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Function and the Origins of the Design Stance

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We report 2 experiments addressing children's developing understanding of design. Experiment 1 showed that although 5-year-old children judged an object's function according to its original design rather than a subsequent accidental activity, design was not preferred over a subsequent intentional use. Adults select the design function in both cases, suggesting that children's initial assignment of function is based on any intended goals for which the object is used. Experiment 2 compared assignment of function with object categorization, demonstrating that although 5-year-old children's assignment of object function is based on any goals associated with the object, their categorization is adult-like and based on the category intended by the object's creator (over a category assigned by another agent). We conclude that preschoolers appreciate the link between creators and categories before constructing a design stance supporting reasoning about artifact functions.

How do people identify and reason about object functions? How do they decide what objects such as cars, clocks, and cradles are for? Researchers interested in human knowledge and reasoning about object function have often assumed this issue to be identical to questions about artifact categorization (i.e., how one decides which objects *are* cars, clocks, and cradles). Indeed, the two issues—beliefs about artifact function and beliefs about artifact categorization—are closely related in what has become known as the *design stance*, in which an entity's properties, be-

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havior, and existence is explained in terms of its having been designed to serve a particular purpose (Dennett, 1987).

Several pieces of empirical work now suggest that adults do indeed reason about artifacts in terms of a design stance (e.g., Hall, 1995; Keil, 1989; Kelemen, 1999; Matan & Carey, 2001; Rips, 1989; see also Bloom, 1996; Malt & Johnson, 1992). For example, Rips (1989) showed that adults tend to judge category on the basis of original design rather than appearance. When presented with an object that looks like a lampshade, adults will nonetheless judge that it is really an umbrella if told that it was originally intended to be used for protecting people from falling rain (Rips, 1989; but see also Malt & Johnson, 1992). Similarly, adults judge category membership on the basis of original design in cases in which the object is currently being used for a different purpose (e.g., an object that was intended to be a watering can but now used as a teapot; Hall, 1995; Matan & Carey, 2001).

Whether or when children begin to attend to design per se in their reasoning about artifacts has recently attracted the attention of developmental psychologists with somewhat mixed results (German & Defeyter, 2000; Kelemen, 1996, 1999; Matan & Carey, 2001). Kelemen (1999) argued that the design stance is in place at a very early age, having developed out of a developmentally prior intentional stance. In her studies, Kelemen (1999) told preschoolers and adults stories of unfamiliar objects that had been created intentionally for one purpose then later used for a different purpose, either accidentally or intentionally. When asked what the object was for, both adults and preschoolers tended to ignore the object's ultimate use (or accidental activity) in favor of what it was originally intended for. This was the case regardless of whether the alternative use occurred once or repeatedly. From these data, Kelemen (1999) argued that as early as 4 years of age children demonstrate understanding of the design stance.

Matan and Carey (2001) argued that although preschoolers grasp some of the relevant facts about artifacts, such as the fact that they are human made (Gelman & Kremer, 1991), the typical functions to which they are put (Gauvain & Greene, 1994) and that their categorization can depend on their functions (Kemler Nelson & students, 1995; Kemler Nelson, Frankenfield, Morris, & Blair, 2000), whether they connect these three issues into a single notion of design is still unclear. Using a categorization paradigm, Matan and Carey presented 4-year-olds, 6-year-olds, and adults with stories about unseen objects (thus providing no form information) that had been created for one purpose ("to water flowers with"), but used for another ("to make tea in"). Participants then decided whether the object belonged to the category associated with the purpose for which it was created ("watering can") or the category associated with the purpose for which it was actually used ("teapot"). Six-year-olds and adults overwhelmingly chose the category associated with the originally intended function. Four-year-olds did not always do so (main effect of Study 3), and indeed Matan and Carey argued that on the whole the evidence weighs against a design stance in preschoolers. Nonetheless, even in Matan and Carey's studies, sometimes

4-year-olds did show a selective sensitivity to the originally intended function (main effect of Study 2 and order effects of both Studies 2 and 3), and therefore the picture is not considerably cleared by this study.

Contrary to either Kelemen's (1999) or Matan and Carey's (2001) findings, German and his colleagues (German & Defeyter, 2000; German & Johnson, 1997) have argued that until relatively late in development, young children assign an object's function on the basis of any goals for which any agent uses the object. Because of this flexibility in assigning functions, German and Defeyter predicted that young children should be less susceptible to the phenomenon of functional fixedness (e.g., Duncker, 1945) than older children. They found just that in a study in which 5-year-old children were significantly better than 7-year-olds at solving problems that required objects to be used in ways counter to their conventional (or originally intended) use.

A further line of evidence comes from research into the related, but distinct question about the relation between form and function in children's artifact categories. As well as the positive findings of Kemler Nelson and her colleagues (Kemler Nelson, 1995; Kemler Nelson et al., 2001), as noted previously, there are also a number of studies suggesting that children younger than 6 years of age fail, as a matter of routine, to use information about function as a basis for the extension of novel names and base their categorizations on appearance instead (e.g., Gentner, 1978; Graham, Williams, & Huber, 1999; Landau, Smith, & Jones, 1998), and this evidence might reasonably be viewed as problematic for the notion that younger children operate with a design stance.

Although failure to use function information in categorization might be considered as evidence against understanding of design, it is not clear that Kemler Nelson et al.'s (2000) evidence that children can learn function-based names, noted previously, can be considered as evidence that children do in fact understand design. Note that what Kemler Nelson et al. (2000) show, in a series of elegant studies, is that an object's current function under certain facilitating conditions can provide the basis for extending names to novel entities rather than overall appearance or shape in children as young as 3 years of age. Although current function might be a reliable cue to intended function, the notion of design we are interested in requires children to attach importance to original design over current use. The study of Kemler Nelson et al. (2000) does not address this question because she pits current function, not original design, against appearance. Indeed, it is by stressing the plausibility of the goals underlying the functions in question as they relate to the structures of the objects presented that Kemler Nelson et al. (2000) achieved some of their success in young children's function-based categorization. This result is in line with the suggestion defended here: that young children's understanding of function is based on consideration of the generic goal-based uses of object without particular emphasis on the original intentions of the designer.

This article was designed to address two possible methodological and theoretical issues that might account for the seemingly contradictory results across the studies of Kelemen (1999) and Matan and Carey (2001). Methodologically, Kelemen's (1999) study contains at least two possible biases against the legitimacy of the alternative uses in her scenarios. In her one-time alternative-use condition, an object was created for one purpose and then later used intentionally for a different purpose. Participants were then told, however, that even though the actor was pleased with the outcome, she never used the object that way again, implying that perhaps the purpose was not legitimate after all. Furthermore, in the repeated-use condition, even though the alternative use was repeated, the language used implied that the repetition was accidental ("... it happened again") rather than intentional ("... she always used it that way")—despite this intentional language being used in a related control condition. In fact, in the repeated-use condition, the 4-year-olds produced considerably more alternative use judgements than in the other conditions (though they still selected it significantly less often than chance). Experiment 1 of this article addressed these issues by presenting stories in a condition based on Kelemen (1999), but one in which the alternative use occurs in a satisfying, goal-directed way. Performance here, as in Kelemen's (1999) study, was compared with performance on a control condition in which an alternative activity occurs by accident.

Second, we note that Matan and Carey (2001) used a categorization task (i.e., "What is it?") in their study rather than asking directly about function (i.e., "What is it for?"), as did Kelemen (1999), or using a function-based problem, as did German and Defeyter (2000). Children in the Matan and Carey study were asked to choose between two familiar categories, one prototypically associated with the creator's intended function of the object and one prototypically associated with the object's current use. Matan and Carey assumed that children would first judge which function was the relevant function and then select the appropriate category on that basis. However, recent work by Bloom and Markson (1998) raises the possibility that some children may have selected the original category in the Matan and Carey study not because they considered the object's function to be the originally intended function, but because they simply considered the object's category to be the originally intended category (a strategy that we dub here use of the *creator-category* rule).

In their study, Bloom and Markson (1998) found that children as young as 3 years classify the referent of a picture based on the artist's intended referent at the time of creation rather than the picture's actual appearance. For instance, 3-year-olds were asked to draw a lollipop and a balloon, generally resulting in pictures that were indistinguishable from each other. Nonetheless, the children insisted on categorizing the pictures based on the category they were using at the time they created each picture. Given this result, it is possible that children in Matan and Carey's (2001) study converted the functions into their associated categories and then used the creator-category relation itself to make their judgements, resulting in some judgements that were otherwise indistinguishable from design-based judgement. Indeed, Matan and Carey took pains to use category-function pairings that young children would be familiar with and could identify readily. The overall effect of such a strategy would be to shift the results away from a general goal-based pattern of reasoning.

In Experiment 2 therefore, we went on to addresses the possibility that young children apply a creator-category rule in reasoning about object artifacts as well as pictures, independent of either functional or form information about the object.

EXPERIMENT 1

Method

Participants

Adults. Forty undergraduate students (25 women, 15 men: M age 22 years, range 18—46) participated at the University of Essex in Colchester, Essex, England. The participants were assigned randomly to either the function or identity conditions.

Children. Thirty-two 5-year-olds participated from the reception and Year-1 classes of infant schools in the area of Colchester, Essex, England. They were divided into an intentional change of use condition (7 girls, 9 boys; M age 5 years 5 months, range 5 years 2 months to 5 years 8 months; SD = 1.7 months) and an accidental change of use condition (7 girls, 9 boys; M age 5 years 5 months, range 5 years 1 month to 5 years 11 months; SD = 2.9 months). A further 10 children were excluded and replaced for failure to pass control questions or exhibiting response bias (see Procedure section).

Materials

All children were presented with four stories. For each story children were shown a picture of a novel object. They were first told the object's name (e.g., "This is a *tog*") and asked to repeat the name.

Intentional change of use condition. Children were told information about the object's originally intended function (e.g., "A long time ago an inventor made the tog to trap bugs") and conflicting information about an alternative use to which it was later put (e.g., "Now it belongs to someone else. Everyday they use it to collect raindrops."). Children were shown a corresponding picture to illustrate each function (e.g., one picture of bugs and another of raindrops). After each function was explained the child was asked to repeat it. Finally, the two functions were summarized, "So this object was made a long time ago to trap bugs but now it is used everyday to collect raindrops," and the children were again asked to repeat the two functions as a memory control. The test question followed: "What is the tog really for? Is it for trapping bugs or collecting raindrops?" Finally, children were asked to justify their answers.

Accidental change of use condition. Stories in this condition were the same as those in the intentional change of use condition with the exception that the alternative uses were converted into nonintentional activities occurring when the current owner accidentally dropped the object (e.g., "Now it (the tog) belongs to someone else. They were carrying it along one day and guess what? They dropped it! When it landed it collected raindrops.").

For both conditions, the pictures were mounted on colored card: orange for objects (size = 22 cm × 16 cm) and green for function targets (size = 14 cm × 11 cm). The objects and candidate functions used across all studies appear in the Appendix. In both conditions, for two of the stories the children heard the history of the object told in chronological order (i.e., design function first, alternative use or accident second). In the other two stories, the order of the function presentation was reversed so that children heard about the alternative use (accident) first and the design function second. Half the children heard a story in which design information was presented first, followed by two stories in which the alternative use was presented first and ended with another story where design information was presented first. The other half heard the reverse order of stories. Furthermore, the specific functions were also reversed for half the stories; that is, for a given object, half the children heard stories where function x was the design function and function y was the alternative use function, and the other half heard the reverse assignments. The reminder information, the control questions, and the sequence of alternatives in the test question were all asked in the same order in which the information appeared in the story.

Procedure

Children were tested individually in the infant school in a small area away from the main class. Children were told they would be seeing some pictures of and hearing some stories about some strange objects that they would never have seen before. If a child failed a control question, they were told to listen again, and the summary information was repeated. If they failed a second time, the story was repeated from the beginning. Children were required to answer both control questions, in sequence, correctly without error to proceed to the test question. Children who still failed control questions on their third attempt were not asked the test question for that item and were excluded from the study and replaced.

One additional measure taken was to exclude children who displayed a straight response bias, suggesting they failed to engage in the task at all. Children who answered all test questions with the last function they heard or the first function they heard were also excluded and replaced.

Adults were tested as part of an undergraduate laboratory class. The stories were presented without picture cues in a booklet with a separate story on each page. The adults answered the questions on spaces in the booklets on each page. The same counterbalancing measures were used.

Results

Adults

Judgements in favor of the originally intended name or function were given a score of 1. Responses in favor of the current name or use were given a score of 0. A participant's total score for all four stories could therefore range from 0 to 4. The mean score in each condition and distribution of participants scoring 0, 1, 2, 3, and 4 from a total score of 4 is shown in Table 1.

A preliminary item analysis revealed that the functions chosen were equally plausibly afforded by each object; no specific functions were preferred for any given object. A 2 × 2 × 2 analysis of variance (ANOVA) on the experimental variable of condition (intentional change of use vs. accidental change of use) and the counterbalanced variables of presentation order (chronologically natural vs. reversed) and function assignment revealed no main or interaction effects. The closest effect was that of experimental condition, with the scores for the accidental change of use judgements tending to be higher than that for the intentional change of use judgements. This difference, however, failed to reach significance, $F(1, 40) = 3.79$, $p = .08$.

TABLE 1
Experiment 1: Number of Participants Choosing the Originally Intended Function or Name Zero, One, Two, Three, or Four Times and Group Mean Score According to Condition and Age

Group	*Condition*	*n*	*0*	*1*	*2*	*3*	*4*	*M*	*SD*
Adults	Intentional change of use	20	1	1	9	2	7	2.65	1.18
	Accidental change of use	20	0	0	6	2	12	3.30	0.92
5-year-olds	Intentional change of use	16	4	3	6	2	1	1.66	1.21
	Accidental change of use	16	0	3	2	4	7	2.94	1.18

As expected, adults showed evidence of a design stance with respect to the function of the novel artifacts with an overall mean score in the intentional change of use condition of 2.65 out of 4 ($SD = 1.18$). This score was different from chance, in which chance was defined as a score of 2.0; $t(19) = 2.46$, $p < .02$, two-tailed.

Nonparametric analyses on the distribution of individual response patterns revealed the same effects (see Table 1). In both conditions, there were more adults selecting the original intended function four times out four than would be expected by chance (7 out of 20 in the function condition and 12 out of 20 in the accidental change of use condition; binomial theorem, $ps < .0001$). Out of all 40 adults tested across both conditions, only 1 picked the current activity on all four trials.

Children

The judgement data from the children were scored in the same manner used for the adults. A preliminary item analysis revealed that, as for the adults, there were no items for which one of the two candidate functions was more often chosen than the others. The means and distribution of children scoring 0, 1, 2, 3, and 4 from a total score of four are shown also in Table 1. A 2 × 2 × 2 ANOVA on experimental condition (intentional change of use vs. accidental change of use), presentation order (chronologically natural vs. reversed), and specific function assignment revealed a main effect of experimental condition, $F(1, 32) = 9.55$, $p < .005$. Unlike adults, the 5-year-olds in this study treated the two conditions very differently, selecting the original design function less often in the intentional change of use condition compared to the accidental change of use condition. No other main effects or interactions were observed, highest $F(1, 32) = 1.79$, *ns*.

The overall mean score for the intentional change of use condition was 1.66 ($SD = 1.21$). When judging the correct function for a novel object in a situation in which the original design is pitted against an alternative deliberate use, children were not more likely to pick the original designed activity over the current use. A two-tailed t test revealed that their tendency to select between the two candidate goals was not significantly different from that expected by chance, $t(15) = -1.45$, *ns*. This result fails to replicate the significant, though weak, bias toward the originally intended function found by Kelemen (1999).

The overall mean score in the accidental change of use condition was 2.94 ($SD = 1.18$). Unlike the intentional change of use condition, children here showed a strong preference for the function originally intended by the object's creator when it was pitted against a current activity that occurred by accident, a preference that was significantly different from chance responding; $t(15) = 3.16$, $p < .01$. This confirms that children prefer to select an intentional designed function over an accidental activity, as found by Kelemen (1999).

The distribution of individual response patterns in the intentional change of use condition (see Table 1) reveals the same pattern of results as the group means. Unlike adults, in the intentional change of use condition, only one child picked the original function on all four trials. This did not exceed the number expected by chance (binomial theorem, $p > .7$). The only deviation from chance in this condition were more children than would be expected (4) selecting the current use as the function on all four trials (binomial theorem, $p = .0035$).

In the accidental change of use condition, the results were similar to the adult pattern. Nearly half (7) of the children selected the original intended function over the accidental activity on all four trials (binomial theorem, $p < .0001$).

Children's Justification Data

The children's justifications were coded into four mutually exclusive categories: design/origins, agents/goal, object, and uncodable. Design/origins explanations included those in which the child referred to the invention or chronological origins of the object either directly or obliquely, such as "Cause it's been invented a long time ago and that was first"; "Cause it was used for that a long time ago." Agent/goal explanations included those in which the child referred to an agent performing an action, the object being used by a specific or generic agent, or references to an agent's explicit desire to satisfy or avoid one of the goals implied by the functions. References to goals in the absence of the agents was also included in this category. Examples included, "So they can cook it and eat it [fish]"; "Cause he wants to collect raindrops." Object-based explanations included anything that referred to the object in the absence of the agent or any explicit or implied goal. This might be a reference to a specific property of the object or a reference to the object itself performing the activity (e.g., "Cause it's the right size"; "Because it clears the snow up."). Explanations that did not fall into one of these three categories were placed into the uncodable category. They included mostly responses of "I don't know" or irrelevant tangents to the story (e.g., "Because it snows every year.").

Two individuals coded the 128 explanations. The second coder was uninformed about the hypotheses under test. Interrater agreement was 98% ($r = .98$). In cases of disagreement the first coder's categorization was used. Once the justifications were coded, the children themselves were classified into groups on the basis of their overall justification patterns. We were interested in one primary contrast: the ability of children to use justifications based on design and origins relative to their tendency to produce generic agent/goal justifications. To generate the most liberal interpretation of children's performance as possible (against our conservative hypothesis that children are indifferent to design), we first assigned any child who ever produced a design/origins explanation to that category, regardless of the other types of explanations they may have produced. Children who never gave a codable response were assigned to the uncodable category. Finally, the remaining children were assigned to whichever of the agent/goal or object category they produced more justifications for. Ties between that children interpret novel words as invitations to form categories from as early as late infancy (e.g., Waxman & Markow, 1995; Xu & Carey 1996).

Children and adults were told about an object they had never heard of or seen before. For example, "A long time ago an inventor made this thing and called it a 'tog', but now someone else owns it and he calls it a 'fep'. What is it really, a tog or a fep?." Note that the current task goes somewhat beyond the scope of the task employed in Bloom and Markson (1998). In that study, children were required to decide between two equally plausible labels (e.g., *balloon* or *lollipop*) and were able to use information about their own earlier intention (as the designer) to disambiguate the category. However, the children were not required to select the designer's intent when pitted against the intent of a different agent.

This categorization condition was compared with a function version of the task based on the intentional change of use condition of Experiment 1. Participants were shown the same novel objects, but now the category membership was given and unquestioned (e.g., a "tog"). Only the object's function was disputed. That is, participants were told, "This is a tog. A long time ago an inventor made it for catching raindrops, but now it belongs to someone else. One day, he used it for trapping bugs. What is it really for, collecting raindrops or trapping bugs?" As in Experiment 1, no implication was made that the alternative use was not a legitimate, goal-satisfying use. We included this condition both by way of direct comparison to the categorization condition and also to provide a replication of the relevant function condition of Experiment 1, given the dispute in the literature over the ability of young children to assign function based on original design. However, unlike Experiment 1, and to match the condition precisely with the categorization condition, we did not describe the alternative use as happening many times but as happening "one day."

We predicted that children would choose the object's category on the basis of the creator's original intent, but determine the object's function on the basis of either agent's intended use. Moreover, if children see the creator as having a privileged role in determining an object's category but not its function, origin-based explanations should begin to appear in children's category justifications despite their continued absence in function justifications.

Method

Participants

Adults. Forty undergraduate students (27 women, 13 men; *M* age 24 years, range 18–46) participated at the University of Essex in Colchester, Essex, Englnad. The participants were assigned randomly to either the function or categorization conditions.

Children. Thirty-two 5-year-olds (17 girls, 15 boys; *M* age 5 years 6 months, range 5 years 1 month to 5 years 9 months; *SD* = 2.7 months) were recruited from an infant school in Colchester, Essex, England. Seven additional children were excluded for repeated failure on the memory questions. Participants were assigned pseudo-randomly to one of two conditions with the constraint that the range and mean age were kept approximately equal for the categorization group (8 girls, 8 boys; *M* age 5 years 6 months, range 5 years 1 month to 5 years 9 months; *SD* = 3.0 months) and the function group (9 girls, 7 boys; *M* age 5 years 6 months, range 5 years 1 month to 5 years 9 months; *SD* = 2.6 months).

Materials and Stories

Categorization condition. Participants were presented with four stories, each accompanied by a line drawing of a novel object mounted on a card. For instance, they heard, "A long time ago an inventor made this thing and called it a tog. What did the inventor call it? Now, this thing belongs to someone else. They call it a fep. What did someone else call it? So a long time ago an inventor made this thing and called it a tog, then recently someone else found it and called it a fep." Line drawings of the two actors were presented along with the names. Finally participants were asked, "What do you think this thing is really, is it a tog or is it a fep?" Children were asked to explain their answers. The stimuli appear in the Appendix.

Function condition. The objects and task structure were the same as in the categorization condition. However, the wording was changed to reflect information about function rather than naming. Participants were first told the object's name (e.g., "This is a tog.") and asked to repeat it. Then they were told information about its originally intended function (e.g., "A long time ago an inventor made the tog to trap bugs.") and conflicting information about an alternative use to which it was later put (e.g., "Now it belongs to someone else. One day they used it to collect raindrops."). Drawings were introduced to illustrate each function (e.g., one picture of bugs and another of raindrops). Memory checks and summaries paralleled those in the categorization condition followed by the test question, "What is the tog really for? Is it for trapping bugs or collecting raindrops?" The children were asked to justify their answers. Again, the stimuli can be found in the Appendix.

Procedure

The procedure for testing both the adults and children in this study, as well as the counterbalancing measures employed, were the same as described for Experiment 1.

Results

Adults

The data from one adult participant were excluded owing to an experimenter error. This left 19 participants in the categorization condition and 20 in the function condition.

Judgements in favor of the originally intended category or function were given a score of 1. Responses in favor of the current category or use were given a score of 0. A participant's total score for all four stories could therefore range from 0 to 4. Preliminary analyses revealed that there were no effects of the particular names on the tendency for them to be selected. The mean score in each condition and distribution of participants scoring 0, 1, 2, 3, and 4 out of a possible total of 4 are shown in Table 3. A 2 × 2 × 2 ANOVA on the experimental variable of condition (categorization vs. function) and the counterbalanced variables of presentation order (chronologically natural vs. reversed) and function assignment revealed no main or interaction effects, highest $F(1, 39) = 1.07$, *ns*.

As predicted by the literature, adults showed a strong design stance with respect to the function of the novel artifacts, with an overall mean score in the function condition of 3.25 out of 4 ($SD = 1.16$) in which chance was a score of 2.0, $t(19) = 4.80$, $p < .0001$, two-tailed. They also showed strong creator-category understanding with respect to the artifacts' category. That is, when faced with two possible names for an object, one used by the object's creator and one by its current owner, they chose the name used by the creator an average of 3.58 times out of 4 ($SD = 0.70$), $t(18) = 9.94$, $p < .0001$, two-tailed.

Nonparametric analyses on the distribution of individual response patterns revealed the same effects (see Table 3). In both conditions, about two thirds of the adults (13 out of 20 in the function condition and 13 out of 19 in the categorization condition) chose the originally intended function or name on four out of four items (binomial theorem, $p < .00001$). Out of all 39 adults tested, only 1 never picked an originally intended function or name.

TABLE 3
Experiment 2: Number of Participants Choosing the Originally Intended Function or Name, Zero, One, Two, Three, or Four Times and Group Mean Score According to Condition and Age

Group	*Condition*	*n*	*0*	*1*	*2*	*3*	*4*	*M*	*SD*
Adults	Categorization	19	0	0	2	4	13	3.58	0.70
	Function	20	1	2	2	2	13	3.25	1.16
5-year-olds	Categorization	16	0	1	2	3	10	3.37	0.96
	Function	16	0	9	3	3	1	1.81	0.98

Children

The data from the 5-year-olds were examined to answer three questions:

1. Like adults, do children use a creator-category rule for the categorization of objects?
2. Unlike adults, but as in Experiment 1, do children fail to privilege originally intended functions over other generic goal-directed uses of an object?
3. Do children invoke object origins to justify their category judgements, despite their failure to do so for judgements of function?

Children's Judgement Data

The judgement data from the children was scored in the same manner used for the adults. The means and distribution of children scoring 0, 1, 2, 3, and 4 out of a possible total of 4 is shown in Table 3. A 2 × 2 × 2 ANOVA on experimental condition (categorization vs. function), presentation order (chronologically natural vs. reversed), and specific function assignment revealed a main effect of experimental condition, $F(1, 32) = 19.4$, $p < .0001$. Unlike adults, the 5-year-olds in this study treated the two conditions very differently. No other main effects or interactions were observed.

The overall mean score for the categorization condition was 3.37 ($SD = 0.96$). When judging the category of a novel object, children picked the label used by the object's creator rather than that used by another agent (the object's owner) more than three out of four times. A *t* test revealed that this average was significantly different than expected by chance, $t(15) = 5.75$, $p < .0001$, two-tailed. This finding confirms the use of a creator-category rule in children with respect to the categorization of objects, just as in adults.

The overall mean score for the function condition was 1.81 ($SD = 0.98$). Unlike the categorization condition, children showed no preference for the function originally intended by the object's creator, $t(15) = -0.76$, *ns*.

The distribution of individual response patterns (Table 3) reveal the same pattern of results as the group means. Like adults in the categorization condition, about two thirds (10) of the children picked the originally intended label on all four trials (binomial theorem, $p < .00001$). None failed to pick it at least once. Unlike the adults in the function condition, however, only one child in the function condition chose the originally intended function on all four trials (binomial theorem, $p > .70$), replicating the result in the intentional change of use condition of Experiment 1. Unlike Experiment 1, however, children did not select the current use significantly more than would be expected by chance (binomial theorem, *ns*).

Children's Justification Data

The children's justifications were coded into the four categories used in Experiment 1: design/origins, agents/goal, object, and uncodable. All categories were defined as described in Experiment 1, with the additional criterion that design/origins explanations also included those in which the child referred to the invention or chronological origins of the category or name of the object either directly or obliquely (e.g., "Because he called it that when he made it."). As before, explanations that did not fall into one of the three content-based categories were placed into the other category.

Two coders again coded all 128 justifications. The second coder was blind to the hypotheses under test. Agreement was 97% ($r = .99$.) As in Experiment 1, cases of disagreement were resolved by using the primary coder's categories.

Once the justifications were coded, the children themselves were classified into groups on the basis of their overall justification patterns, exactly as described for Experiment 1.

The pattern of justifications given by children is shown in Table 4. This pattern differed across experimental conditions but did correspond to their patterns of judgements. The distribution of children coded as design/origins justifiers, relative to the other categories combined, varied across conditions, $\chi^2(1, N = 32) = 4.8, p < .05$, two-tailed. The most common explanation pattern in the categorization condition was an appeal to the origin of the object (e.g., "That's what he called it when he made it"; "Cause the inventor said it was a dap really"). By contrast, but like the children in Experiment 1, the majority of children in the function condition never mentioned origins, instead explaining their choice in terms of agents and goals (e.g., "He wants to catch them [bugs]"; "So they can eat them [fish]").

Discussion

Both the adults and the 5-year-olds in this experiment believed that, given two alternative categorizations of an object espoused by two different agents, the category espoused by the object's creator was the true one. These findings extend the work of Bloom and Markson (1998), who showed that 3-year-old children use the artist's original intent (their own in that case) to disambiguate the identity of pictures of ambiguous appearance.

TABLE 4
Experiment 2: Number of Children and Overall Percentage of Explanations (in Parentheses) Falling Into Each Explanation Category According to Condition

		Explanation Category		
Condition	*Design/Origin*	*Agent/Goal*	*Object*	*Uncodable*
Categorization[a]	9 (50%)	0 (0%)	5 (32%)	2 (18%)
Function[a]	3 (8%)	9 (45%)	3 (27%)	1 (20%)

[a]$n = 16$.

These data also replicate the findings from Experiment 1 that when (a) the question of originally intended function is divorced from the issue of categorization, and (b) alternative uses are presented as legitimate and accepted uses, unlike adults children do not show a preference for any particular intended goal over another when judging an object's function. That is, the originally intended function of an object has no privileged status in young children's judgements of the object's real function. Instead, children at this age seem to assign the function of an object based on the apparent goals of any agent who uses it. Further support for this interpretation comes from children's explanations of their own judgements. When justifying their judgements of the object's category, the children commonly invoked the origins of the object and ignored the role of goals. However when judging function, the majority of the children referred to the goals of the agents involved and ignored the objects' origins.

GENERAL DISCUSSION

Preschoolers grasp some of the facts about artifacts that are relevant to constructing a design stance, such as the fact that they are human made (Gelman & Kremer, 1991), that they must be intentionally created (Gelman & Bloom, 2000; Gelman & Ebeling, 1998), and that their categorization can depend on their functions rather than their appearances (Kemler Nelson et al., 1995; Kemler Nelson et al., 2000). However, our results suggest that preschoolers do not yet connect these issues into a single notion of "made intentionally for the purpose of" as seen in the design stance of adults. Instead, when preschoolers assign functions to unfamiliar objects, they do so on the basis of any successful goal-directed use by any agent.

Furthermore, children's failure to grant the original goals of the designer a privileged status cannot be due to a general failure to consider the role of origins in causal reasoning. Indeed, children seem extremely sensitive to the origins of objects and creators' intentions when reasoning about the probable categories to which unfamiliar objects belong. In this case, they seem to follow a sort of creator-category rule, something like "objects are made intentionally to be of a specific kind." Note that this sensitivity goes beyond the sensitivity to makers' intentions demonstrated by Bloom and Markson (1998) because children in this task selected the category used by the creator over another category assigned by another agent rather than merely to disambiguate two possible categories suggested by the object's appearance.

Further evidence that children do not begin to organize their artifact concepts around the notion of the designed function until relatively late comes from Defeyter and German (2001). In a task where 5- and 7-year-old children were required to generate as many different functions for familiar objects as they could think of, older and younger children tended to generate responses in different ways. The older children generated responses based on the conventional function of the named object (e.g., in the case of a brick, they tended to list possible objects that a brick could be used to build, such as a wall, a school, a castle, etc). The younger children, by contrast, though they also produced the conventional function of the object, were more likely to produce entirely novel functions (e.g., using a brick to keep a door open) rather than variations of the conventional function. This pattern of evidence is consistent with the idea that between 5 and 7 years of age, children begin to organize their understanding of artifacts around a core notion of the designed function.

What account might be offered to explain the relative difficulty preschoolers have in coordinating their knowledge of the various components of a design stance into the coherent explanatory framework of the design stance itself? Why does the stance not materialize until after the preschool years? We offer the following four suggestions.

First, and most straightforward, it is the case that information about the original intentions relevant at the time an object was created may be relatively inaccessible, even to adults. The creation of most objects will be a matter of historical fact rather than something easily attended to and processed. Instances in which a child gets direct information about intentions at creation are likely to be extremely rare relative to instances in which children experience an object being used to fulfil a goal.

Second, even when information about original intentions is available, there is an important difference between object category labels and object functions that may result in experience with alternative object uses providing misleading evidence. Given the arbitrariness of labels, the original category label represents a conventionalized "fact of the matter" and uses of an alternative label within a given language (misnomers) are easily detected as false and avoided by young children (Clark, 1987; Markman, 1990). By contrast, the relation between an object's structure and the functions it can support is not arbitrary; the functions are importantly constrained by the form of the object (i.e., its "affordances"; see, e.g., Kemler Nelson et al., 2000). Cases in which an object is used for an alternative purpose are very likely, in fact, to satisfy the goal of the user, and alternative uses are therefore not appropriately considered false in the same way that a misnomer is. Fulfilled alternative goals may actually be misleading in terms of the evidence they provide for the assignment of function.

Third, and as noted by Matan and Carey (2001), information about origins is not readily accessible for younger children in other domains. Though the results of the categorization condition of Experiment 2 suggest that children use origin information in their judgements and justifications of artifact category, there is evidence from the domain of folk biology that attention to information about biological origins emerges relatively late in development (Johnson & Solomon, 1997; Keil, 1989; Solomon, Johnson, Zaitchik, & Carey, 1996). This suggests that information about origins may in general be difficult to attend to early in development, and that its proficient use here in deciding artifact category membership is an unusual case.

Finally, we suggest that understanding design is more complex, in representational terms, than understanding a simple goal-directed object use. This proposal stems from the idea that the notion of "intentionally made for purpose *x*" involves coordinating two mental states: first, that of the maker, and second, that of a subsequent user. One way of capturing the notion of design, therefore, is as a recursive mental state, as in "the maker intends that 'the user intends that *x*'." On this analysis, it might be the ability to handle, as a matter of routine, second-order mental states that is a limiting factor. If the maker's intention (to create the object) cannot be segregated from the final goal (the purpose for which the maker intends the object to be used), then the child will not be able to even attend to the former aspect of the event and thus not be able to learn about its importance. Although mental state reasoning competence is available early in development (see, e.g., Csibra, Gergely, Bíró, Koós, & Brockbank, 1999; Johnson, 2000; Leslie, 1994, 2000), the ability to deploy this early competence is affected by various performance factors that continue to develop over the period between 5 and 7 years of age (see, e.g., German & Leslie, 2001; Leslie & Pollizi, 1998). Some mental state contents are computed and attributed with more difficulty than others (e.g., false beliefs, conflicting desires) and critically, reasoning about recursive mental state contents is known to lag behind reasoning about first-order mental states (Perner & Wimmer, 1985; Sullivan, Winner, & Hopfield, 1995).[1]

In sum then, the experiments presented here provide evidence relevant to the controversy over whether preschool children assign functions according to an understanding of the design intended by the object's creator (Kelemen, 1999; Matan & Carey, 2001). Although 5-year-old children are able to use information about the intentions of a creator to determine the category to which a novel object belongs, their notion of function is wider and includes alternative purposes to which the object is put by agents other than the designer. In the early school years, the full design stance is constructed and with it the ability to organize artifact concepts around the notion of original intended function. The emergence of this ability appears to be marked by children's increasing susceptibility to the phenomenon of functional fixedness

[1]It is important to stress that we are not claiming that children below the age of 6 years cannot attribute recursive mental states. There is, in fact, evidence that they can under circumstances when processing demands are reduced (e.g., Sullivan, Zaitchik, & Tager-Flusberg, 1994). Our proposal is rather that, given the processing demands inherent in complex mental state reasoning, the user's goal will be computed with relatively less effort and perhaps more quickly than the more complex "intentionally made for the purpose" representation; the goal of the (eventual) user overshadows the maker's intention (to create the object).

(Defeyter & German, 2001; German & Defeyter, 2000) and a shift in the strategies children employ in generating novel functions for everyday objects (Defeyter & German, 2001). Additional consequences of this reorganization in children's knowledge may well become apparent with future research.

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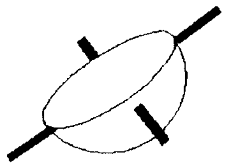
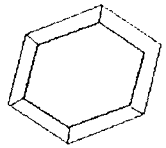
APPENDIX
Object pictures, names, and functions



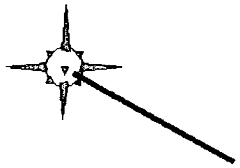
Function 1: Trapping bugs
Function 2: Collecting raindrops

Name 1: Tog
Name 2: Fep



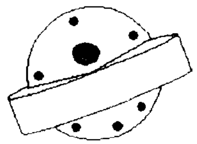
Function 1: Squashing flowers
Function 2: Sliding down hills

Name 1: Zig
Name 2: Bem



Function 1: Collecting leaves
Function 2: Catching fish

Name 1: Dax
Name 2: Grak



Function 1: Floating on water
Function 2: Clearing snow

Name 1: Wug
Name 2: Zav