options, children in this study learned about two novel tools that looked different but were equally capable of performing identical functions. However, only one of the tools was demonstrated achieving a goal (i.e., ringing a bell), and the question was whether the tool would quickly become viewed as "for" that task and that task alone. This was assessed by asking children to achieve two types of goals: the demonstrated goal (generalization trials: bell ringing) and a new, alternative goal (dissociation trials: pasta crushing), noting the pattern of children's tool choices across trial types.

To explore enduring learning, testing was split across two days. In addition, to explore the universality of any tool-function mappings, a new experimenter tested half of the children on their Day 2 visit. The rationale was that if 24-month-old view function as intrinsic to a tool, then all children should respond to tool trials similarly regardless of agent (i.e., a "bell-ringing tool" should be viewed as a bell-ringer regardless of who asks). If, however, toddlers are merely cued by the presence of the individual who demonstrated a function in the first place, then those tested by the same experimenter on Day 2 should show a stronger preference for the demonstrated tool than those tested by a new experimenter.

In addition to tool trials, children's novelty preferences, memory for object properties, and tendency toward indiscriminate imitation were assessed. The relevance of these tasks is described in the next section.

1. Methods

1.1. Participants

Participants were 24 two-year-olds ($M = 24$ months, 7 days; $SD = 13$ days). Parents were present but silent and outside the child's line of sight.

1.2. Materials and procedures

1.2.1. Familiarization

The experimenter sat at a table across from the child and introduced two tools (Fig. 1). One tool, the "blicket," was demonstrated ringing a bell. The blicket was

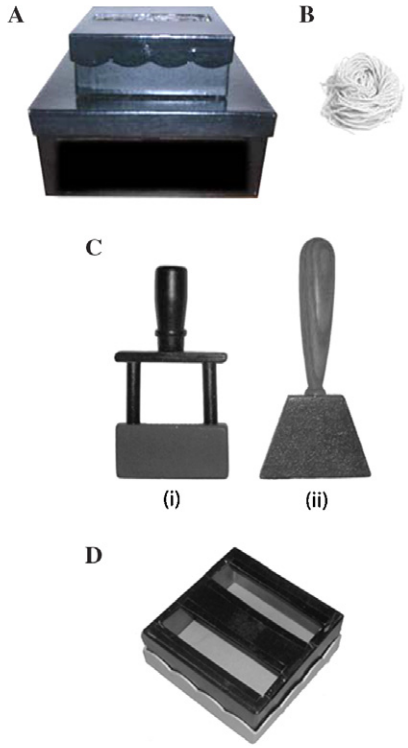

Fig. 1. Materials used in familiarization. The experimenter rang the (A) bellbox and crushed the (B) pasta nest with (C) tool (i) or (ii). To stress the tools' functional equivalence, both tools were inserted into identical slots in (D) a tool holder at the end of familiarization.

not described; the experimenter simply called attention to it then performed the action by inserting the tool into the slot of a box a single time and quickly striking an internal bell 2 to 3 times. The child was invited to try once too.

The other tool, the ''dax,'' was equally affordant for ringing the bell but was not demonstrated achieving that goal. Instead, children performed the action of unwrapping it from colorful paper. An inner transparent wrapping layer was included to give preliminary visual access to the tool during unwrapping. The experimenter was animated about the dax, making it particularly salient by pointing out its characteristics (e.g., color, texture).

The experimenter invited children to insert the dax into the slot of another box (its ''holder''), causing children to physically manipulate the alternative tool in a manner nearly identical to the demonstration tool. This ''holder'' had matching side-by-side slots in the top (Fig. 1). After children slotted the dax into one hole, they were invited to slot the blicket into the other hole so the two tools stood beside one another in identical openings, non-verbally emphasizing the tools' physical equivalence. Because children had now inserted the blicket twice (i.e., once into the bellbox, once into the holder), the experimenter removed the dax and had the child insert it a second time. Tools were counterbalanced for order of presentation and assignment as blicket or dax.

In preparation for later dissociation trials, the experimenter placed a "nest" of dried pasta (Fig. 1) on the table and put the dax and blicket on either side of it. The experimenter blocked this array from the child's sight with an opaque screen then quickly and noisily proceeded to smash the pasta with a tool, requiring the child to infer which tool had been used. The screen was removed and the child saw the end-state (i.e., pasta bits) between the tools. All materials were put away.

1.2.2. Tool trials

Children received a total of eight tool trials across two days. On Day 1, following familiarization, children received four test trials. First, the bellbox was placed in front of the child and he or she was offered the pair of tools in a new color (generalization trials). The experimenter encouraged the child to make a choice by holding the tools end-to-end in front of the child, saying, "Here! You do it! Can you do it?!" After children made a choice and rang the bell, the experimenter put away the objects, placed a pasta nest in front of the child, then again held out the tools saying, "Here! You do it! Can you do it?!" (dissociation trials). Both trials were later repeated upon completion of the control tasks (described below).

To explore enduring learning, children returned two to four days later and received another two generalization and two dissociation trials, this time in a new room. As noted earlier, a very strong test of children's universality assumptions was included: On Day 2, half were tested by a new experimenter.

1.2.3. Control tasks

In addition to tool trials, children completed a series of control tasks on Day 1. If children selectively return to a particular object on tool trials, this behavior would contrast with children's typical preference for novelty. To verify novelty preferences here, the experimenter presented the child with a small toy, either (a) a tall plastic cylinder that moaned when inverted or (b) a rubber toy that squeaked when squeezed. After children discovered the toy's hidden property (often with assistance), the experimenter took the toy back, briefly held it beneath the table, then reintroduced it along with the other toy. Children's selection of the familiar or the new toy was recorded. If they chose the familiar toy, after a few seconds the experimenter replaced it with the new toy so children learned the non-obvious properties of both objects.

As a memory check, ensuring that toddlers could accurately recall a novel object's non-obvious property after brief exposure, the toys from the novelty task were reintroduced later on. The experimenter looked for immediate recognition of the hidden properties (i.e., did the child immediately squeeze one and invert the other to achieve the sounds?).

Children's bias toward indiscriminate imitation was also monitored. Four tasks explored whether any preferences children might show for using the demonstrated tool could be due to wholesale tendencies to copy any action performed by the adult model. The first two tasks were part of a coloring project. The experimenter took two crayons in hand: brown and gray. Making her color selection very salient, she looked at them in turn then decidedly chose one (“Hm…*This* one”) and put the other aside. Then, while coloring in a printed triangle, the experimenter stopped herself on three separate occasions. Each time, she struck the crayon on the edge of the table with three methodical taps, then resumed coloring; while striking the table, she looked satisfied with the activity and made occasional eye contact with the child. Next, she offered both crayons to the child, along with another printed triangle, and said, “Here, you do it!” The child was evaluated for copying the experimenter’s (a) color selection and (b) tapping behavior.

The third and fourth imitation assessments utilized a different non-tool paradigm: manipulation of non-biological natural objects. The experimenter began by taking out two small but easily discriminated rocks, different in overall coloring and shape. She placed one stone to her left and one to her right, then placed a laminated card (8.5″ × 11″) between the stones. The card had a red “bulls-eye” target printed in the center; the target was prominent and container-like due to a cardboard ring attached to its perimeter (Fig. 2).

The experimenter took one rock in her fingers and scrutinized it, then held it toward the child, saying, “Ooh, see this? Wow.” She replaced it and repeated the performance with the other rock. Then, surveying the array, she decidedly chose one rock and “hopped” it across the table toward the center; the rock landed in the target after several hops. The experimenter looked satisfied with her selection and performance, then re-created the array in front of the child, saying, “*You* do it.” Children were monitored for two types of imitation: (a) choosing the same rock, and (b) moving their chosen rock in a similar manner and path (i.e., hopping to the ring).

2. Results

2.1. Tool tasks

The main question was whether 24-month-old children would show a teleo-functional tendency to return to the demonstrated tool. A 2 (trial: generalization, dissociation) × 2 (day: Day 1, Day 2) × 2 (experimenter: same, different) ANOVA

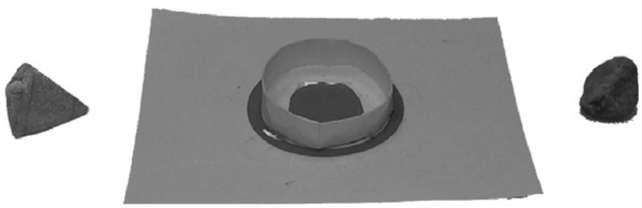

Fig. 2. Materials used for the “rock hopping” task in the imitation battery.

explored children's tool selections. No main effects or interactions were detected. However, as Table 1 shows, this was not due to random or directionless responding. Instead, participants consistently chose the demonstrated tool across days of testing, across experimenters, and, unlike older children, regardless of trial type. Follow-up analyses confirmed this finding. Collapsing day of testing, paired samples t-tests revealed that children's tendency to choose the demonstrated tool on generalization trials ($M = 75\%$) and dissociation trials ($M = 71\%$) was statistically identical, $t(1,23) = .70$, n.s. Children actively preferred the demonstrated tool in all circumstances, as compared to chance, generalization: $t(1,23) = 3.92$, $p < .01$, dissociation: $t(1,23) = 3.62$, $p < .01$.

An independent samples t-test confirmed that children's use of the demonstrated tool on Day 2 was not diminished among participants who saw a different experimenter, generalization: $t(1,22) = -.28$, n.s.; dissociation: $t(1,22) = .30$, n.s. Specifically, children tested by the same experimenter throughout both sessions used the demonstration tool 71% and 75% of the time on generalization and dissociation trials, respectively; children tested by a new experimenter used the demonstration tool 75% and 71% of the time on those same trials.

2.2. Control tasks

Children displayed typical novelty preferences: 75% chose to explore the novel object, exact binomial $p = .023$. Likewise, their memory for non-obvious object properties, following a single exposure, was excellent; 100% accurately recalled the objects' hidden properties.

Four tasks assessed children's tendency to precisely imitate the experimenter. No task, however, revealed a bias toward indiscriminate copying. On the two forced choice imitation tasks, children responded at chance levels: 42% chose the same colored crayon as the experimenter, 46% chose the same rock, both binomial ps n.s. On the two open-ended tasks, independent samples t-tests detected no meaningful differences between children who imitated and children who did not with respect to choice of the demonstration tool. Specifically, those children who copied rock hopping behavior were no more likely to copy the experimenter's tool choice on generalization, $t(1,21) = .737$, n.s., or dissociation trials, $t(1,21) = .718$, n.s. Mimicking the experimenter's crayon tapping likewise did not reveal wholesale tendencies toward imitation. Indeed, children who copied crayon tapping were *less* likely to copy the

Table 1
Mean percentage (and p-values comparing to chance) of times 24-month-olds chose the demonstrated tool

	Generalization	Dissociation
Collapsed	75 ($p = 0.001$)*	71 ($p = 0.001$)*
Day 1	75 ($p = 0.005$)*	67 ($p = 0.057$)**
Day 2	73 ($p = 0.005$)*	73 ($p = 0.002$)*

* Significantly different from chance, $p < 0.05$, two-tailed.
** Significantly different from chance, $p < 0.05$, one-tailed.

experimenter's tool choice, although this finding only obtained for generalization trials, $t(1,21) = -2.729$, $p < 0.01$, not dissociation trials $t(1,21) = -1.291$, n.s.

To investigate any possible individual relationships between tendency to copy and tendency to use the demonstrated tool, each child was assigned a score from 0 to 4 based on the number of imitation tasks on which he or she had copied the experimenter. Bivariate correlations detected no relationship, however, between children's overall imitation score and their tendency to choose the demonstrated tool on tool tasks (generalization: $r = -.074$, n.s.; dissociation: $r = .02$, n.s.). This finding was upheld even when children were artificially dichotomized: A "high imitation" group consisted of children who replicated the experimenter's choice or action on 2, 3, or 4 of the imitation tasks (12 children) and a "low imitation" group consisted of children who followed the experimenter on 0 or 1 tasks (12 children). One-way ANOVAs detected no differences between groups on tool choices; both "high" and "low" imitators were equally likely to use the demonstrated tool in generalization trials, $F(1,22) = .102$, n.s., and dissociation trials, $F(1,22) = .126$, n.s.

3. Discussion

This investigation explored the development of the teleo-functional stance. Do 24-month-old toddlers show the same type of rapid, socially mediated learning for artifact function demonstrated by adults and preschool-aged children (Casler & Kelemen, 2005)? Or do they, like monkeys, believe artifact function is guided by transient goals, based on an object having suitable physical features?

The answer is mixed. In distinct human fashion, toddlers in this study learned the function of an artifact rapidly. After only brief exposure to a model using an artifact to achieve a particular goal, toddlers consistently returned to that artifact when subsequently asked to achieve the same goal. Their tool choices were enduring in that they used the same tool on the initial day of learning and again several days later. Likewise, their choices were not affected by a change in experimenter or testing location. In short, 24-month-old toddlers already are approaching the understanding shown by older children and adults; they do not flexibly use any workable object to achieve any desired goal. This is not monkeylike behavior.

However, toddlers' performance was not entirely like that of older children: they did not form *exclusive* tool-function categories. Specifically, toddlers did not choose a different tool when asked to achieve a different goal. Instead, they continued to use the demonstrated tool across both generalization (bell ringing) and dissociation (pasta crushing) trials. Given the abilities of much younger infants to infer goal-states and make action predictions in the absence of visual access (Csibra, 2003; Csibra, Biro, Koos, & Gergely, 2003; Meltzoff, 1995), it seems unlikely that the pasta-crushing goal was simply too difficult for children to grasp. Additionally, the penchant for the demonstrated tool did not clearly reduce to several other potential biases. On the non-tool imitation tasks, 24-month-olds showed no overarching tendency to faithfully mimic the experimenter's object choices or actions. On the novelty control, they were not simply inclined toward choosing familiar items.

So what does this mean? On one hand, in consistently reusing a tool for tasks, toddlers demonstrate a burgeoning awareness that objects exist "for" socially-determined purposes – a substantial accomplishment that, at present, has not been empirically demonstrated in any other tool-using species. This contrast between children and monkeys is significant, supporting a proposal that intentional reasoning (already in a toddler's cognitive toolkit but arguably a uniquely human constellation of abilities) forms the core of artifact concepts.

On the other hand, it cannot be ignored that toddlers' tool-function mappings are not yet specified, and therefore cannot be used as a reliable basis for distinguishing artifact concepts. This finding has provocative theoretical interpretations. An initially attractive explanation of toddlers' lack of dissociation is that observers in this paradigm simply have no basis for assuming that the alternative tool is "for" pasta crushing, or anything else for that matter, so they continue using the demonstration tool. However, Casler and Kelemen (2005) found that preschoolers and adults do use a new tool for a new task, suggesting that conclusions about non-demonstrated tools are indeed licensed. But this leads to a new question: why are they licensed?

One possibility is that for adults and older toddlers, the "new tool, new function" mapping does not reflect any kind of artifact-specific knowledge but is really a pragmatic response based on the kind of "principle of contrast/mutual exclusivity" reasoning about speaker intentions found for words (e.g., Clark, 1987; Markman, 1989; Markman & Wachtel, 1988) and facts (Diesendruck & Markson, 2001). That is, just as a person might assume that if her friend wanted the pen she would have asked for it, and so "dobby" must refer to the novel alternative object on the desk, individuals also assume that an experimenter must want them to use a new tool for a novel task (because she already demonstrated that the other tool was for a more familiar task). However, one finding that mitigates against a general pragmatic rather than tool specific interpretation of the generalization-dissociation response is that older children do not show strong generalization-dissociation patterns when objects other than tools are used in this kind of study. Specifically, preliminary results suggest that, on seeing a novel natural object (not a perceptually regular artifact) demonstrated for one purpose, older toddlers have no significant preference for that object over an alternative when asked to perform the task again and thus no firm basis for dissociating to an alternative, via the principle of contrast, when asked to perform a new task (Kelemen, Casler, & Phillips, 2006). Furthermore, younger toddlers' failure to dissociate in the present study also speaks against a bare pragmatic explanation of the dissociation response. Before 24 months, children successfully and regularly use mutual exclusivity to guide word acquisition (Littschwager & Markman, 1994; Markman, Wasow, & Hansen, 2003; Xu, Cote, & Baker, 2005). If similar pragmatics guide tool learning, then these children ought to dissociate here too, like their older counterparts. The implication is that tool learning may be a rather special domain; humans have a set of tool-specific expectations that are supported by rich intentional understanding, and are not underpinned by general learning principles alone.

At 24 months, we conclude then, toddlers are constructing a rudimentary version of a teleo-functional stance. Their construal supports some of the behaviors that a full teleo-functional stance permits older children and adults, such as enduring mapping of a function to an object and the recognition that functions "belong" to tools irrespective of users. Several more months will pass, however, before toddlers view artifacts as existing for specialized, non-overlapping purposes. In sum, it appears that human artifact concepts differ from those of non-human, tool-using animals from early in development. More to the point, artifact concepts appear to rely on uniquely human intentional abilities, such that artifact concepts undergo changes across development that reflect maturing intentional reasoning. To fully assess this developmental account, a non-verbal test for a teleo-functional stance must be brought to even younger infants, more directly exploring its relationship to very early developing social-intentional understanding.

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