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How Specific is the Shape Bias?

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Children tend to extend object names on the basis of sameness of shape, rather than size, color, or material—a tendency that has been dubbed the "shape bias." Is the shape bias the result of well-learned associations between words and objects? Or does it exist because of a general belief that shape is a good indicator of object category membership? The present three studies addressed this debate by exploring whether the shape bias is specific to naming. In Study 1, 3-year-olds showed the shape bias both when asked to extend a novel name and when asked to select an object of the same kind as a target object. Study 2 found the same shape bias when children were asked to generalize properties relevant to category membership. Study 3 replicated the findings from Study 1 with 2-year-olds. These findings suggest that the shape bias derives from children's beliefs about object kinds and is not the product of associative learning.

The surrealist painter Rene Magritte's most famous work is a realistic picture of a pipe, floating above the heading "Ceci n'est pas une pipe"—This is not a pipe. Magritte was making a statement about the relationship between representation and reality, and about the illusory nature of art: One should not confuse a picture of a pipe with an actual pipe. But when you first look at this work, there is a jolt because the sentence seems so obviously false. Of course it is a pipe—it looks exactly like a pipe, and it would certainly be called a pipe. Magritte's picture illustrates, and mocks, our strong tendency to name things based on their appearance and, in particular, their shapes. This tendency is what Landau, Smith, and Jones (1988) have called *the shape bias*.

What is the nature of this bias? One proposal—dubbed *attentional-learning account* by Smith (1999)—is that there is a direct link between names, and specifically count nouns, and shape. This link exists because children are exposed to many count nouns (words that appear in contexts such as "This is a X") denoting objects that are similar in shape (objects such as chairs and balls). As a result, children learn that count nouns tend to refer to objects of the same shape and, more generally, that an object's shape determines the name it gets (see also, Smith, Jones, & Landau, 1996).

In support of this account, several studies have found that when taught a new noun for a new object, 3- to 4-year-olds show a strong tendency to extend the name to other objects that are similar in shape to the target object, not to objects similar in color, size, or texture. They do not show such a preference for shape when simply asked to "pick another one that goes with this" (Jones, Smith, & Landau, 1991; Landau et al., 1988). Furthermore, there is a positive correlation between the number of count nouns in children's vocabulary that define categories based on shape and the strength of children's shape bias (Samuelson & Smith, 1999).

An alternative proposal—dubbed *shape-as-cue* by Bloom (2000)—is that the relationship between count nouns and same-shaped objects is not due to a direct association. It instead exists because children believe that count nouns refer to object kinds, and that shape is a reliable cue to the kind to which an object belongs or, in the case of a picture, the kind that is being represented (see also, Bloom & Markson, 1998; Gelman & Diesendruck, 1999; Soja, Carey, & Spelke, 1992).

Consistent with a shape-as-cue account, a number of findings have shown that from an early age, children seem to have a notion of object kind. For instance, 1-year-olds seem to understand that count nouns, but not proper names, extend to kinds (Hall, Lee, & Bélanger, 2001; Katz, Baker, & Macnamara, 1974), and 14- to 18-month-olds induce properties of

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objects based on kind membership (see Mandler, 2000, for a review). Moreover, the importance of shape in object categorization is uncontroversial; all theories of how objects are categorized—even by nonlinguistic creatures—assume that this is done by attending to the shape of objects and their parts, not their color, texture, or size (e.g., Marr, 1982; Tarr & Bulthoff, 1999). It is less clear why shape is such a good cue to object kind; one proposal is that objects that share more essential nonperceptual properties, such as biological structure and intended function, tend to have a common shape (Bloom, 1996; Keil, 1994).

There have been many attempts to experimentally contrast these alternative accounts. This has usually been done by exploring the role of factors other than shape in children's acquisition and use of names. According to the attentional learning account, object naming is driven by associations between words and perceptual features, and hence more top-down factors, such as the function of an object, should not affect how it is named. Something is *a pipe* if it is shaped like a typical pipe, regardless of its intended function and its internal composition. According to the shape-as-cue account, the name an object gets is determined by the kind to which it belongs, and shape is merely a cue to kind membership, albeit an important one. According to this theory, then, other information might override shape. Something might be *a pipe* even if it is not shaped like a typical pipe, so long as it possesses a certain intended function and internal structure. A third view on this issue proposes developmental change. Children start off by weighting perceptual cues more heavily than conceptual or social cues when generalizing words. As a result of cognitive and linguistic development, the weights of the cues change, and children may move to generalize words on the basis of taxonomic membership (Hollich, Hirsh-Pasek, & Golinkoff, 2000; see also, Imai, Gentner, & Uchida, 1994; Merriman, Scott, & Marazita, 1993, for similar accounts).

Several studies have addressed this issue, typically by presenting children with an object, naming it, and seeing what other objects are given the same name. These studies, however, have produced conflicting findings and thus have not decisively resolved the debate among the different theoretical positions. The first study to contrast shape with function found an unexplained U-shaped curve: Two- to 5-year-olds generalized on the basis of shape, 5- to 15-year-olds on the basis of function, and adults back to the basis of shape (Gentner, 1978). A number of studies have found that children—as old as 5 years old—will extend names based on shape, even at the expense of functional or taxonomic similarity (Baldwin, 1992; Graham, Williams, & Huber, 1999; Imai et al., 1994; Landau, Smith, & Jones, 1998; Merriman et al., 1993; Smith et al., 1996). But several other studies have suggested that children—as young as 2 years old—extend labels to objects based on function, designer's intent, and other "deeper" properties, even at the expense of shape (Diesendruck, Gelman, & Lebowitz, 1998; Gelman & Bloom, 2000; Kemler Nelson, 1995; Kemler Nelson, Russell, Duke, & Jones, 2000).

One attempt to reconcile these conflicting findings consistent with a shape-as-cue perspective is as follows (Bloom, 2000; cf. Landau et al., 1998). Because all of the previous studies focused on artifact kinds, the relative importance of shape and function should depend on the extent to which these different factors are seen as cues to the intent underlying the creation of the object. For instance, in Landau et al. (1998), which found a shape bias, the functions—such as wiping up water—were simple and dependent only on the substances that the artifacts were made of. There was no motivation to believe, then, that the objects were created with the express intent that they fulfill that function, and function was in little position to override shape. In Kemler Nelson (1995), which did not find a shape bias, the functions—such as painting four parallel lines—were highly specific and reflected intentional design; being able to paint parallel lines isn't the sort of thing that an artifact can do by accident. This hypothesis as to why these experiments obtained different results is consistent with a series of more recent studies done with the goal to explain the disparity (Diesendruck, Markson, & Bloom, in press; Kemler Nelson, Frankenfield, Morris, & Blair, 2000).

In this study we explored a different way to distinguish the attentional-learning account and a shape-as-cue view. As noted earlier, according to the attentional-learning account, the shape bias results from learned associations between count nouns and shape similarity. The bias is therefore claimed to be specific to the context of naming. In contrast, according to the shape-as-cue account outlined in Bloom (2000), the shape bias is just a reflection of children's beliefs about object categories. It applies to count nouns only because count nouns refer to object categories. Hence, under this shape-as-cue perspective, the shape bias should manifest itself not only in the context of naming but also in any context in which children are required to make categorizations by object kind. An alternative version of the shape-as-cue account agrees that shape is only a reliable indicator of object kind, but argues that the lexical categorization of objects engages special mechanisms (e.g., Woodward & Markman, 1998).

One might argue that this issue has already been tested, and resolved. After all, many of the studies cited earlier compared a name-extension task (e.g., ‘‘Which one of these is a dax?’’) with a nonlexical task (e.g., ‘‘Which one of these goes with this?’’), and they typically found that the shape bias only applied for the name, as predicted by the attentional-learning view. But this comparison is inconclusive. The shape-as-cue theory does not claim that any instructions should lead to a shape bias. It claims only that instructions that motivate categorization by object kind should lead to the shape bias.

For instance, in the Landau et al. (1988) and the Jones et al. (1991) studies, children in the nonlexical condition were asked which among the test objects ‘‘goes together with,’’ ‘‘matches,’’ ‘‘belongs with,’’ or ‘‘makes a group with’’ the target object. The authors correctly noted that these are the sorts of instructions used in perceptual categorization tasks, and the failure of children to generalize by shape when given such instructions does suggest that the shape bias is not due to perceptual similarity. It remains an open question, however, whether the shape bias would show up when children are asked, not about perceptual similarity, but about category membership. Consistent with this possibility, Kemler Nelson, Frankenfield, et al. (2000; Experiment 3) found that 2- and 3-year-olds were equally likely to pick a perceptually similar object when asked to extend the name of a target object as when asked to ‘‘pick another one like it.’’

To explore this issue more directly, in the present studies we used a procedure similar to the one used by Landau et al. (1988). The experimenter showed children a target object, provided some information about it (such as a novel name), and asked children to determine which of three test objects this information should be generalized to. One of the test objects was similar only in shape to the target object, a second test object was similar only in color, and a third was similar only in terms of the material it was made of. Study 1 tested whether 3-year-olds’ shape bias is specific to naming or whether it extends to categorization by kind, as well, in a task that does not involve extending a novel name. According to the attentional-learning account, children were expected to manifest a shape bias only when extending names. According to the shape-as-cue account presented here, children were expected to manifest a shape bias when extending names and when categorizing by kind, but not when making a perceptual categorization. Study 2 further explored the role of the shape bias in nonlexical tasks, testing the prediction that children would manifest a shape bias more strongly when generalizing properties relevant to object kind than when asked to generalize properties irrelevant to object kind. Finally, Study 3 asked the same question as Study 1 for 2-year-olds, examining the possibility that the strength and generality of the shape bias might change between 2 and 3 years of age.

Study 1

Method

Participants. Forty-eight 3-year-olds participated in this study (*M* = 3,7; *range* = 3,1–4,1). There were 26 boys and 22 girls. All children were recruited from preschools in the cities surrounding Bar-Ilan University. Only children with written parental permission participated in the study.

Materials. Four sets of objects were especially created for this study. Each set consisted of a target object, an object similar in shape to the target but different from it in terms of color and material (shape match), an object similar in color to the target but different from it in terms of shape and material (color match), and an object similar in material to the target but different from it in terms of color and shape (material match). The objects were created from materials such as clay, wood, and plastic, and were altered according to the experiment’s requirements. Figure 1 displays the stimuli.

Design. Children were randomly assigned to one of three conditions: (a) name, (b) kind, or (c) goes with. The name and goes with conditions were intended to be replications of conditions used in previous studies addressing the shape bias. They were included to verify that the present stimuli would give rise to the same pattern of findings reported in the literature. The kind condition is the primary addition to the literature. Sixteen children participated in each of the conditions. The average ages of children in the three conditions did not differ significantly. Approximately the same number of boys and girls participated in each condition. Two additional groups of sixteen 3- and 2-year-olds were tested in a preference condition to verify that the shape match was not a priori the one most likely to be picked by the children. In this condition, the experimenter showed children the target object by saying, ‘‘Look at this. See this,’’ presented them the three test objects, and asked the children to ‘‘choose one of these.’’ We found that both the 3-year-olds

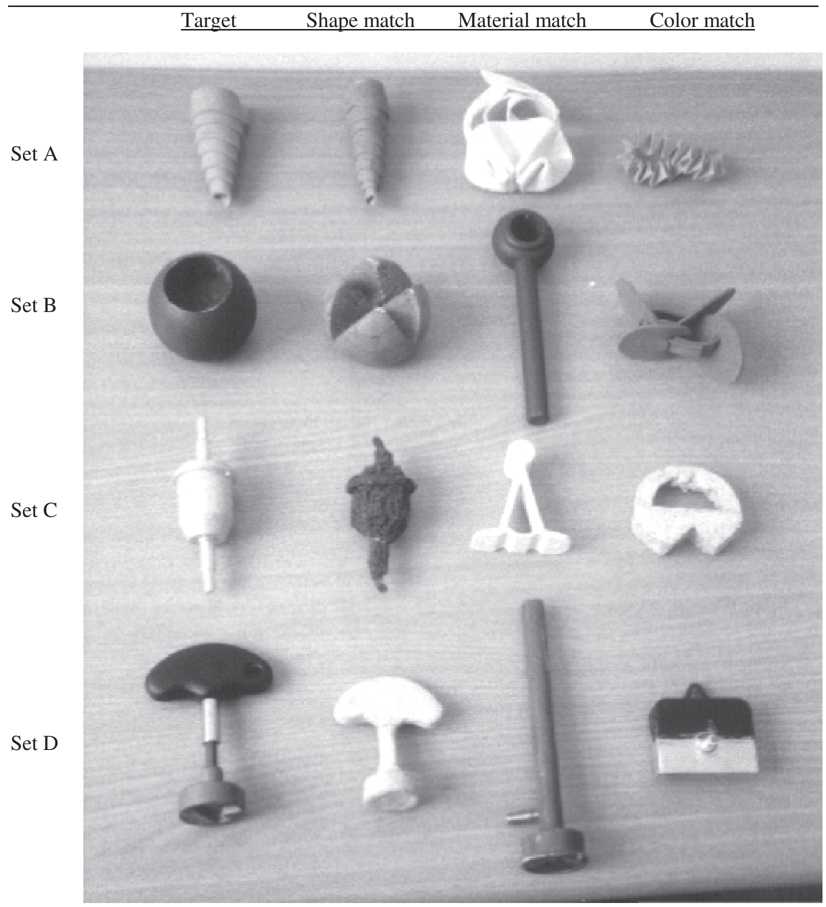

Figure 1. Black-and-white photographs of the actual colored stimuli used in all studies.

($M = 1.4$, $SD = 1.0$, *ns*) and the 2-year-olds ($M = 1.3$, $SD = 0.6$, *ns*) tested in this condition selected the shape match at a rate not significantly different from that expected by chance.

Procedure. Children were tested individually by one of three undergraduate female research assistants in a quiet area of their preschools. The basic procedure for all three conditions was similar. The experimenter showed children the target object of the first stimulus set, described it according to the child's condition, presented the three test objects together placing them in a random left-to-right position, and asked the child to choose one of the test objects. All children were tested in Hebrew. The instructions described next are translations from the Hebrew instructions.

In the name condition, the experimenter showed children the target object and named it with a novel name by saying, ''Look at this. It's a Patoo. See, it's a Patoo. This is a Patoo.'' She then presented the three test objects and asked the child, ''Which one of these is also a Patoo?'' In the kind condition, the experimenter showed children the target object by saying, ''Look at this. See this,'' presented the three test objects, and asked the children, ''Which one of these (pointing to the test objects) is of the same kind like this (the target)?'' Finally, in the goes with condition, the presentation of the objects was as in the kind condition, but the experimenter asked children, ''Which one of these (pointing to the test objects) goes with this (the target)?'' In all three conditions, this procedure was repeated for the four sets of objects for each child.

The novel names were the following meaningless Hebrew sounding words: Patoo, Teega, Zavee, and Melo.

Results and Discussion

The alternative hypotheses for Study 1 concerned whether the shape bias would be manifested only in the name condition or whether it would show up in both the name condition and the kind condition. To address these hypotheses we calculated the mean number of shape-match selections made by children in the different conditions.

An ANOVA with condition and gender as between-subjects variables revealed a significant effect of condition, $F(2, 42) = 6.07$, $p < .01$, but no effect of gender and no interaction. Scheffé post hoc tests revealed a significant difference between the goes with and the name conditions ($p < .05$) and between the goes with and the kind conditions ($p < .05$). The difference between the name and kind conditions was not significant ($p > .9$). As can be seen in Table 1, children in the name and kind conditions selected the shape match on more than 75% of the sets. To further evaluate the extent to which children's responses in the name and kind condition were similar or different, we compared the mean number of color-match and material-match selections made by children in these two conditions. The analyses revealed no significant differences, strengthening the conclusion that children in these two conditions were guided by the same considerations. (Similar analyses performed on Study 3 with 2-year-olds revealed the same findings.)

Given that there were four object sets and that on each set children had three test objects to choose from, chance performance would provide a mean of 1.33 shape match choices. Replicating previous studies, children in the name condition selected the shape match significantly more than expected by chance ($M = 3.1$, $SD = 1.1$), $t(15) = 6.51$, $p < .001$, whereas children in the goes with condition selected the shape match at chance level ($M = 1.9$, $SD = 1.4$), *ns*. Most important, children in the kind condition also selected the shape match significantly more than expected by chance ($M = 3.2$, $SD = 1.1$), $t(15) = 6.69$, $p < .001$. Evidently, then, children did not reveal a shape bias only when extending names, but at the same time, it was not the case that children revealed a shape bias in all generalization tasks. In particular, children manifested a shape bias consistently when asked to pick an object "of the same kind" as the target, but not when asked to pick an object that "goes with" the target.

In addition to the analyses on means, we also analyzed children's individual pattern of responses. Specifically, we classified children into two groups based on whether they selected the shape match on three or four of the four sets (shape-biased children) or on less than three of the four sets (not-shape-biased children). We then compared the distribution of shape-biased and not-shape-biased children across conditions. The results were consistent with the parametric analyses. As can be seen in Table 2, although the majority of the children in the name and kind conditions were shape biased, the minority were in the goes with condition, $\chi^2(2, N = 48) = 6.40$, $p < .05$.

Table 1

Mean Number, Standard Deviation, and Difference From Chance, of Shape-Match Selections in All Studies

Study/condition	Mean	*SD*	Difference from chance
Study 1 (3-year-olds)			
Name	3.1	1.1	*
Kind	3.2	1.1	*
Goes with	1.9	1.4	
Study 2 (3-year-olds)			
Category-relevant property	2.7	1.1	*
Category-irrelevant property	2.0	0.6	*
Study 3 (2-year-olds)			
Name	2.9	1.0	*
Kind	3.1	1.1	*
Goes with	1.4	1.1	

*$p < .05$.

Table 2

Number of Children Selecting the Shape Match on Three or Four Out of the Four Trials (Shape Biased) or on Less Than Three of the Trials (Not Shape Biased) in All Studies

Study/condition	Shape biased	Not shape biased
Study 1 (3-year-olds)		
Name	12	4
Kind	12	4
Goes with	6	10
Study 2 (3-year-olds)		
Category-relevant property	9	7
Category-irrelevant property	3	13
Study 3 (2-year-olds)		
Name	12	4
Kind	11	5
Goes with	2	12

In sum, recall that according to the attentional-learning account, children's shape bias is specific to naming contexts. Thus, only children in the name condition should reveal a preference for shape. According to the shape-as-cue account, children's shape bias reflects their beliefs about object categories. Thus, children in both the name and kind conditions should reveal a preference for shape. Consistent with both theories, and with previous research (e.g., Landau et al., 1988), children manifested a shape bias when extending names and did not do so when simply asked to "choose one that goes with" the target. These findings are important because they indicate that the present stimuli were comparable to stimuli used in previous work. More important, consistent with the shape-as-cue account and contrary to the predictions of the attentional-learning account, we found that children also showed a shape bias when asked to find another object "of the same kind" as the target object.

One possibility that is consistent with the present findings is that children manifest a shape bias outside the domain of naming only when explicitly asked about "kinds." This possibility would be incompatible with the shape-as-cue account. Specifically, according to the shape-as-cue account, the shape bias should be manifested as well in tasks in which children have to generalize properties of objects and should be most pronounced when the properties are relevant to the category membership of the object. Study 2 addressed this question.

In Study 2, children were told that the target object possessed a certain property and were asked which of the three test objects also possessed this property. In one condition, the property was relevant to the category insofar as it specified an "objective" feature of the object. In the other condition, the property was irrelevant to the category insofar as it specified a feature of the object that was unique to a particular object. The hypothesis was that if children's shape bias reflects their notion of object kind—as stipulated by the shape-as-cue view—they should select an object similar in shape to the target when asked to generalize a category-relevant property but should be less likely to do so for a category-irrelevant property.

Study 2

Method

Participants. Thirty-two 3-year-olds participated in this study ($M = 3{,}5$; *range* = 3,0–4,2). There were 21 boys and 11 girls. All children were recruited from preschools in the cities surrounding Bar-Ilan University. Only children with written parental permission participated in the study.

Materials. The same four sets of objects used in Study 1 were used in Study 2. The sets consisted of a target object and three test objects: a shape match, a color match, and a material match.

Design. Sixteen children were randomly assigned to one of two conditions: (a) category-relevant property or (b) category-irrelevant property. The average ages of children in the two conditions were not significantly different. Boys and girls were evenly distributed between conditions.

Procedure. The procedure was the same as in Study 1, except for the information children received about the objects. The only difference between the two present conditions was in the type of property ascribed to the target object. For instance, children in the category-relevant property condition were shown the target object and were told, "Look at this. It was made at Isradex factories. See, this was made at Isradex factories." Children were then asked to generalize this property to one of the test objects, "Which one of these (the test objects) was also made at Isradex factories?" In each condition, this procedure was repeated for four different sets of objects, each with a different property.

The four properties in the category-relevant property condition were: "It was made at Isradex factories," "It was made especially to play with cats," "It comes in a special box," and "It is used in the kitchen." The four properties in the category-irrelevant property condition were: "I got this for my birthday," "My uncle gave this to me," "I bought this in Jerusalem," and "I keep this in my bedroom."

Results and Discussion

The main dependent measure was the number of times, out of four object sets, children selected the shape match, where 1.33 selections was considered chance. A comparison between the two conditions revealed that children in the category-relevant property condition were significantly more likely than children in the category-irrelevant property condition to select the shape match, $t(30) = 2.2$, $p < .05$ (see Table 1). Children in the category-relevant property condition selected the shape match significantly more than expected by chance ($M = 2.7$, $SD = 1.1$), $t(15) = 5.03$, $p < .001$. It is surprising that children in the category-irrelevant property condition also selected the shape match significantly more than expected by chance ($M = 2.0$, $SD = 0.6$), $t(15) = 4.22$, $p < .005$. Our admittedly ad hoc explanation for this finding is that, faced with the request to generalize these properties to one of the test objects, these children may have defaulted to treating these properties as category relevant. That is, in contrast to the goes with condition of Study 1 in which children were asked to choose freely one of the test objects, the category-irrelevant property instructions may have given some children the impression that there was a "correct" object to pick. Under these circumstances, children might have fallen back on the most reliable strategy available to them, namely, choosing by shape.

Our analysis of the number of shape-biased and not-shape-biased children in each of the conditions also seemed to mitigate the previous finding. As can be seen in Table 2, a comparison of the conditions confirmed that more children in the category-relevant property condition were shape biased than in the category-irrelevant property condition, $\chi^2(1, N = 32) = 4.80$, $p < .05$. It seems that the 2.7 average shape-match selections found in the category-relevant property condition resulted because more than half of the children (9 of 16) in that condition selected the shape match consistently. In contrast, the 2.0 above-chance mean number of shape-match selections found in the category-irrelevant property condition did not seem to result from this sort of consistency, as only 3 of the 16 children in that condition were shape biased.

In sum, consistent with the shape-as-cue account, 3-year-olds extended on the basis of shape not only when given a new count noun and not only when explicitly asked about kinds, but also when asked to generalize certain properties. Specifically, as predicted by the shape-as-cue account, this tendency was manifested consistently when children were asked to generalize properties that were relevant to category formation, and more strongly than when they were asked to generalize properties irrelevant to category formation.

Having explored the specificity of the shape bias among 3-year-olds in Studies 1 and 2, Study 3 addressed to what extent this kind bias existed even among 2-year-olds. In the context of the attentional-learning account, the importance of investigating this age is twofold. First, given that according to the attentional-learning account the shape bias results from associations learned by children in the early stages of language acquisition, the bias is supposed to grow stronger between the ages of 2 and 3 years (Jones et al., 1991; Smith, 1999). As Smith (1999) concluded, "As children learn more and more words and experience more and more linguistic acts used to refer to objects, language and the act of naming should take strong control over attention to objects—so strong and so automatically, perhaps, that it blocks the learning of other associations or other forces on attention" (p. 297). Second, Landau et al. (1988) suggested that although the bias continues to be primarily word specific even among 3- and 4-year-olds, there seems to be a tendency for the bias to become more general between the ages of 2 and 3 years. To examine these issues, Study 3 replicated Study 1 with the youngest age group for which there was evidence that the kind instruction would be understood as denoting category inclusion (Diesendruck & Shatz, 1997, 2001).

Study 3

Method

Participants. Forty-six 2-year-olds participated in this study ($M = 2{,}8$; *range* = 1,11–3,1). There were 21 boys and 25 girls. All children were recruited from preschools in the cities surrounding Bar-Ilan University. Only children with written parental permission participated in the study.

Materials. The same four sets of objects used in Studies 1 and 2 were used in Study 3.

Design. Children were randomly assigned to one of three conditions: (a) name, (b) kind, or (c) goes with. Fourteen children participated in the goes with condition, and 16 participated in each of the other two conditions. The average ages of children in the three conditions were not significantly different. Boys and girls were evenly distributed between conditions.

Procedure. The procedure in the three conditions was exactly the same as in Study 1.

Results and Discussion

An ANOVA with condition and gender as between-subjects variables revealed a significant effect of condition, $F(2, 40) = 11.61$, $p < .001$ (see Table 1). Neither the effect of gender nor the interaction was significant. Scheffé post hoc tests revealed a significant difference between the goes with and the name conditions ($p < .005$) and between the goes with and the kind conditions ($p < .005$). The difference between the name and kind conditions was not significant ($p > .9$; see Table 1). Children in the name condition selected the shape match significantly more than expected by chance ($M = 2.9$, $SD = 1.0$), $t(15) = 6.43$, $p < .001$, whereas children in the goes with condition selected the shape match at chance level ($M = 1.4$, $SD = 1.1$), *ns*. Most important, children in the kind condition also selected the shape match significantly more than expected by chance ($M = 3.1$, $SD = 1.1$), $t(15) = 6.16$, $p < .001$.

As in the previous two studies, we compared the number of shape-biased and not-shape-biased children across conditions (see Table 2). As with the 3-year-olds in Study 1, we found that the majority of 2-year-olds in both the name and kind conditions were shape biased, whereas the majority of 2-year-olds in the goes with condition were not, $\chi^2(2, N = 46) = 13.14$, $p < .005$.

To gain a clearer picture of possible developmental changes, we compared the mean number of shape-match selections made by 2-year-olds in the name and kind conditions of Study 3, with the mean number of shape-match selections made by 3-year-olds in the name and kind conditions of Study 1. An ANOVA with condition, age group, and gender as the variables revealed no significant results. In other words, 3-year-olds in either condition were not more shape biased than were 2-year-olds in either condition. In addition, we tested for a correlation between the age in months of the participants in the name condition and the mean number of shape-match selections. This correlation was not significant ($r = .27$, *ns*).

In sum, the 2-year-olds in this study responded just like the 3-year-olds in Study 1. Consistent with both theories and previous findings, children manifested a shape bias when extending names and did not do so when simply asked to ''choose one that goes with'' the target. But, in support of the shape-as-cue account and contrary to the predictions of the attentional-learning account, the shape bias among 2-year-olds was as strong and as nonlexical specific as the one found among 3-year-olds.

General Discussion

The focus of this research was the theoretical debate surrounding children's tendency to name objects based on their shape. The attentional-learning account makes two claims about the underlying reason for this bias. The first claim has to do with the origin of the bias. In particular, the claim is that as children learn count nouns, they learn that these nouns commonly extend to objects that are similar in shape to one another. The second claim has to do with the process by which children extend novel names to novel objects. Specifically, the argument is that once the association between count nouns and similarity in shape is established, the extension of a novel name is driven by nonstrategic mechanisms of attention. Two empirical predictions derive from this account. The first prediction is that the shape bias is specific to the context of naming, certainly by 2 years of age, and by most accounts until 3. The second prediction is that the bias should grow stronger between the ages of 2 and 3 years.

In contrast, the shape-as-cue account argues that children's shape bias derives from a general belief that shape is a reliable cue to object kind (Bloom, 2000). According to this account, the shape bias is not unique to the context of naming, but rather applies to all contexts of categorization of objects by kind. Moreover, the bias should be evident and general by the earliest age at which children can understand experimental manipulations that tap into their notion of kind.

The present three studies did not address the origin of the bias. Instead, they focused on how specific it is. The results of the studies supported the shape-as-cue proposal. Study 1 revealed that 3-year-olds' tendency to select a shape match to a target object when asked to extend the target's name was similar to that manifested when asked to select an object of the same kind as the target. In that study, children showed no such tendency when asked to select an object that goes with the target. Study 2 showed that this tendency was specific to cases in which children were asked to generalize kind information. Finally, Study 3 revealed that the shape bias in 2-year-olds was also not specific to naming contexts, but rather was manifested when making kind categorization as well.

These results might seem mystifying given that so many other studies arguing that the shape bias is specific to language included nonlexical controls and found random behavior. Indeed, we replicated this finding here; when asked to ''choose one that goes with'' the target, children showed no bias to choose an object of the same shape as the target object. This shows that not just any instructions will generate a shape bias. But there are many sorts of nonlexical tasks. Some, like the one just described, motivate random behavior or, at best, a search for perceptually similar objects. Others, such as category-relevant property generalization and instructions to find one ''of the same kind'' motivate a search for objects that belong to the same category (see Deak & Bauer, 1996, for a similar argument). When given such instructions, 2-year-olds and 3-year-olds generalize on the basis of shape. This suggests, at minimum, that it was premature for scholars to conclude, on the basis of findings from only one type of nonlexical control, that the shape bias is special to language. We found here that there are two sorts of nonlexical situations in which the shape bias occurs consistently: instructions to generalize on the basis of kind (Study 1 and Study 3) and instructions to generalize a category-relevant property (Study 2).

Also in conflict with earlier findings (e.g., Jones et al., 1991; Landau et al., 1988), the present studies revealed no developmental change in the strength of children's shape bias in naming contexts. This finding may also seem contradictory to the existence of a positive correlation between count-noun vocabulary size and the strength of the shape bias (Samuelson & Smith, 1999; Smith, 1999). One possible reason for this disparity has to do with differences in the ages of the participants in these studies. Specifically, 2-year-olds in the present study were on average 2 years and 8 months old, whereas 2-year-olds in Jones et al.'s (1991) and Landau et al.'s (1988) studies were on average 4 months younger than that. In the longitudinal studies reported by Samuelson & Smith (1999) and Smith (1999), starting ages of the children were less than 2 years of age. Thus, it is possible that the shape bias in naming grows stronger in the first half of children's third year (see Hollich et al., 2000, for a compatible argument). Other possibilities for the disparity in the findings have to do with differences in the stimuli and procedures. For instance, in the present studies, children had to answer four name-extension questions on four different object sets. In contrast, in Jones et al. (1991), children had to answer 16 name-extension questions on two sets of objects, with some repetitive items. It is possible that the latter task was more taxing, especially for 2-year-olds.

Whatever the reason for this disparity, it is important to note that the mere existence of a developmental trend in terms of the shape bias does not in itself contradict the shape-as-cue account. First, it is possible that children's acquisition of count nouns results from developments in children's notion of object kinds (Gopnik & Meltzoff, 1997). Alternatively, children's acquisition of count nouns could facilitate object categorization (Balaban & Waxman, 1997; Waxman & Markow, 1995; Xu, in press). Whichever the direction of influence, the increase in count-noun vocabulary would correspond to an increasingly sophisticated understanding of object categories, which, in turn, would lead to a more robust understanding of the role of shape as a cue to category membership.

In our view, the present finding that by 2.5 years the shape bias is not specific to the context of naming is consonant with two more general claims about how children learn and understand the meanings of words. The first is that children's remarkable ability to learn the meanings of words might not be due to knowledge that is specific to word learning, either innate constraints or learned associations. Instead, it might be the result of more general capacities that children possess, including the ability to form concepts, to reason about the intentions of other people, and to appreciate mappings between syntax and semantics (see Bloom, 2000). Evidence in support of this claim comes from studies finding that the ability to fast map is not specific to words (Markson, 1999; Markson & Bloom, 1997); that direction of gaze is a cue that children use when learning many properties of objects, not just their names (Baldwin, 1991, 1993; Baldwin & Moses, 1994); and that children's mutual-exclusivity bias might apply to other referential acts other than names (Diesendruck & Markson, 2001).

None of these examples is uncontroversial (see Waxman & Booth, 2000; Woodward & Markman, 1998), and we do not expect our shape-bias finding to go unchallenged. One response might be to modify radically the attentional-learning proposal such that the shape bias is only special to words very early in development; by the time children are 2.5 years old, it applies more generally. The studies reported here do not bear on this hypothesis, as we did not directly investigate the origins of the bias. A different response is to propose that the shape bias for count nouns emerges from associationist learning and is special to count nouns—the shape bias we found when children were asked to find objects that belonged to the same kind or to generalize properties has an entirely different origin. This is possible as well, but it does not seem particularly parsimonious or comprehensive. The present studies revealed a variety of conditions under which a shape bias is manifested consistently (i.e., the name, kind, and category-relevant property conditions) and conditions in which it is not manifested consistently (i.e., the goes with and category-irrelevant property conditions). We see these results as compatible with a simpler account: Count nouns refer to categories of objects, and shape is crucial for object categorization, whether it is done by man, monkey, or machine (Tarr & Bulthoff, 1999).

This brings us to the second claim supported by our finding, which is that children treat names as referring to kinds. They use *dog* to refer to dogs and *chair* to refer to chairs. This might seem like a banal claim, but it is in sharp conflict with a popular view in developmental psychology that children, or at least young children, use names to refer to things that share a common appearance, where appearance often reduces to shape. From this perspective, *dog* and *chair* might correspond to dog shaped and chair shaped. We suggest, on the contrary, that children use appearance as adults do: Something that looks like a dog or a chair is likely to be called *dog* or *chair* because what something looks like is an excellent cue to what it actually is.

According to this perspective, one might expect that children's naming should be affected by nonperceptual features of objects. In the domains of artifacts, there are several studies showing that information about the intention of the artifact's creator plays an important role in how children name it. This applies for both the naming of representations such as drawings (Bloom &

Markson, 1998; Gelman & Bloom, 2000; Gelman & Ebeling, 1998) and the naming of nonrepresentational artifacts such as chairs (Diesendruck et al., in press; Gelman & Bloom, 2000; Kemler Nelson, Frankenfield, et al., 2000). Furthermore, this view predicts that the types of perceptual features that children do use should be influenced by the sort of object they are naming. And, indeed, children are appropriately flexible in their categorization. The properties children attend to when categorizing a novel entity depend on whether it is a rigid object or a nonsolid substance (Soja, Carey, & Spelke, 1991), a frog or a rock (Keil, 1994), a real monkey or a toy monkey (Carey, 1985), an animal or a tool (Becker & Ward, 1991), or an artifact with a plausible structure–function relation as opposed to one with an implausible structure—function relation (Kemler Nelson, Frankenfield, et al., 2000). A shift in the properties that underlie categorization can be caused by subtle cues, as when eyes are added to simple geometrical shapes giving them the appearance of being snakelike animals (Jones et al., 1991), or when objects are described as animals as opposed to artifacts (e.g., Keil, 1994).

Children are often described as smart word learners. One of the most exciting research programs of recent years has been the attempt to show that this smart word learning is actually rooted in ''dumb'' associationist mechanisms of learning. This proposal has many positive features, especially that of parsimony. But there is a growing body of evidence, including the studies presented here, that supports a very different view. The intelligence of children's word learning and word use is the product of their considerable linguistic and conceptual competence—in the domains studied here, their understanding of count nouns and of object categories. Children are smart word learners because, in at least some domains, children are smart.

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