Research Report

Conditions Under Which Function Information Attenuates Name Extension via Shape

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ABSTRACT—*Children often extend names to novel artifacts on the basis of overall shape rather than* core *properties (e.g., function). This bias is claimed to reflect the fact that nonrandom structure is a reliable cue to an object having a specific* designed *function. In this article, we show that information about an object's design (i.e., about its creator's intentions) is neither necessary nor sufficient for children to override the shape bias. Children extend names on the basis of any information specifying the artifact's function (e.g., information about design, current use, or possible use), especially when this information is made salient when candidate objects for extension are introduced. Possible mechanisms via which children come to rely less on easily observable cues (e.g., shape) and more on core properties (e.g., function) are discussed.*

What is the nature of people's knowledge about common artifacts and their functions? What is the origin of this knowledge, and how does it develop over the life span? Cross-disciplinary work in cognitive science has increasingly focused on these questions, delineating formal aspects of conceptual representations of artifacts and other kinds of objects (Bloom, 1996; Prasada, 2000), universal aspects of conceptual representations of artifacts (German & Barrett, 2005), brain circuits for representing tools and tool use (Johnson-Frey, 2004; Martin, Wiggs, Ungerleider, & Haxby, 1996), artifact representation and tool use in some nonhumans (Hauser, 1997), and the acquisition of conceptual representations of artifacts (Casler & Kelemen, 2005; Defeyter & German, 2003; German & Johnson, 2002; Kelemen & Carey, in press; Kemler Nelson, Frankenfield, Morris, & Blair, 2000; Kemler Nelson, Russell, Duke, & Jones, 2000).

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Most researchers in this domain agree that function information is central to mature conceptual representation of artifacts: Artifacts are considered members of a particular kind by virtue of sharing a *core* function property with other members of the same kind (German & Barrett, 2005; Prasada, 2000; though see also Bloom, 1996, for a related view). Scholars of cognitive development have been interested in the extent to which children share this adult reliance on a core property (rather than relying on more easily observable properties such as mechanical structure) in categorizing artifacts, reasoning about them, and using them to solve problems.

One extensive literature bearing on this question has centered on name extension in young children. These studies investigate the extent to which function information is important when children learn a label for a novel artifact. A typical study involves trials in which children hear a novel label applied to a novel artifact and then are asked to extend that label to candidate objects that either (a) match the labeled target in shape but afford a different function or (b) have a different shape but afford the same function (e.g., Gentner, 1978). Although some researchers argue that function information becomes central to word understanding only later in development (e.g., not until about age 6), as indicated by an early bias to select shape-matches in these studies (Gentner, 1978; Landau, Smith, & Jones, 1998; Smith, Jones, & Landau, 1996), others maintain that children are sensitive to information about function much earlier (Diesendruck, Markson, & Bloom, 2003; Kemler Nelson, Frankenfield, et al., 2000; Kemler Nelson, Herron, & Morris, 2002).

Diesendruck et al. (2003) presented a persuasive argument that shape information may be critical to name extension precisely because an artifact's specific shape signals that it has been designed for a specific purpose; that is, the shape bias may result from shape being a reliable and easily accessible cue to an artifact's function. The authors predicted, therefore, that shape will be used only to the extent that it is a plausible cue to function; when children are given information demonstrating that shape is a poor cue to function, they will overlook shape in favor of better cues. In their first study, Diesendruck et al. showed that children overcame the shape bias when there was an alternative explanation for why the target object and the shape-match candidate object had the same shapes (such as one object having the function of containing the other). In a second study, the shape bias was reduced by specific information that the target object and the candidate object with a different shape were "made for" the same specific function—a function different from that for which the shape-match candidate object was made.

Although the evidence provided by Diesendruck et al. (2003) and related studies (e.g., Kemler Nelson, Frankenfield, et al., 2000) shows that 3- and 4-year-old children can extend names on the basis of function under some circumstances, it remains an open question whether they are responding specifically to information about *design* (i.e., information about the intentions of the object's creator, rather than simply information about any plausible goal-directed action the object can fulfill). The findings of Diesendruck et al. have been taken as evidence of the stronger claim (e.g., Casler & Kelemen, 2005; Kelemen, 2004; Kelemen & Carey, in press; Kemler Nelson, Holt, & Chan Egan, 2004), even though there is evidence from other sources that children do not distinguish creator's intent from other types of intentions until later in development (Defeyter & German, 2003; German & Defeyter, 2000; German & Johnson, 2002; Matan & Carey, 2001).

The key justification for interpreting the results as supporting the stronger claim is that Diesendruck et al. (2003) failed to find that children extend names on the basis of an object's possible function (rather than its designed function; Experiment 2). However, closer examination of the methods reveals that only children in the *made-for* condition[1] were provided with additional information in which the shape similarity (but function mismatch) of the shape-match candidate object and the function similarity (but shape mismatch) of the function-match candidate object was pointed out (see Diesendruck et al., 2003, p. 167). Because the additional information was not included in the *can-do* condition, the possibility remains that it was this explicit comparison information—and not information about design—that led to the reduction in shape-match choices (relative to the can-do condition). Because it is unclear precisely what functional and mechanical inferences young children automatically generate after brief exposure to novel artifacts, it seems plausible that explicit marking of function and shape similarities and dissimilarities may aid children in using nonshape cues to function.

[1]"Creator's intent" and "design" are used synonymously to describe what an object was "made for." Diesendruck et al. (2003) referred to conditions containing this kind of information as *label + intended*; we feel this label is confusing, as intentional uses of an object may not match the *creator's* intentions. For this reason, we refer to these conditions as the *made-for* conditions. We refer to conditions that Diesendruck et al. referred to as *label + possible* (in which a possible function is mentioned but explicit intentions are not mentioned) as the *can-do* conditions. Like Diesendruck et al., we refer to conditions that do not reference any functions as *label-only*.

In the current study, we addressed the possible importance of this explicit comparison information—as well as the relative importance of different types of function information—in aiding children to overcome the tendency to extend names to artifacts of similar shape. We compared a baseline condition in which children received only the object label with three conditions in which they received one kind of function information about the target object: what it (a) was "made for," (b) is "used for," or (c) "can do."[2] Some children (no-comparison conditions) received this function information only about the target object before being asked to extend the name to the candidate objects, whereas other children (comparison conditions) also received explicit shape and function information about the candidate objects, so that the shape and function matches and mismatches were demonstrated for children in each condition.

The predictions tested were as follows. First, because Diesendruck et al. (2003) found that function information alone had a measurable though small effect in their can-do condition, we expected that providing any function information without explicit additional comparisons between target and candidates would result in reduced shape-match choices compared with the label-only baseline. Second, we predicted that drawing attention to the function mismatch between the target and the shape-match candidate (as Diesendruck et al. did only when presenting information about design) would result in reduced shape-match choices. Finally, the hypothesis that information about creator's intent is critical to naming via function among children under age 6 (Diesendruck et al., 2003) was tested against the hypothesis that they do not distinguish different kinds of information about function (German & Johnson, 2002). The former hypothesis predicts that there should be reduced shape-match choices only when children receive information about design (i.e., made-for condition only), whereas the latter predicts equivalent reduction in shape-match choices in all three function conditions.

METHOD

Participants

One hundred fifty-eight 3- and 4-year-olds (M = 4 years 1 month, range: 2 years 8 months–4 years 11 months; 68 boys, 90 girls) from preschools in California were randomly assigned to one of seven conditions (see Design and Procedure). Mean age, age range, and sex ratio were matched across conditions.

Materials

All participants were presented with four triads of objects (see Table 1). Each triad consisted of a target object, a shape-match

[2]The used-for condition was added because the can-do condition is ambiguous with respect to whether the function occurs deliberately, as a by-product, or by accident (e.g., a vacuum cleaner makes noise and might scare the cat, but neither outcome is its function).

TABLE 1
Target (Named) and Candidate Objects

	Name			
Object	Bem	Wug	Jop	Dax
Target	Rectangular felt (cleans glass)	White PVC pipe (flattens clay)	Round plastic disk (cuts clay)	Heart-shaped cushion (holds pins)
Shape-match	Rectangular sandpaper (smooths wood)	Vinyl (pliable) pipe (makes clay snakes)	Round disk made of felt (wipes up water)	Heart-shaped wood (makes heart shapes)
Function-match	Pyramidal sponge (cleans glass)	Round disk with handle (flattens clay)	Thin rectangular wood (cuts clay)	Rectangular dry foam (holds pins)

Note. The function of each object is given in parentheses.

object, and a function-match object. The shape-match had a shape similar to that of the target object but afforded a different function because of some other property. The function-match afforded the same function as the target object but had a different shape.

Design and Procedure

There were seven conditions. A label-only condition served as a baseline. The remaining conditions varied across two factors: (a) the type of function information presented (what the object can do, is used for, or was made for) and (b) the presence or lack of additional information making explicit the match or mismatch between each of the candidate objects and the named object in terms of shape and function.

In the *can-do* conditions, participants were told a function that the target object could fulfill (e.g., "Let me show you a bem. Look at this; it's a bem. It can dust. See, this is a bem, and it can dust."). In the *used-for* conditions, participants were given information about what the target object is used for (e.g., "Let me show you a bem. Look at this; it's a bem. I use it for dusting. See, this is a bem, and I use it for dusting."). In the *made-for* conditions, participants were given information about what the target object was made for (e.g., "Let me show you a bem. Look at this; it's a bem. It was made for dusting. See, this is a bem, and it was made for dusting."). In the conditions in which any functions were mentioned, the experimenter mimicked the functions with the object.

In the *no-comparison* conditions, no additional information about either of the candidate objects was mentioned. In the *comparison* conditions, the experimenter pointed out the similarity in shape and dissimilarity in function when presenting the shape-match object, and the dissimilarity in shape and similarity in function when presenting the function-match object. The function information was always worded in the same way as the information that had been given about the target object (e.g., in the made-for, comparison condition: "See this one. This one *wasn't made for* smashing clay because it *was made for* making clay snakes.").

Each participant was seen individually at his or her preschool by a female experimenter (who was sometimes accompanied by a female assistant or trainee). Participants were usually seated across a table from the experimenter. The objects were next to the experimenter in a box and were not visible to the participants until the experimenter presented them.

The basic procedure for each object across all conditions was as follows: First, during the *naming event*, the experimenter presented and named the target object. Second, during the *presentation of candidate objects*, the experimenter presented each of the candidate objects and gave the child a chance to interact with them. Finally, during the *name extension*, the experimenter asked the child to extend the name of the target object to one of the two candidate objects.

RESULTS

Four participants were excluded from all analyses (3 because of experimenter error; 1 additional participant refused to answer any questions after the first triad), leaving a total of 154 participants. To test our hypotheses, we analyzed the total number of shape-matches (out of four) made by each participant (see Table 2 for summary statistics and *n*s for all cells).

The results supported the first hypothesis. Fewer shape-match choices were made in the three no-comparison conditions in which function information was provided than in the label-only baseline condition, $t(59, 365) = 2.796$, $p_{rep} > .99$, $d = 0.55$.

The second and third hypotheses were tested in a 3 (function information: can do vs. used for vs. made for) × 2 (comparison information: comparison vs. no comparison) analysis of variance. This analysis revealed a main effect of comparison information, $F(1, 122) = 19.0$, $p_{rep} > .99$, $\eta^2 = .134$; fewer shape-match choices were made in the comparison conditions than in the no-comparison conditions. There was no significant effect of function information ($F < 1$), and the effect of comparison information was constant across all levels of function information, indicated by the lack of an interaction ($F < 1$). This analysis thus supports the prediction that explicit comparison between target and candidate objects would reduce shape-match choices and

TABLE 2
Mean Number of Shape-Match Choices (as a Function of Condition)

Comparison information	Function information			
	Label only	Can do	Used for	Made for
No comparison				
M	3.27	2.67	2.69	2.52
SD	0.919	1.20	1.38	1.25
n	26	24	26	27
Comparison				
M		1.50	1.75	1.59
SD		1.20	1.44	1.23
n		18	16	17

Note. The maximum number of shape-match choices was four.

fails to support the hypothesis that information specifically about creator's intent is important in reducing the tendency to name via shape.

Regression analysis allowed us to capture age and sex as predictors, as well as the effects of comparison information and the different types of function information. This analysis revealed that age ($\beta = -.163$, $p_{rep} > .91$), function information (can do: $\beta = -.232$, $p_{rep} > .91$; used for: $\beta = -.187$, $p_{rep} > .85$; made for: $\beta = -.257$, $p_{rep} > .94$), and comparison information ($\beta = -.335$, $p_{rep} > .99$) were all significant unique predictors of fewer shape-match choices (the model included these predictors as well as sex), $R^2 = .228$, $F(6, 47) = 7.234$, $p_{rep} > .99$.

DISCUSSION

The results of this study show that although providing children with information about the function of artifacts reduces their tendency to select a shape-match object as the referent of a novel name, the kind of function information does not matter. Specifically, information about a user's intended function and any possible function was just as effective at reducing the shape bias as was information about creator's intent (design). Moreover, reductions in shape-match choices were considerably larger under conditions in which the function and shape matches and mismatches between the target and candidate objects were explicitly demonstrated. Finally, regression analysis showed that there was a tendency to become less shape biased with increasing age.

These results are consistent with evidence suggesting that children's early artifact representations include information about function, but that this information is not restricted to the intentions of the object's designer, as claimed by many researchers in this area (Casler & Kelemen, 2005; Diesendruck et al., 2003; Kelemen, 1999, 2004; Kemler Nelson et al., 2002, 2004; Kemler Nelson, Frankenfield, et al., 2000). Instead, the information at the center of children's artifact concepts appears to be more broad information about plausible goals the object can be used to fulfill (Defeyter & German, 2003; German & Johnson, 2002).

Though we disagree with some other scholars about the nature of the information that is central to artifact concepts, it seems plausible to us to consider seriously the following notion: Children's shape-match choices might result from a cognitive system that defaults to attending to shape as a reliable cue that an object has an underlying core function (that might not be readily observable). This default would generally serve children well because of the correlation that exists between material, mechanical structure, and function (see, e.g., Christie, Markson, & Spelke, 2005; Prasada, 2000; Prasada, Ferenz, & Haskell, 2002). Researchers in this domain should now seek to articulate the nature of the information-processing mechanisms that give rise to children's changing patterns of attention to various sources of information about the underlying properties of artificial and natural things.

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