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REPORT

Young children's rapid learning about artifacts

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Abstract

Tool use is central to interdisciplinary debates about the evolution and distinctiveness of human intelligence, yet little is actually known about how human conceptions of artifacts develop. Results across these two studies show that even 2-year-olds approach artifacts in ways distinct from captive tool-using monkeys. Contrary to adult intuition, children do not treat all objects with appropriate properties as equally good means to an end. Instead, they use social information to rapidly form enduring artifact categories. After only one exposure to an artifact's functional use, children will construe the tool as 'for' that particular purpose and, furthermore, avoid using it for another feasible purpose. This teleo-functional tendency to categorize tools by intentional use represents a precursor to the design stance – the adult-like tendency to understand objects in terms of intended function – and provides an early foundation for apparently distinctive human abilities in efficient long-term tool use and design.

Introduction

When encountering an unfamiliar gadget or tool, adults tend to presume it is for some purpose and, furthermore, that the nature of this function is intimately tied to the intentions of the person who designed the object. These historically based intuitions provide strong organizing principles for adult conceptions. They guide judgments concerning the functions, names and category memberships of novel artifacts (e.g. Bloom, 2000; German & Johnson, 2002; Kelemen, 1999; Matan & Carey, 2001; Rips, 1989). More importantly, they exert profound influence on active behavior since the ability to form stable artifact category representations based on intended function (a.k.a. 'adopting the "design stance" ', Dennett, 1990) makes us highly efficient. Consider how easily people solve common tasks (e.g. writing). Rather than thinking, on each occasion, about what object might physically achieve the goal ('which of these things can make lasting marks on this page?'), we effortlessly bring to mind the category of tool designed for the task (i.e. pens), find one, use it, and then – apparently unlike any other species – repeatedly store it for later use should a similar need reoccur (see McGrew, 1996). On encountering novel instances of such artifacts we easily recognize for what task they are meant.

To be sure, a downside to representing artifacts in terms of intended design is that it may inhibit us from violating that function when an alternative use might be advantageous ('functional fixedness', Defeyter & German, 2003; German & Barrett, 2005; Kelemen, 2001, 2004). This is a small price to pay, however, for the powerful benefits of the design stance. It significantly underpins our capacities as the most organized and efficient species of tool-using problem-solvers. Even more distinctively, it permits us to manufacture and use an astonishing diversity of specialized tools, since our stable representations of what existing objects are 'for' allow us to innovate and use new objects for new tasks (Kelemen, 2005; Tomasello, 1999). Unlike other primates, we do not 'make do' with relatively unspecialized implements discarded after limited re-use (see Boesch & Boesch, 1984; McGrew, 1996).

Children begin to adopt the design stance during early school years. For example, 5-year-olds judge that an object made for stretching clothes but used every day for exercising a bad back is really 'for' stretching clothes (Kelemen, 1999), should be called something like 'clothes-stretcher' (German & Johnson, 2002; Matan & Carey, 2001), and belongs with laundry rather than gym equipment (Kelemen, 2001; also Diesendruck, Markson & Bloom, 2003; Kemler Nelson, Herron & Morris, 2002; for review, Kelemen, 2004; Kelemen & Carey, in press). But if children do not recognize the relevance of design to object function until kindergarten or later, it raises an important question: How do they view artifacts prior to this?

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One possibility is that, prior to the design stance, young children approach tools much like captive capuchin and tamarin monkeys. Specifically, one unexpected by-product of studies demonstrating monkeys' sensitivity to tools' physical affordances (Cummins-Sebree & Fragaszy, 2004; Hauser, 1997; but see Povinelli, 2000) is that they also reveal how very unlike adult human behavior their tool use is. For example, even after extensive, successful training to pull a particular tool to obtain food, monkeys show no preference for that tool if workable alternatives become available, that is, they never seem to code one tool as 'for' food pulling and selectively return to it – a strategy detracting from their longer-term computational and practical efficiency. Recent work has suggested phylogenetic continuities between children's and monkeys' tool use behavior (Fragaszy, 2004; Lockman, 2000). Consistent with this perspective then, pre-design stance children may, like monkeys, treat tools as simple means to ends, opportunistically using anything available that can serve an immediate need without forming enduring, function-based representations of objects. If children essentially treat objects as 'for' whatever they currently want, it would certainly conform to adults' commonsense intuitions that children are unconstrained and non-adultlike in their approach to common artifacts (Casler, 2005).

Another possibility, however, is that despite not understanding the relevance of an object's design history, children nonetheless form stable artifact categories, construing artifacts in terms of particular uses that they regard as enduring, intrinsic properties of objects themselves rather than transient extensions of individuals' own goals. Although lacking the inferential depth and power of a full-blown design stance (Kelemen, 2005; Kelemen & Carey, in press; Matan & Carey, 2001), this precursor teleo-functional stance would support many of the efficient problem-solving patterns observed in human adults: rapid mapping of a function to a tool with selection and preferential re-use of that category of tool for the task over time. In short, children may realize that tools have intrinsic, dedicated functions even though their mapping strategies (i.e. paying attention to intentional cues) might make them susceptible to being misled regarding the normative, designed function that ought to be dedicated.

No prior direct tests have distinguished between these possibilities or explored how rapidly, exclusively and enduringly young children form artifact categories for the purposes of actual tool use. The following studies therefore explored these questions using a straightforward, behavioral measure: children's tendency to return to a particular kind of tool for a particular kind of task. In each study, we showed children two dissimilar novel objects and briefly demonstrated one of the objects performing a function for which both objects were physically equivalent (e.g. launching a toy from a tube). We then measured children's object selections when they were subsequently, repeatedly, asked to perform this function or an alternative task. Of interest was whether, despite repeated questioning – which under other circumstances tends to promote answer-switching – children would tend to consistently use a particular class of tool for the original task, thus 'generalizing' from initial demonstration to subsequent occasions. Also of interest was whether they would 'dissociate' and avoid using the demonstrated artifact when asked to perform an alternative function (e.g. crushing crackers instead of toy launching). Generalization and dissociation in combination would provide the clearest evidence of a teleo-functional stance since it would suggest that children rapidly form a representation of an artifact as 'for' an enduring function that is integral to the object itself and potentially exclusive to it. Generalization without dissociation would provide weaker evidence of a teleo-functional stance insofar as children's return to a particular tool for a particular task would suggest an enduring function-based representation but not a highly specified one. Finally, a pattern in which children arbitrarily use either tool for either task would suggest a short-term pragmatic strategy much like that of monkeys who do not display behaviors consistent with stable teleo-functional construals of artifacts as existing 'for' purposes.

Study 1 focused on older preschool children due to more taxing methodology. The simplified method of Study 2 permitted testing toddlers as young as 2.

Study 1

Participants

Participants were 18 4-year-olds (M = 52 months, SD = 4 months), 18 5-year-olds (M = 67, SD = 5) and 16 undergraduates.

Procedure

Participants were familiarized with two dissimilar objects in counterbalanced order (Figure 1). One object ('blicket') arrived in commercial-looking packing and was briefly demonstrated by the experimenter launching a small toy out of a tube (children could also try if they desired), although both objects were equally good for this task. The other object ('dax') came wrapped in birthday paper but no implicit function information was provided. Instead, participants spent time exploring its

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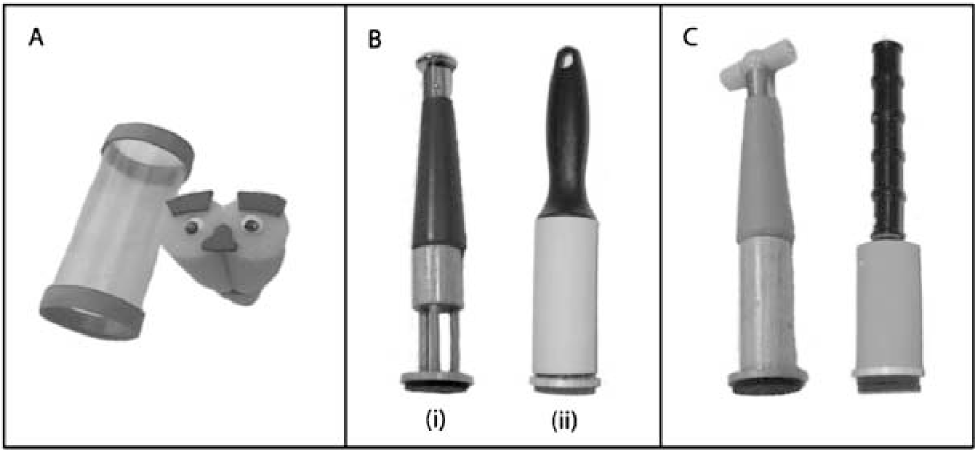

Figure 1 *Materials from Study 1. During familiarization, the experimenter launched (A) the foam toy from the tube with (B) tool (i) or (ii). In test trials, (C) shape and/or color of the tools were modified.*

Table 1 *Description of trials in Study 1*

Trial	Type	Description
1	Generalization	Offered the original tools (red), now in a new post-familiarization testing context
2	Generalization	Offered the tools in a new color (green)
3	Dissociation	Offered the original tools (red) but asked to crunch a cracker, not launch a foam toy: 'If you wanted to show (Teddy, your neice, etc.) how to crunch up this cracker, which one do you need?'
4	Effort	Offered the demonstrated blicket in a new color (blue) versus the alternative dax in original, familiar color (red)
5	Effort	Offered the original tools (red) but the blicket/demo tool was placed out of easy reach versus the dax/alternative tool close by
6	Generalization	Offered the tools in slightly modified shapes and a new color (orange)
7	Effort	Offered the original tools (red) inside identical clear, plastic containers, with the top tightly screwed on the blicket/demo tool container and the top resting loosely on the dax/alternative tool container
8	Dissociation	Offered the tools in a new color (green) and asked to crunch a cracker, not launch a foam toy (see trial 3)

properties, heard interesting facts about it ('this comes from Peru!'), then slotted it into a tubular container – equivalent to the blicket's launching tube – while selecting a box in which to store the object. Thus, despite only seeing one tool demonstrated, children manipulated both tools equivalently by inserting them into very similar tubes. Neither tool was explicitly described as 'for' any particular function and tool assignment as 'blicket' or 'dax' was counterbalanced. Participants' exposure to the objects was intentionally brief, 1 minute per tool, because of our interest in how quickly children form mappings. To balance the fact that only the blicket was used for a function, the experimenter was highly animated about the dax to ensure it was viewed as desirable and interesting.

After familiarization, children were introduced to a bear ('Teddy') and adults were asked to imagine a child they knew. The experimenter presented participants with a different tube and foam toy, held out the two tools, and asked, 'If you want to show (Teddy, your niece) how to pop this out and make it go flying, which one do you need?' The question was asked eight times in fixed trial order (Table 1). This method represented a strong test of children's commitment to any tool-function mapping, given children's tendency to answer-switch under repeated questioning. Three 'generalization' trials explored participants' choices when requested to straightforwardly perform the demonstration task. These trials tested children's responses on presentations of the standard task, one time using the original tools, another time using color variants, and another time using shape and color variants, thus exploring children's generalization to novel exemplars of both tools. In three 'effort' trials, participants were offered a demonstrated tool that was less familiar or more difficult to access than the alternative (e.g. the blicket was in a tightly closed container and the alternative was easily available in an identical open container). The effort trials tested whether preference for the

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blicket might reduce to low-level mechanisms of accessibility or habit. Finally, two 'dissociation' trials explored choices when participants were asked to perform a different, undemonstrated function – cracker crushing – for which both tools remained equally affordant. This provided a strong test of the specificity of any tool-function mappings.

In addition to tool trials, children received two control tasks. Young children usually have strong novelty preferences and given that evidence of a teleo-functional stance primarily means returning to familiarity, we wanted to determine whether children would show normal novelty preferences with objects outside the tool domain. Participants were allowed to explore a toy and discover its hidden property (e.g. squeaking, rattling), then children's novelty preference was checked by asking which of two objects – the familiar one or a novel one – they subsequently needed. Our second control ensured children could accurately remember the hidden property of an object after only brief exposure. The toys from the novelty task were therefore displayed again later in the session and children recalled their hidden properties (squeaking, rattling).

Results

Preliminary analyses found performance at ceiling on the memory task; 100% of children remembered the toys' unobservable properties after brief exposure. Children also showed strong preference for novelty over familiarity outside the tool use context: 16 out of 18 4-year-olds ($\chi^2 = 10.9$, $p < .001$) chose the novel toy, as did 17 of 18 5-year-olds ($\chi^2 = 14.2$, $p < .001$).

To investigate children's teleo-functional tendency to return to the demonstrated tool, a 3 (age: 4-year-olds, 5-year-olds, adults) × 3 (trial: generalization, effort, dissociation) ANOVA was conducted on the number of times participants selected the demonstrated tool. Proportion scores controlled for different numbers of trial types.

As Table 2 shows, there was a significant effect of trial type, $F(2, 98) = 39.36$, $p < .0001$. Overall, children and adults were more likely to choose the demonstration tool when asked to launch the toy on generalization trials ($M = 81\%$) and effort trials ($M = 80\%$) than when asked to crush a cracker on dissociation trials ($M = 37\%$). There was also an age by trial type interaction, $F(4, 98) = 4.86$, $p < .001$. This occurred because although participants within each age chose the demonstration tool equally in generalization trials and effort trials, and significantly more often in both these trial types than in dissociation trials (paired *t*-test results: Table 3), adults' tendency to reject the blicket during dissociation trials was stronger than either group of preschool children's (one-way ANOVAs: dissociation: $F(2, 49) = 6.482$, $p = .003$, both Bonferroni *t*-tests $p < .05$; generalization: $F(2, 49) = 1.176$, $p = .317$, n.s.; effort: $F(2, 49) = 0.473$, $p = .626$, n.s.). Indeed, while children chose the demonstration tool significantly more in effort/generalization trials than in dissociation trials, their tendency to select the alternative tool in dissociation trials, unlike adults, did not differ from chance.

Table 2 *Mean percentage (and* p*-values comparing to chance) of times children chose the demonstrated tool for each trial type in Study 1*

	Generalization	Effort	Dissociation
4-year-olds	76 ($p = .000$)*	80 ($p = .000$)*	50 (ns)
5-year-olds	76 ($p = .007$)*	76 ($p = .005$)*	47 (ns)
Adults	90 ($p = .000$)*	85 ($p = .000$)*	13 ($p = .000$)*

* = significantly different from chance at the 0.05 level, two tailed.

Table 3 *Paired samples* t*-tests comparing performance in each trial type for each age group in Study 1*

	Conditions compared	*t*	Significance
4-year-olds	generalization – effort	–0.61	0.547
	generalization – dissociation	2.83	0.011*
	effort – dissociation	3.19	0.005*
5-year-olds	generalization – effort	0.003	0.998
	generalization – dissociation	2.03	0.059~
	effort – dissociation	2.06	0.055~
Adults	generalization – effort	0.82	0.432
	generalization – dissociation	8.02	0.000*
	effort – dissociation	7.60	0.000*

* = significantly different from chance, $p < .05$, 2-tailed; ~ $p < .05$, 1-tailed.

Discussion

On briefly seeing an artifact intentionally used for a purpose, children, like adults, had a strong tendency to return to the tool as 'for' that purpose when asked to repeat the function, and were significantly less likely to choose it when asked to do something else. A rapid, socially learned preference emerged, regardless of which tool was used as the demonstrated object and despite the fact that both tools were equally able to perform both functions. Although children's tendency to change tools when asked to perform a new function was less marked than adults', they chose the demonstration tool significantly less often when asked to crunch a cracker (dissociation trials) than when asked to launch a toy (generalization / effort trials). Importantly, preferences were not limited to specific training tools; all participants

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readily formed categories and used instances of the tools in new colors or modified shapes with the new tube and toy.

Most striking, children and adults alike sought a particular tool even at a cost (stretching for it across a table, taking it from a closed container), despite the more convenient presence of a different but equally functional tool. If tool use is governed by simple pragmatism or attention to whether an object has suitable features, then we would expect participants to choose the 'handiest' object. Instead, their performance supports an account in which artifact use is guided by a teleo-functional interpretation of objects, derived from brief observation of another's intentional actions. That is, preschoolers and adults seemed predisposed to rapidly classify categories of objects as expressly 'for' a function, using them accordingly to the exclusion of perfectly feasible alternatives.

In sum, Study 1 provides moderate evidence of teleo-functional reasoning. Several questions remain, however. Although children put both objects into equivalent tubes during familiarization, perhaps participants used the dax less for toy launching because they were not sure it would fit. Also, although children's imitation of the experimenter's tool choice (in addition to dissociation) provided a measure of how well children formed tool-function mappings after brief exposure to implicit function information, perhaps situational novelty or general contextual cues would have led children to replicate the unfamiliar adult's choices even outside of the tool use task. To address these issues, Study 2 included explicit discussion of the tools' functional equivalence and a separate imitation control task. Second, Study 1 was designed as a strong test of teleo-functional tendency and included repetitive questioning. However, the pragmatics of such questioning – it prompts answer-switching as children question whether their responses are inappropriate – may have interfered with children's performance; specifically, it may have led to chance responding on dissociation trials. Because of this, the procedure of Study 2 was simplified and shortened. Given equivalent performance on Study 1 generalization and effort trials, effort questions were removed and generalization trials were simplified to exclude shape variants to which children readily generalized in Study 1. Testing was split across two brief, non-repetitive sessions, creating a test environment simple enough for toddlers. It also allowed us to explore the degree to which children's function-based representations endured across time, an issue not explored in the artifact literature to date. Study 2 focused exclusively on children given adults' clear intuitions in Study 1.

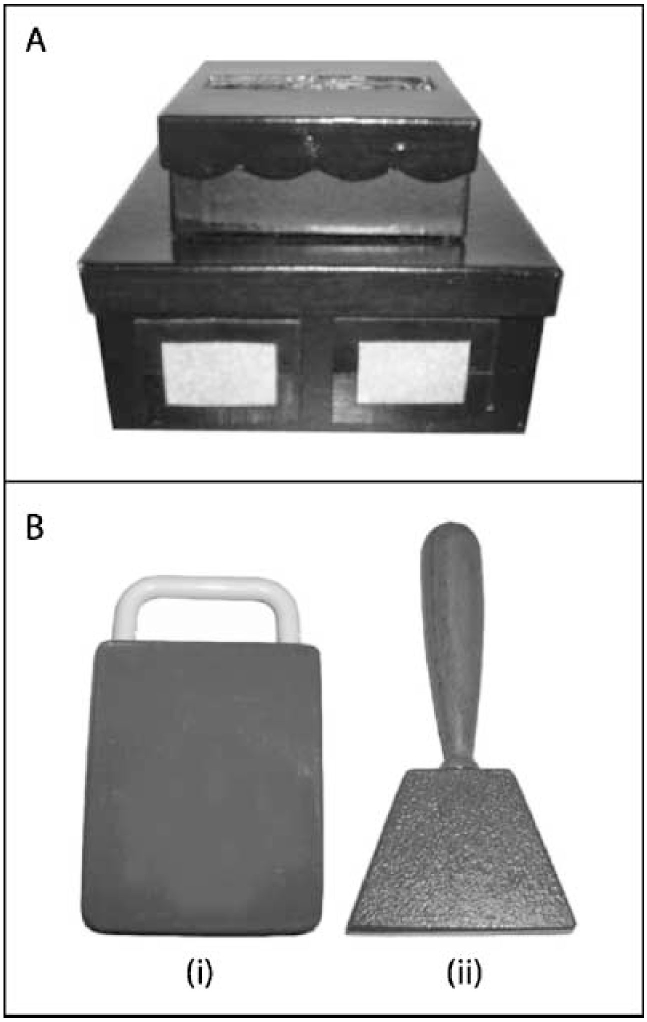

Figure 2 *Materials from Study 2. The experimenter turned on (A) the lightbox by inserting (B) tool (i) or (ii) into the slot in the top of the box.*

Study 2

Participants

Participants were 16 2-year-olds (M = 31 months, SD = 4 months), 16 3-year-olds (M = 43, SD = 2), and 16 4-year-olds (M = 51, SD = 3).

Procedure

As before, children were familiarized with novel objects (see Figure 2). One tool ('blicket') was demonstrated turning on a special light by inserting it into a slot on a box (children could try if they desired). The other ('dax') was functionally equivalent for this task but not

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Table 4 *Description of trials in Study 2*

Day	Type	Description
1	Generalization	Offered the tools in a new color (yellow): 'While I write something down, would you turn that light back on? Which one do you need to turn on the light so we can see it in the windows?'
1	Dissociation	Offered the tools in the new color (yellow): 'Here, which one do you need to crunch up this cracker and make it into crumbs?'
1	Generalization	Offered the tools in the new color (yellow): 'If you want to show your mommy how to turn on this light, which one do you need?'
1	Dissociation	Offered the tools in the new color (yellow): 'If you want to show your mommy how to crunch up this cracker, which one do you need?'
2	Generalization	Offered the original red tools: 'If you want to show your mommy how to turn on this light, which one do you need?'
2	Dissociation	Offered the original red tools: 'If you want to show your mommy how to crunch up this cracker, which one do you need?'
2	Generalization/ Conventionality	Offered the original red tools: 'Was your teacher here when we looked at these things yesterday? No, she wasn't. If your teacher wanted to turn on this light,which one would she need?'
2	Dissociation/ Conventionality	Offered the original red tools: 'If your teacher wanted to crunch up this cracker, which one would she need?'

demonstrated performing any particular function. However, the experimenter paid special attention to it ('I've been looking for my dax! It's really cool; I didn't want to lose it!') and invited children to insert the dax into the slot of another box (its 'holder'), causing them to physically manipulate the alternative tool in a manner nearly identical to the demonstration tool. She also explicitly pointed out the identical nature of the tools' ends, holding them end-to-end to clearly demonstrate similarity ('Hey, I noticed something. These look really different, but at the bottom, they're exactly the same size. Wow! See that?').

After familiarization, children received four test trials: they were offered the pair of tools (or color variants) and twice asked which one they needed to turn on the light (generalization), twice to crush a cracker (dissociation). To decrease repetitiveness, one pair of questions asked children what tool they needed for themselves and the other asked what they needed if showing someone else. To explore enduring learning, children received another two generalization and two dissociation trials in a second session 1 to 3 days later (see Table 4). On Day 2, one of the pairs of generalization and dissociation questions incorporated a test of children's grasp of the universality and conventionality of tool-function mappings. Instead of asking children which tool they, themselves, needed for a task, they were asked what tool someone else would need ('Was your teacher here when we looked at these things yesterday? No, she wasn't. If your teacher wanted to turn on this light, which one would *she* need?').[1] Children therefore received eight questions (four generalization, four dissociation) over 2 days.

[1] The expected benefit of reducing trial numbers led to a trade-off decision: confounding time delay and conventionality manipulations. The results rendered our concerns about this confound irrelevant.

Counterbalancing measures and novelty and memory controls were identical to Study 1 but a new task was added. To assess whether children copied any modeled actions, the experimenter carefully selected one of two crayons to color in a printed triangle (brown or grey, to avoid children's color preferences). After watching this, children were offered another triangle, the color that the experimenter had just selected plus the alternative color, and asked 'Which one do you need?'

Results

Analyses of the control tasks found that children of all ages were oriented to novelty, $\chi^2 = 4.0$ (75% of 2-year-olds), 6.3 (81% of 3-year-olds), 9.0 (88% of 4 year-olds), *p*s $< .05$; had no difficulty remembering a non-obvious object property after just one exposure, $\chi^2 = 11.3$ (93%), 12.3 (94%), ceiling (100%), $ps < .001$; and did not indiscriminately imitate the experimenter. Indeed, while 3-year-olds' color choice was statistically at chance as expected (37% chose the same color as the experimenter), 88% of 2-year-olds ($\chi^2 = 9.0$) and 81% of 4-year-olds ($\chi^2 = 6.3$) chose the non-modeled color, both $ps < .05$.

Children's selection of the demonstrated tool was explored in a 3 (age: 2-, 3-, 4-year-olds) × 2 (trial: generalization, dissociation) × 2 (day: Day 1, Day 2) ANOVA. Results indicated a main effect of trial type, $F(1, 45) = 61.98$, $p < .0001$. As Table 5 shows, the findings were clear. Children at all ages and across days chose the demonstrated tool when asked to turn on the light but avoided using that tool when asked to perform a different function, crushing crackers. The main effect of trial type was upheld in separate examinations of each age group; paired samples *t*-tests – collapsing day of testing – revealed a significant difference at each age between

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Table 5 *Mean percentage (and* p*-values comparing to chance) of times children chose the demonstrated tool for each trial type in Study 2*

	Generalization	Dissociation
2-year-olds		
Collapsed	77 (p = .004)*	31 (p = .048)*
Day 1	78 (p = .007)*	38 (p = .215)
Day 2	75 (p = .015)*	25 (p = .015)*
3-year-olds		
Collapsed	86 (p = .000)*	34 (p = .106)
Day 1	88 (p = .000)*	38 (p = .216)
Day 2	84 (p = .000)*	31 (p = .083)~
4-year-olds		
Collapsed	86 (p = .000)*	23 (p = .016)*
Day 1	84 (p = .000)*	25 (p = .027)*
Day 2	88 (p = .000)*	22 (p = .014)*

* = significantly different from chance, $p < .05$, 2-tailed; ~ $p < .05$, 1-tailed.

Table 6 *Percentage of children in Study 2 on Day 2 choosing the demonstrated tool on the standard ('what would you need?') versus conventionality ('what would your teacher need?') form of the test question*

	Generalization (%)	Dissociation (%)
2-year-olds		
you need?	75	19
teacher need?	75	31
3-year-olds		
you need?	88	31
teacher need?	81	31
4-year-olds		
you need?	81	25
teacher need?	94	19

generalization and dissociation trials, 2-year-olds: $t(1,15) = 5.09$; 3-year-olds: $t(1,15) = 4.48$; 4-year-olds: $t(1,15) = 4.44$; all ps < .001. As Table 6 shows, on Day 2 children at all ages gave similar answers when asked what tool they would need for each task or what someone else would need (Fisher Exact Tests, all ps > .5).

Discussion

Results suggest that from as early as age $2\frac{1}{2}$, children need only one exposure to an adult intentionally using a novel tool to rapidly and enduringly construe the artifact as 'for' that particular purpose rather than any arbitrary activity it physically affords. When tested under less repetitive Study 2 conditions, children consistently selected the demonstration tool when asked to turn on the light, rejecting that tool for cracker crushing both at initial testing and a few days later, despite its ability to perform either activity. In addition to construing each tool as possessing a particular enduring function from their own perspective, children at all ages appeared to view these functions as intrinsic properties of the objects recognizable by others. Thus, although all participants were old enough to understand that someone else's desires and needs can be unlike their own (e.g. Repacholi & Gopnik, 1997), they consistently indicated that the tools they needed for each task would be the same as those needed by an absent party. Children's 'universality' assumption (along with their Day 2 performance) speaks against viewing children's choices as products of the immediate pragmatics of the task; mutual exclusivity should not necessarily extend to what *others* would choose (Diesendruck & Markson, 2001). Finally, Study 2 results indicate that children's selection of particular tools for particular tasks is not just about reproducing what others do in novel contexts. Outside the instrumental tool use task, children made choices independent of those demonstrated by an adult model (coloring task). This contrast in task performance was particularly striking for the youngest children, for whom coloring – like the activity of lightbox operating – was somewhat unfamiliar and one for which they were unskilled; indeed, it is surprising that they did not imitate more indiscriminately. Thus, while the tendency to attend to and imitate others' actions may be part of the pathway to learning about novel artifacts, the current results do not seem to be explained by indiscriminate tendencies to imitate intentional actions across all contexts and contents.[2]

General discussion

Tool use is central to interdisciplinary debates about the evolution and distinctiveness of human intelligence (e.g. Byrne, 1997; Hauser & Santos, in press; McGrew, 1996; Povinelli, 2000; Jalles-Filho, Teixeira Da Cunha & Salm, 2001). Despite this, an emphasis on children's formation of lexical categories has meant that although there are many studies (and mixed results) on children's artifact naming, little is known about how children actually approach tool use. The present studies reveal that, between the ages of 2 and 3, children already approach tools in ways distinctive from captive tool-using monkeys (Hauser, 1997; also Cummins-Sebree & Fragaszy, 2004): Young children do not opportunistically treat all

[2] This discussion addresses some 'simple task pragmatics' explanations of the current results. This is not to deny that accounts could be marshaled which invoke different principles for performance on each trial type (e.g. generalization, dissociation, imitation control, posttest, conventionality respectively). It is to suggest that these accounts are less parsimonious than the interpretation for which the findings also offer support: that children rapidly form enduring teleo-functional representations of what artifacts are 'for'.

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objects with appropriate properties as equally good means to a currently desired end. Instead, they needed just one exposure to an adult intentionally using a novel tool to rapidly and enduringly construe the artifact as 'for' that privileged purpose, consistently returning to the object to perform that function over time (as indicated by Study 2 multi-day testing), regardless of short-term expediency (as indicated by Study 1 effort trials), and with the assumption that such knowledge is public (as suggested by Study 2 conventionality trials). In short, although young preschoolers may not possess a fully elaborated design stance – the rich causal-explanatory framework rationalizing an artifact's existence, structure and function in terms of designer's intention – they nevertheless possess a relatively powerful, somewhat adult-like, teleo-functional construal of artifacts. In categorizing by intentional use, this construal has the potential to support children's function-based inquiry, inference and efficient long-term tool use (see Kelemen, Widdowson, Posner, Brown & Casler, 2003; Kemler Nelson, Chan Egan & Holt, 2004; Tomasello, 1999).

Of course, the present results still leave many questions unanswered. For example, the assumption made here is that young children's well-documented sensitivity to others' goal-directed behavior is centrally relevant to the competence revealed here (e.g. Carpenter, Akhtar & Tomasello, 1998; Meltzoff, 1995; Rakoczy, Tomasello & Striano, 2005). Is this assumption justified? The presumption is that children's attention to another's intentional action permits fast-mapping of function from only one demonstration, and that intentional action forms the content of what they map (see Tomasello, 1999) – but two questions arise. First, might children simply require dynamical displays of an object in use to grasp its affordance, and not an intentional use per se? Although dynamic display surely plays a role (an intentional use implies a dynamic display), our emphasis on intentionality seems warranted: Participants were required to dynamically manipulate *both* objects in equivalent ways (inserted both tools into similar tubes during familiarization, Study 1, and identical slots, Study 2), yet they only took the intentional use as a cue to function and subsequent use. Second, and in the same vein, would children have been as likely to fix a salient *accidental* action to a tool as a salient intentional one? Although further work is needed for clarification on this point, other research again suggests intentionality is critical. In a recent study, 2- and 3-year-old children witnessed an absent-minded adult 'accidentally' select a good tool for a task and then intentionally exchange it for a patently sub-optimal tool on realizing her 'mistake'. The findings revealed that, although their choice had practical costs, many children selected the sub-optimal tool, both initially and after a delay, when asked to perform the task themselves (DiYanni & Kelemen, 2004).

Another issue to be addressed is children's performance on the dissociation task. When asked to accomplish a new, undemonstrated goal, children became significantly less likely to use the original tool – particularly in the simplified second study where the absence of repeated questioning confused matters less. Might children's established preference for novelty have prompted them to avoid the tool they had already used and try the alternative? Although possible, this pragmatic explanation seems unlikely. If a blanket novelty preference applies to tool use, then it is unclear why participants concurrently heavily favored the *familiar* tool when achieving the original goal. A teleo-functional explanation seems to explain the pattern better: Children repeatedly used the familiar tool for the original task because they believed it was specifically 'for' that function, not simply a 'generally useful thing' to be used in any circumstance, and they therefore chose a new tool for a new task.

In summary, the present results provide evidence that young children exhibit rapid learning for artifact function, already possessing an early foundation to some of our most remarkable capacities as tool manufacturers and users. Further questions remain regarding the contexts in which these abilities show themselves and the degree to which this ability will be revealed as truly distinctive when systematic comparisons to natural tool-using great ape species are conducted. These issues await future developmental and comparative research.

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