Developmental Psychology
2005, Vol. 41, No. 6, 1003–1019


0012-1649/05/$12.00 DOI: 10.1037/0012-1649.41.6.1003

# The Absence of a Shape Bias in Children's Word Learning

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There is debate about whether preschool-age children interpret words as referring to kinds or to classes defined by shape similarity. The authors argue that the shape bias reported in previous studies is a task-induced artifact rather than a genuine word-learning strategy. In particular, children were forced to extend an object's novel label to one of several stand-alone, simple-shaped items, including a same-shape option from a different category and a different-shape option from the same superordinate category. Across 6 experiments, the authors found that the shape bias was eliminated (a) when the objects were more complex, (b) when they were presented in context, or (c) when children were no longer forced to choose. Moreover, children preferred the different-shape category alternatives when these were part of the same basic-level category as the target. The present experiments suggest that children seek out objects of the same kind when presented with a novel label, even if they are sometimes unable to identify the relevant kinds on their own.

*Keywords:* word learning, taxonomic bias, shape bias

The controversy about the existence of a shape bias in early word learning can be seen as part of a larger debate about whether cognition undergoes a perceptual-to-conceptual shift with development. On the one hand, it has been argued that preschool children's object labels are perceptually based; they pick out same-shaped or similar-looking things regardless of the taxonomic categories to which these objects belong (e.g., Imai, Gentner, & Uchida, 1994; Landau, Smith, & Jones, 1988). According to this view, the word *cat,* for example, would refer to something like cat-shaped things. On the other hand, it has been claimed that children's object labels refer to kinds—to categories of objects whose members share unforeseen and nonobvious properties as well as perceptual features (e.g., Booth & Waxman, 2002; Gelman, 2003; Markman, 1989; Soja, Carey, & Spelke, 1991). According to this view, the word *cat* refers to the natural kind cat whose members are expected to not only often look alike but also share a range of behavior, internal structure, and so forth. Moreover, children should allow that objects that don't look much alike might still be members of the same kind and be called by the same label. There is no disagreement that perceptual information plays an important role in language learning and use (e.g., Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). In particular, shape similarity is useful when children have to carve out the extension of a new word on their own, as it is reliably correlated with shared category membership. What is at issue, however, is whether preschool children are *limited* to considering superficial perceptual properties when learning and extending object labels—in other words, whether shape similarity is necessary or sufficient for preschoolers' word extension.

There is now abundant evidence against the claim that children's early cognition is limited to superficial perceptual similarities. For example, children judge the identity of an artifact (Gelman & Bloom, 2000) or a drawing (Bloom & Markson, 1998; Gelman & Ebeling, 1998) on the basis of the intent of its creator and not just its perceptual properties. They can base inductive inferences on an object's kind rather than its appearance (Gelman & Coley, 1990; Gelman & Markman, 1986, 1987), and even 16-month-old infants expect objects of the same kind but dissimilar appearance to share nonobvious properties (Welder & Graham, 2001). Preschoolers extend the name of an unfamiliar artifact to other artifacts that share the same salient function (e.g., Kemler Nelson, Russell, Duke, & Jones, 2000) or causal property (Gopnik & Sobel, 2000), even when perceptual similarity conflicts with these properties. Creator's intent also overrides perceptual information in children's novel word extension, as shown by Diesendruck, Markson, and Bloom (2003). In the same vein, 3-year-olds are able to categorize perceptually identical novel objects as either animals or artifacts, depending on the conceptual information provided in the task—that is, whether the objects in question are described as having animal-like properties or artifact-like properties (Booth & Waxman, 2002).

Despite this evidence, the shape bias hypothesis still has plausibility because of several striking demonstrations of children's reliance on shape in extending newly learned words. For instance, Baldwin (1992) taught preschoolers a novel word for a familiar object (the target) and then asked them to extend it to either an object that looked like the target but was not a member of its

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This research was supported in part by a Regina Casper Stanford Graduate Fellowship to Andrei Cimpian. We are grateful to the children, parents, and teachers at Bing Nursery School. We also thank Ambika Sud for her assistance in testing and coding the data; Cristina Sorrentino and Vikram Jaswal for useful suggestions and discussion; and Dedre Gentner for graciously providing the stimuli used in Imai, Gentner, and Uchida (1994). Portions of this work were presented at the October 2003 Cognitive Development Society conference in Park City, Utah.

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category or one that was perceptually dissimilar but belonged to the same kind as the target. Children frequently applied the label to the perceptually similar alternative. Baldwin's result has been replicated by Imai et al. (1994) and Golinkoff, Shuff-Bailey, Olguin, and Ruan (1995) and is consistent with the conclusions of a series of studies by Smith and her colleagues (e.g., Jones & Smith, 1993; Landau et al., 1988; Landau, Smith, & Jones, 1992; Smith, Jones, & Landau, 1992), which suggested that shape similarity is paramount in children's early categories and object labels.

Given that preschool children are capable of going beyond perceptual similarity, why are they so consistently showing a shape bias in these studies? We argue that none of the studies in which children preferred the perceptually similar alternatives over the same-category alternatives (namely, Baldwin, 1992; Golinkoff et al., 1995; and Imai et al., 1994) actually demonstrate that young children treat words as referring to categories organized by perceptual similarity. Instead, we believe, the shape-bias results are artifacts of the methodology used in this research. Before laying out the details of our argument, we review the methods and conclusions of these studies in more detail.

The shape-bias studies were in part a reaction to Markman and Hutchinson (1984), who proposed that when hearing a new word, children make the implicit assumption that it refers to objects of the *same kind*. This taxonomic assumption allows children to rule out many other logically possible but incorrect meanings for words. In particular, children should be able to ignore the thematic relations they otherwise find so salient (Smiley & Brown, 1979). When asked to sort or classify objects, young children usually group them on the basis of spatial relations (e.g., the plates are in the cabinet), on the basis of causal relations (e.g., scissors cut paper), or more generally because they are part of the same event (e.g., people sit on chairs, cows give milk). To test whether children can override their preference for these thematic relations and make use of the taxonomic assumption in the presence of a novel word, Markman and Hutchinson (1984) presented preschool children with an object (say, a cow) that was labeled with a novel word in "puppet language" (say, a *dax*) for half of the children and not labeled for the other half. The children were subsequently asked to find either "another one" or "another *dax*" from a pair of stimuli consisting of a taxonomic alternative (e.g., a pig) and a thematic alternative (e.g., milk). Children were more likely to pick the taxonomic alternative (the pig) when asked to find "another *dax*" than when asked for "another one," suggesting that children take novel count nouns to refer to taxonomic categories and not to groups of objects defined by thematic relations. Markman and Hutchinson's (1984) study was criticized, however, because it failed to control for the similarity in shape between the target and the taxonomic alternatives. Children avoided thematic meanings when object labels were present, but it is not clear whether their attention shifted to taxonomic categories, as Markman and Hutchinson supposed, or to more superficially defined, shape-based categories.

Baldwin (1992) tested this alternative hypothesis by pitting shape similarity against both taxonomic and thematic relations. Preschoolers were introduced to a familiar object (say, a flower) labeled with a novel word. Baldwin then tested children's extension of the label by presenting them with two alternatives: a similarly shaped, unrelated object (e.g., a wheel) and a thematic choice (e.g., a bee, in Study 1) or a differently shaped taxonomic choice (e.g., a tree, in Study 3). As in Markman and Hutchinson (1984), hearing a label caused children to move away from choosing the thematic alternative. When choosing between a same-kind and a same-shape option, however, children selected the object that had the same shape as the original on 54% of the trials, despite the presence of the taxonomic alternative.

A more powerful demonstration of this phenomenon was provided by Imai et al. (1994), who used a match-to-sample task similar to Baldwin's (1992). Adults, 3-, and 5-year-olds were taught a new label for a familiar object (e.g., a carrot) and later were asked to extend it to one of three test objects: one similar in shape to the target but otherwise unrelated (a nail), one that was related thematically (a rabbit), and one of the same taxonomic kind but different shape (a potato). Children who heard the target items labeled were less likely to choose the thematic alternatives than the ones who did not—again replicating the original Markman and Hutchinson (1984) result. In support of Baldwin's (1992) findings, however, when given a novel label for the target, both groups of children preferred the shape alternative over the taxonomic one on a majority of trials (62%). (For similar results, see Golinkoff et al., 1995.)

We argue that the shape bias obtained in the studies just described is not a genuine word-learning strategy but rather an artifact of the stimuli and procedures used. In all of these studies, children were *forced* to extend a novel label to one of the options. However, it is very likely that children thought none of the choices were suitable referents. On our account, preschoolers take words to refer to kinds rather than classes of same-shaped things, and hence they are unlikely to use the same label for objects that belong to different categories but happen to have the same shape (e.g., a carrot and a nail). Yet children in these studies might have also been reluctant to choose the *superordinate* taxonomic alternatives, because at this age, they often have difficulties identifying these categories (e.g., Horton & Markman, 1980), especially in the absence of perceptual support. Faced with these options, children probably sought some basis for responding other than their knowledge of what words mean, which in turn increased the number of shape choices, because (a) they were shown overly simplistic line drawings of objects; (b) the stimuli overemphasized the similarity between the targets and shape alternatives by presenting objects in isolation; and (c) the shapes used were often very simple, which could have made the dimension of shape more salient and may have even led children to believe they were being taught shape terms. We now go on to describe each of these methodological issues in more detail.

All of the shape-bias studies mentioned used a forced-choice procedure: Children were first provided a novel label (e.g., *sud*) for a known object (e.g., a birthday cake) and then had to pick "another *sud*" from among two or three other items (e.g., a top hat, a pie, and a present). Children were forced to choose exactly one of the alternatives provided, even if they were not at all sure which one was the other *sud* or whether there was another *sud* at all. It is quite possible that children would find none of the alternatives appropriate in this situation. The shape alternative (in this example, the top hat) would not be a valid option if, as we argue, children realize that mere shape similarity is not enough to justify extending the novel label. Children might also fail to identify the taxonomic option (the pie), however. Recall that in all of the shape-bias experiments (except Golinkoff et al.'s Experiment 6), as well as some of Markman and Hutchinson's (1984) studies, the taxonomic alternatives shared category membership with the target at the superordinate level (e.g., a birthday cake and a pie are kinds of desserts; a carrot and a potato are kinds of vegetables). On their own, preschoolers may not be able to identify and reason about superordinate categories (Horton & Markman, 1980; Markman & Callanan, 1983; Mervis & Crisafi, 1982) and so will not realize that the target (the birthday cake) and the taxonomic alternative (the pie) can be named with the same word. Thus, children should be at a loss as to which response option to choose. Indeed, in a task modeled on Imai et al. (1994), Chouinard (1999) noticed that 43% of her participants were unwilling to select any of the available alternatives, and many children actually tried to search other locations in the testing room in order to find referents for the labels. This reluctance to extend the new words is exactly what one would expect of children if they indeed sought other exemplars of the same category as the target and were unable to find any. When the experimenter insists that they pick one of the items in front of them, children choose the shape alternative because shape similarity is the most salient relationship among the stimuli.

We are arguing that children extend novel labels to objects that share kind membership rather than to objects that are merely similar in shape. However, when the kinds involved are as heterogeneous as superordinate categories usually are, children might not be able to identify other objects of the same kind as the target initially labeled without some help (e.g., shared label or perceptual similarity). This analysis also suggests that Markman and Hutchinson's (1984) claim about children's behavior on this task may have been too strong. Recall that in some of their studies they also used superordinate categories and found that when forced to choose, preschoolers preferred these items over the thematic alternatives. As Baldwin (1992) and Imai et al. (1994) pointed out, however, Markman and Hutchinson's superordinate taxonomic items were more perceptually similar to the targets than the thematic options were, so it is possible that the number of taxonomic selections would have been lower had perceptual similarity been controlled for. On our account, this would not imply that children do not have a taxonomic bias—they are just unable to find the relevant kinds under certain circumstances. Consequently, simplifying the category relations by including basic-level kinds may reveal children's taxonomic bias, even when the taxonomic alternatives are dissimilar in shape to the target.

In the present series of studies, Experiment 2 examines the role of the forced-choice methodology in inducing children's preference for same-shaped objects. The impact of the category level (superordinate vs. basic) is investigated in Experiments 3 through 6.

In addition to the type of procedure used in the shape-bias studies, there are also at least three features of their *stimuli* that could have made children more likely to base their answers on shape similarity. First, the perceptual information in the items presented to children was quite sparse. Baldwin's (1992) stimuli consisted of black-on-white pencil illustrations of objects; similarly, Imai et al. (1994) and Golinkoff et al. (1995) used colored line drawings. Some unpublished studies indicate that the number of shape alternatives children select is reduced when photographs (Shi, 1996) or real objects (Chouinard, 1999) are used instead of line drawings. For this reason, in the present studies we used realistic photographs of familiar objects rather than line drawings as stimuli.

Second, all of the objects in the shape-bias studies were portrayed out of context, without any additional information about scale (e.g., a toothbrush was the same size as an axe), and from the perspective that was most apt to emphasize the shape similarity between the target and the shape associate. The result is striking—shape looms large and captures attention immediately. For example, in Imai et al. (1994), even adult subjects made quite a few same-shape selections (33%) despite hearing the targets labeled with a novel word. To test whether the shape bias is partly a consequence of showing objects in isolation, in our first two studies we presented children with objects that were depicted either alone or in a context in which they are likely to be encountered. In addition to providing information about scale, contexts should help children encode the objects as part of a meaningful category (e.g., Murphy & Wisniewski, 1989) and thereby make shape per se less salient. There is also some evidence in the adult perception literature that perceiving objects in scenes with which they are consistent facilitates their identification and elaborates their representation (see Henderson & Hollingworth, 1999, for a review) relative to objects inconsistent with their scenes.

The third feature of the stimuli that could have induced a preference for the shape alternatives is that most of the objects in these studies had very simple shapes. For example, seven out of Imai et al.'s (1994) nine target/shape-alternative pairs were round or oval (apple/balloon, cookie/coin, plate/compact disk), triangular (sandwich/woodblock), cylindrical (drum/bucket), crescent shaped (banana/feather), or rod shaped (carrot/nail). The other two pairs were only slightly more complex—necklace/jump rope and birthday cake/hat. Baldwin's (1992) stimuli were comparably simple in shape, with the exception of two fairly complex stimulus pairs (squirrel/coffee pot and car/iron). The simple, regular shapes of the objects used in these experiments may have made shape particularly salient to children. Moreover, having simple stimuli is problematic because simple shapes are often lexicalized, and it is quite possible that children could have reinterpreted the task as one in which they were learning shape terms (e.g., the puppet word for *circle* or *square*). Thus, in extending the new label to the shape alternatives, they could have been following the taxonomic assumption, in that they applied the label to another entity of the same kind—in this case, another shape of the same kind. In the present experiments, we investigated the influence of shape complexity on children's responses by constructing our stimuli such that half of them were very simple (e.g., cookie, coin, carrot) and half were more complex (e.g., car, boat, bicycle). We should note, however, that the stimuli in our "complex" set were only slightly more complex than the simple ones. The difficulty with using truly complex objects lies in identifying out-of-category shape matches: The more complicated the shape of an object is, the less likely one is to find an object of the same shape that does not belong to the same category. In other words, under normal circumstances, similarity of complex shapes may be more indicative of category membership.

In sum, we argue that the results of the shape-bias studies reviewed overestimate the extent to which young children rely on perceptual information in learning and generalizing new words. Preschoolers are unlikely to use the same label for different kinds of things that happen to have the same shape (say, a birthday cake and a top hat). We hypothesize that children's shape selections in these experiments were artifacts of the testing methods used rather than indications that the shape bias is a feature of children's word learning. More precisely, we identified several methodological issues that could have been responsible for the shape-bias results: Children were forced to make a choice, even if from their point of view none of the choices were correct. In particular, we suggest that children were unwilling to choose the taxonomic alternatives because, at this age, they are often incapable of identifying superordinate-level categories without perceptual support. Therefore, when asked to extend a novel label either to an out-of-category shape match or to a superordinate taxonomic match, children found themselves unable to make a choice based on what they believed the words meant. They then had to find an alternative criterion for choosing, and the criterion that was most readily available in the stimulus display was shape similarity, made even more salient by the use of black-on-white line drawings of simple-shaped, isolated objects.

In Experiment 1, we manipulated both the presence of context and the shape complexity of the items presented and tested the prediction that children are likely to pick the shape over the taxonomic associates only when presented with stand-alone, simple-shaped objects.

## Experiment 1

This study tested whether the shape bias is obtained only when very simple shapes are presented out of context, as in Baldwin (1992), Imai et al. (1994), and Golinkoff et al. (1995). We predicted that children would show no shape bias for objects that are either more complex in shape or presented in a meaningful context. The contexts we used did not include direct illustrations of object function (e.g., the objects are not presented in a scene in which they are being used by someone). Rather, contexts were meant to be scenes in which these objects could occur naturally. We decided to eschew direct representations of object function, because illustrating function would have been a stronger manipulation than providing a neutral, yet relevant, context.

### *Method*

### *Participants*

Twenty-four 3- to 5-year-old children ($M$ = 4 years 4 months; range = 3 years 3 months to 5 years 3 months) from a university-affiliated preschool participated in this study. Equal numbers of boys and girls were tested. Children came from predominantly middle- and upper-middle-class families. Ethnicity information was available for 79% of our participants. Of these children, 42% were European American, 32% were Asian American, 16% were Hispanic American, 5% were African American, and 5% were Native American. All the children were familiar with the experimenter, as he had spent at least one 3-hr session in their classroom prior to testing.

### *Design*

The independent variables of interest were shape complexity (simple vs. complex; manipulated within subject) and presence of context (context vs. no context; manipulated between subjects). The experiment consisted of eight trials, grouped into two blocks according to the complexity of the shapes involved. The order of the two blocks was counterbalanced across participants, such that half of the children saw four simple-shape trials first, whereas the other half saw four complex-shape trials first. On each trial, the experimenter recorded whether the participant selected the shape or the taxonomic response alternative.

### *Materials*

*Experimental stimuli.* Sixteen sets of color pictures depicting familiar objects were used in this study. Half of these sets consisted of stand-alone objects (see Figure 1)—a target, a shape alternative, and a taxonomic alternative—whereas the other half were composed of objects in context (see Figure 2 for two examples). Each of the context stimulus sets was created by placing the objects from a no-context set in a meaningful scene. With the exception of one item, all objects of interest (target, shape alternative, and taxonomic alternative) were completely unobstructed by the context. The size of the objects of interest was roughly equated within a set. We also manipulated shape complexity in the construction of our stimuli: Half of the sets consisted of objects with very simple shapes, and the other half consisted of slightly more complex-shaped objects. Each child was tested on both simple- and complex-shaped objects; however, children saw either all solitary objects or all objects in context.

Twenty-four undergraduates rated the stimuli without context on a scale from 1 to 7. These judgments were used to test two assumptions made in constructing the materials. The first issue was whether the shape alternatives were indeed more similar in shape to the target than the taxonomic alternatives were. The ratings validated this assumption: Overall, shape alternatives were rated as more similar to the target ($M = 5.32$, $SD = 0.68$) than taxonomic alternatives ($M = 2.06$, $SD = 0.95$), paired $t(23) = 14.93$, $p < .001$. This pattern was replicated for each of the individual stimulus triads when these data were analyzed separately (all $p$s $< .05$). Second, the undergraduates rated the complexity of the stimuli. These results confirmed that the objects in our complex stimulus sets ($M = 4.47$, $SD = 0.64$) were significantly more complex in shape than the objects in the simple stimulus sets ($M = 2.49$, $SD = 0.77$), paired $t(23) = 17.70$, $p < .001$.

We also obtained ratings of the similarity between the backgrounds of shape-alternative/target and taxonomic-alternative/target stimulus pairs for the eight context stimulus sets. The backgrounds consisted of context pictures with the target, shape, and taxonomic items removed. These ratings were used to check whether the similarity between the backgrounds of the target items and those of the taxonomic alternatives was comparable to the similarity between the backgrounds of the targets and those of the shape alternatives. Participants judged the backgrounds of the target/taxonomic-alternative stimulus pairs to be overall more similar ($M = 2.72$, $SD = 0.92$) than the backgrounds of the target/shape-alternative pairs ($M = 2.01$, $SD = 0.77$), paired $t(23) = 3.72$, $p < .005$. When the data for each stimulus set were analyzed separately, only four of the eight context sets conformed to this pattern: carrot ($p < .001$), plate ($p < .05$), bicycle ($p < .05$), and flower ($p < .01$). This is a potential confound that we address in the relevant results sections, but two factors mitigate the severity of the problem. First, both similarity averages were quite low (2.01 and 2.72 out of 7), which suggests that the differences, though statistically significant, are not very salient. The second reason is that children's responses were not influenced by this difference in context similarities.

*Warm-up stimuli.* Four sets of pictures were constructed for use during warm-up. Two of these contained stand-alone objects (computer/mouse/train and dog/ball/bed), whereas the other two contained the same kinds of objects (computers, mice, etc.) in context—a computer on a desk, a mouse on a branch. Each child was given two warm-up trials, whose content was matched to the child's experimental condition: Children in the context condition saw the warm-up sets with contextualized objects, whereas children in the no-context condition saw the solitary-object sets.

Both the experimental and the warm-up stimuli were printed on 15 cm × 15 cm pieces of paper that the experimenter introduced separately. Children marked their responses by placing small round stickers (approximately 1.5 cm in diameter) on the selected object. A hand puppet that the experimenter identified as "Mr. Froggy" was used to keep children engaged in the task and to provide the rationale for using words in "frog

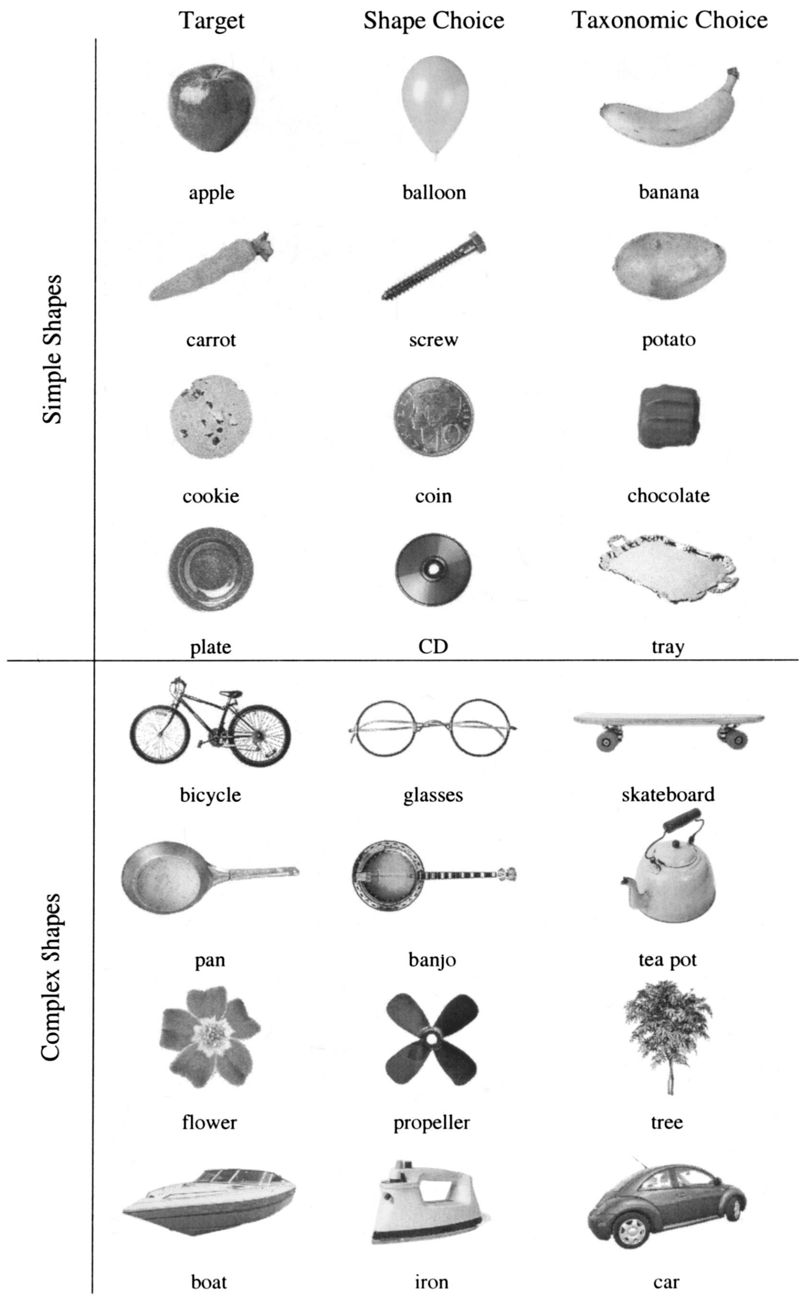


*Figure 1.* No-context stimuli used in Experiments 1 and 2.

language." The eight nonsense/frog-language labels were *wap, zimbo, sud, tilfer, jiggy, blint, fep,* and *figley*.

## Procedure

*Warm-up phase.* Children were seen individually in a quiet room in their preschool. They were introduced to the puppet (Mr. Froggy) and told they would be helping it to "find things in pictures." They were also informed that they should mark their responses by placing a sticker on the sought object. In the two warm-up trials, children were shown three pictures arranged in a line and asked to find a particular object in them. They were asked to find the computer in the computer/mouse/train stimulus set and the ball in the dog/ball/bed set. The order of presentation of these two sets and the position of the individual stimuli (left, middle, or center) were randomly determined. Children's responses were coded on-line. All children chose the correct objects on both warm-up trials.

*Experimental trials.* Following the warm-up trials, the participants were asked to help Mr. Froggy find things that were named in "frog language." On each trial, the experimenter first presented the target, highlighted the object of interest by tracing a circle around it with his index finger, and said, "See this? This is a [novel label] in frog language." This last sentence was repeated in order to make sure the children paid attention and registered the presence of the novel label. The experimenter then introduced the shape and taxonomic alternatives and highlighted each in

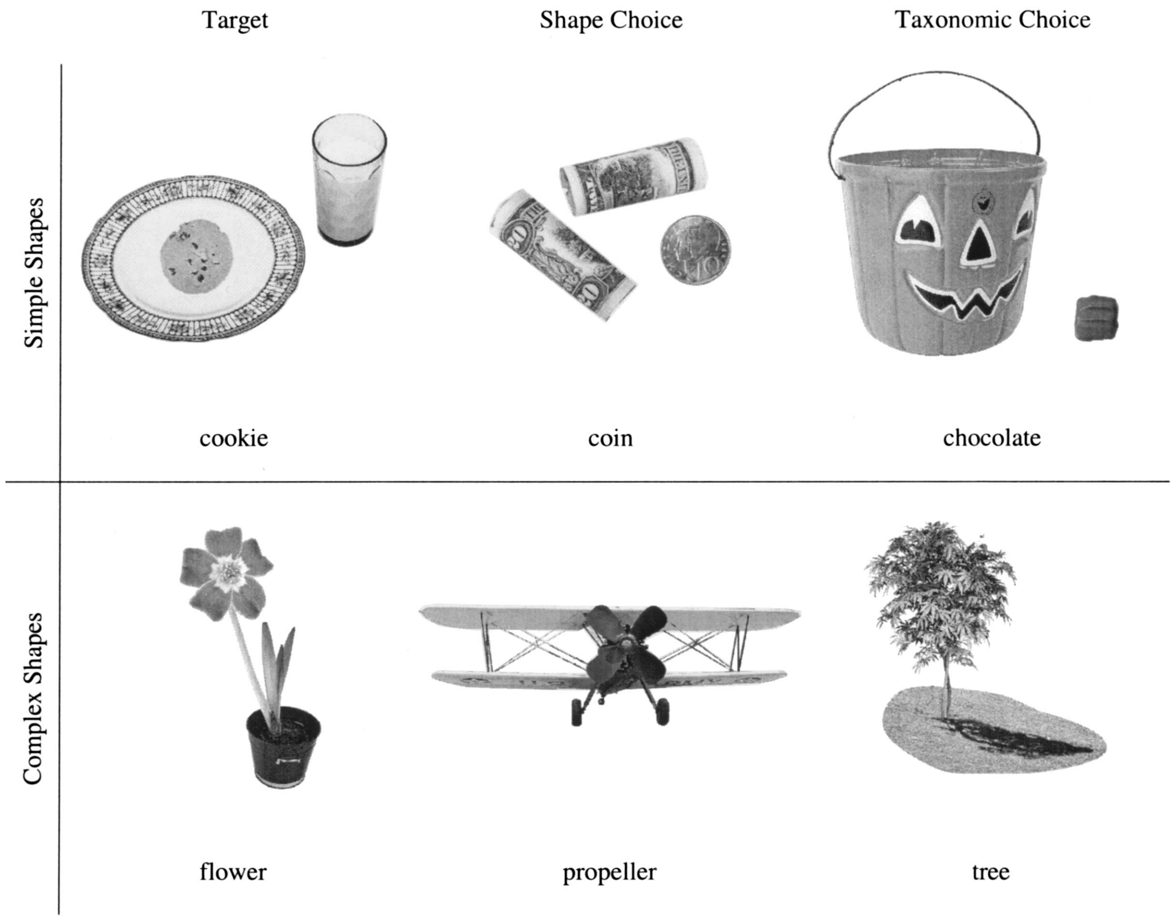


*Figure 2.* Sample context stimuli used in Experiments 1 and 2.

turn both by saying, "See this?" and by tracing around the object with his index finger. The two response choices were placed next to each other and closer to the child than the target. Participants were then invited to "find another [novel label]." If no response was made within about 5 s of the time when the question was asked, the experimenter repeated the question and proceeded to introduce the target and response options again if the children still made no response. If children tried to choose both alternatives on a given trial, the experimenter prompted them to select only one.

This procedure was repeated on all eight trials and was identical for the context and no-context conditions. In the context condition, if the children placed their stickers on objects other than the ones that had been highlighted as the shape and taxonomic alternatives, they were reminded that the answer had to be one of the two and were invited to select one of them by putting another sticker on it. No such confusion was possible in the no-context condition, as the taxonomic and shape choices were the only objects present in the stimulus pictures available to children for responding.

For each of the eight trials, half of the children saw the shape alternative on the left, and half saw it on the right. For each child, the shape alternative was presented in the left position on four trials and on the right in the other four. The order of the left- and right-position trials was randomly determined. The order in which the stimulus triads were presented was counterbalanced across participants, as was the order of the simple-shape and complex-shape trial blocks. The nonsense labels were randomly assigned to the eight triads for each child. All sessions were videotaped.

### *Results and Discussion*

Preliminary analyses revealed no significant main effects or interactions involving gender, age, or order of shape complexity blocks; these factors were therefore eliminated from subsequent analyses. For this and all other analyses testing for age effects, children were divided into two groups around the mean age. Also, for ease of presentation, we report mean percentages instead of the mean number of selections, although the mean number was used for statistical tests.

On each trial, the children could select either the object that was similar in shape to the target but different in category or the object that belonged to the same taxonomic category but was perceptually dissimilar to the target. We predicted that children would prefer the shape alternatives only if shown simple-shaped, solitary objects. One-sample $t$ tests against chance for each of the cells determined by crossing shape complexity and presence of context (see Figure 3) supported our prediction: Children selected the shape alternative on more occasions than expected by chance (70.83% vs. 50%) for the trials involving simple shapes out of context, $t(11) = 1.97$, one-tailed $p < .05$. This result is a clear replication of Imai et al. (1994), Golinkoff et al. (1995), and Baldwin (1992). However, the simple-shapes/no-context condition was the only one for which a

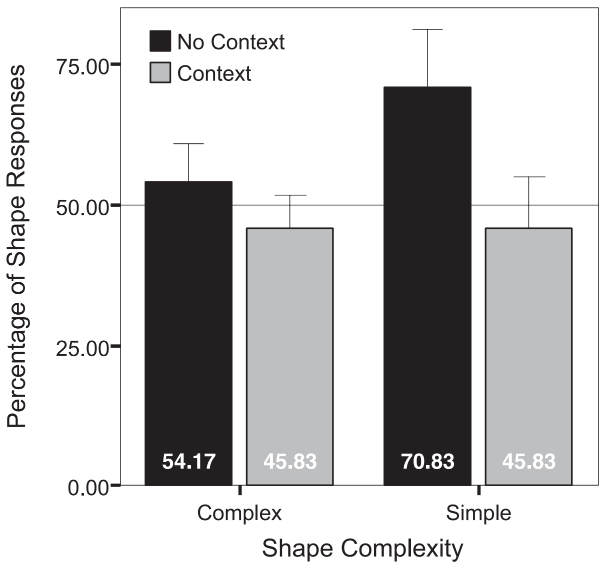


*Figure 3.* Mean percentage of shape responses in Experiment 1 as a function of the presence of context and shape complexity. Error bars represent standard error of the mean.

shape bias was obtained: The number of shape responses in the other three cells did not differ significantly from chance ($p$s > .50). Correspondingly, the number of taxonomic choices was also not different from chance in these conditions.

To assess whether individual children's response patterns mirror these results, children were categorized as having a shape preference within a block of trials if they selected the shape alternative on all four trials. The binomial probability that children would randomly select four shape alternatives within a block is .062. The distribution of children in each of the four cells who met this criterion paralleled our previous results: More children displayed a shape preference in the simple-shapes/no-context block (6 out of 12) than in the simple-shapes/context block (1 child; one-tailed $p < .05$, Fisher's exact test), the complex-shapes/context block (no children; $p < .02$, Fisher's exact test), and the complex-shapes/no-context block (1 child; one-tailed $p < .05$, McNemar test).

A 2 × 2 mixed analysis of variance (ANOVA) with shape complexity as a within-subject factor, presence of context as a between-subjects factor, and subjects as a random variable was conducted on participants' shape choices. This analysis revealed no significant main effects of context, $F(1, 22) = 2.77$, $p > .10$, or shape complexity, $F(1, 22) = 1.79$, $p > .15$. The Context × Shape Complexity interaction also failed to reach significance, $F(1, 22) = 1.79$, $p > .15$. Despite the nonsignificant interaction, we nevertheless checked whether the simple-shaped stimuli presented in isolation elicited higher frequencies of shape choices than the other types of items. As we predicted, children selected the shape alternative on the simple-shapes/no-context trials on more occasions (70.83%) than on the complex-shapes/no-context trials (54.17%), $t(11) = 2.15$, one-tailed $p < .05$; the simple-shapes/context trials (45.83%), $t(22) = 1.78$, one-tailed $p < .05$; and the complex-shapes/context trials (45.83%), $t(22) = 2.05$, one-tailed $p < .05$. Note that the difference between children's performance on the simple-shapes versus the complex-shapes trials could not have been induced by different degrees of similarity between targets and shape alternatives for the two types of stimuli, as there was no significant difference between adults' similarity ratings of target/shape-alternative pairs for simple and complex objects ($M$ = 4.97 vs. $M$ = 5.17), $t(23) = 0.61$, $p > .50$.

We also performed a 2 × 2 mixed ANOVA with items, rather than subjects, as a random variable on the number of shape responses. The other variables included were shape complexity (a between-items factor) and context (within-item). In this analysis, the main effect of context was significant: The no-context items drew more shape responses (62.50%) than the context items (45.83%), $F(1, 6) = 48.00$, $p < .001$. The interaction between context and shape complexity was also significant, $F(1, 6) = 12.00$, $p < .05$. Consistent with our hypothesis, the simple-shaped objects elicited more shape responses than complex objects only when participants were presented with stand-alone objects; when the objects were in context, shape complexity did not affect the pattern of responses (see Figure 3). On the other hand, there was no main effect of shape complexity ($F < 1$). Finally, as predicted, of the four cells of the design, only simple-shapes/no-context (70.83%) was significantly different from chance (50%), $t(3) = 3.87$, $p < .05$.

At this point, we can ask whether children's responses were affected by the similarity of the backgrounds in the context condition. Recall that for four of the stimulus triads, the contexts of the target/taxonomic-alternative pairs were rated as more perceptually similar than the contexts of the respective target/shape-alternative pairs. An independent-samples $t$ test was performed on the number of shape responses elicited by the biased context triads versus the rest of the context items. If the difference in background similarities influenced participants' choices, then we should expect significantly fewer shape choices for the taxonomically biased stimulus triads. This was not the case, as the mean number of shape responses was exactly the same (45.83%) for both groups, $t(6) = 0.00$, $p = 1.00$.

In summary, the results of Experiment 1 argue that the shape bias is not a feature of young children's word learning, as previous results have suggested. The shape bias was seen only when children were presented with solitary, simple-shaped objects similar to the majority of stimuli used by Baldwin (1992) and Imai et al. (1994). If the objects to be labeled were either slightly more complex in shape or placed in context, children reverted to chance levels of responding to the shape alternative. However, taxonomic responding under these circumstances was also not different from chance. These results raise two important questions: First, why do children prefer the shape associates when they see stand-alone, simple-shaped objects? Second, why weren't children picking the taxonomic alternatives when shown objects in context or more complex shapes?

Although it is possible that children do indeed treat words as referring to same-shaped objects under very limited circumstances, there is an alternative explanation for their behavior: As we pointed out earlier, Experiment 1, as well as all of the previous shape-bias studies reviewed, used a forced-choice procedure. Children were asked to choose between a same-shape, out-of-category item and a different-shape, same-category item, where the category was at the *superordinate* level. Previous research suggests that preschoolers find it difficult to reason about superordinate categories (e.g., Horton & Markman, 1980), and so children might not realize that the taxonomic alternatives are indeed part of the same category as the target and hence nameable with the same word. If children are unable to find another object of the same kind among the items presented and also realize that mere perceptual similarity is not sufficient for word extension, they should be at a loss as to which response option to choose. According to this account, the shape bias obtained for the simple-shaped, out-of-context objects in Experiment 1 is simply a consequence of the fact that these stimuli exhibited the strongest demand characteristics (by unduly emphasizing the similarity between the target and the shape alternative). Of course, the same argument applies to the results of the other shape-bias experiments.

Experiment 2 is aimed at distinguishing between these two explanations for the shape bias obtained in the first experiment. The main modification made to the procedure of Experiment 1 was to add a none-of-the-above option (see Gelman, Croft, Fu, Clausner, & Gottfried, 1998) on every trial, thus allowing children to opt out of extending the frog-language label. If children believe that the new label picks out same-shape objects regardless of taxonomic category, this manipulation should have no impact on their choices relative to Experiment 1, especially in the simple-shapes/no-context blocks. In fact, children should just ignore the none-of-the-above option. If, however, their responses in Experiment 1 were driven by the demands of the forced-choice paradigm, the shape bias should disappear.

## Experiment 2

### *Method*

#### *Participants*

Twenty-four 3- to 5-year-old children ($M$ = 4 years 4 months; range = 3 years 4 months to 5 years 1 month) from a university-affiliated preschool participated in this study. Equal numbers of boys and girls were tested. Children came from predominantly middle- and upper-middle-class families. Ethnicity information was available for 67% of our participants. Of these children, 44% were Asian American, 38% were European American, 12% were African American, and 6% were Hispanic American.

#### *Materials*

The materials were identical to the ones used in Experiment 1, with two exceptions. A 15 cm × 15 cm blank piece of paper for the none-of-the-above option was added to each of the experimental and warm-up stimulus triads. The second change to the materials from Experiment 1 consisted in adding four warm-up triads of stimuli (two with context, two without). The additional warm-up trials were necessary in order to teach children to put their stickers on the none-of-the-above option if the object they were told to identify was not present in the pictures. As with the other warm-up sets, the new ones contained highly familiar, easily identifiable objects. The two no-context sets were sandwich/ice-cream/pen and phone/cat/mug. The two context sets contained other instances of these objects placed in familiar contexts.

#### *Procedure*

*Warm-up phase.* The instructions given to participants contained one additional piece of information relative to Experiment 1. After telling children that they would be helping Mr. Froggy find things in pictures and that they should put their stickers on the objects Mr. Froggy is looking for, the experimenter added that sometimes these objects might not be in the pictures. The children could signal this situation to the puppet by placing their stickers on the blank piece of paper that was presented with every stimulus set. There were four warm-up trials, two of which were identical to those in Experiment 1. On the other two, the object the experimenter asked for (by its English name) was not depicted in the stimuli. These trials were intended to serve as practice for using the none-of-the-above option. Before each warm-up trial, the experimenter reminded the participants that they could tell Mr. Froggy the object he is looking for is not in the pictures by selecting the none-of-the-above option. Children were 100% accurate on the two trials in which the sought object was present. In other words, when they knew what the answer was, they were not tempted to use the none-of-the-above option. In the object-absent trials, the children were almost as accurate (91.67%).

*Experimental trials.* In contrast with Experiment 1, children were allowed to select both the shape and the taxonomic alternatives on a given trial. Both alternatives received a score of 0.5 on all such trials. The rationale for allowing multiple selections follows from our attempt to make the task as constraint-free as possible: If children were allowed to choose neither of the objects presented to them (when they selected the none-of-above alternative), it seemed reasonable to allow them to select both. The same rationale prompted a rewording of the question used to elicit participants' responses. Whereas in Experiment 1 the experimenter asked, "Can you find another [novel word]?," in Experiment 2 this question was followed by, "Is there another [novel word] over here?" The reworded question was meant to convey that selection of the shape or taxonomic alternatives was not obligatory, as neither of them may be an adequate choice.

The order of the four warm-up trials was randomly determined for every child. The none-of-the-above choice was always placed in line with the shape and taxonomic alternatives, either to their left or to their right. The position of the none-of-the-above paper (left or right of the other two) was counterbalanced across subjects.

### *Results and Discussion*

Preliminary analyses revealed no significant main effects or interactions involving gender and age. These factors were therefore eliminated from subsequent analyses.

The main question addressed by Experiment 2 concerned the effect the introduction of a none-of-the-above option would have on participants' responses. Would the shape bias disappear even in the simple-shapes/no-context condition? For this experiment, the probability of selecting any one of the three response choices on a given trial is .33. The mean percentage of shape choices in the four cells ranged from 25.00% (complex-shapes/no-context) to 38.50% (complex-shapes/context); see Figure 4 for the other means. None of these means differed from chance (all $ps > .30$). Thus, as predicted, the introduction of a none-of-the-above alternative was effective in eliminating the shape bias across the board.

We sought further evidence of the absence of a shape bias by counting the number of children who displayed a preference for shape responses within these four cells. As in Experiment 1, participants were categorized as having a shape preference within a block of trials if they selected the shape alternative on all four trials. The binomial probability that children would randomly select four shape alternatives within a block is .012. Only 2 children displayed such a preference, and they were both in the simple-shapes/no-context condition. There were no significant differences between this condition and the simple-shapes/context and complex-shapes/context conditions ($ps > .47$, Fisher's exact test) or the complex-shapes/no-context condition ($p = .50$, McNemar test).

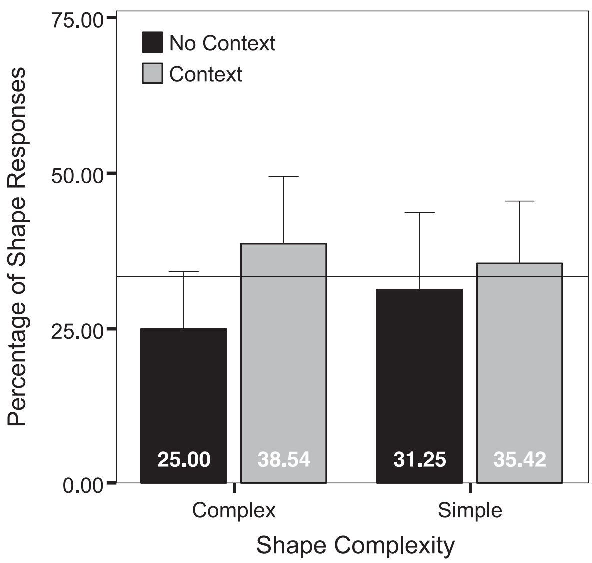


*Figure 4.* Mean percentage of shape responses in Experiment 2 as a function of the presence of context and shape complexity. Error bars represent standard error of the mean.

A 2 × 2 × 2 mixed ANOVA with shape complexity as a within-subject factor, presence of context and block order (simple first vs. complex first) as between-subjects factors, and subjects as a random variable was also performed on participants' shape choices. Only the main effect of block order approached significance, $F(1, 20) = 3.70$, $p < .10$. Participants who saw the simple-shape trials first selected shape associates more frequently (45.25%) than those who saw the complex-shape trials first (19.75%). It may be that children in the simple-first condition, when presented with four consecutive trials involving simple-shaped objects at the beginning of the experimental session, were more likely to arrive at the hypothesis that they were being taught shape terms and to carry over this hypothesis to the following four trials, thus selecting the shape alternatives on more occasions than they would have under other circumstances. In contrast, the children in the complex-first condition may have been more likely to form the hypothesis that neither the shape nor the taxonomic alternatives were adequate choices and thus select them on fewer instances during the following four trials. Two lines of evidence support this account.

First, when analyzing shape responses for the first block only, we found that participants selected more shape alternatives when the block was composed of simple-shaped objects (45.75%) than when it consisted of complex-shape trials (18.75%); the difference approached significance, $t(22) = 1.92$, $p < .10$. Note, however, that even for children in the simple-first condition there was *no* shape bias—the number of shape selections they made did not differ significantly from chance (33.33%), either for the first block, $t(11) = 1.14$, $p > .25$, or for all eight trials, $t(11) = 1.18$, $p > .25$.

Second, when analyzing the none-of-the-above responses for the first block, we found that participants selected significantly more none-of-the-above alternatives when the block contained complex-shaped items (77.00%) than when it consisted of trials involving simple objects (39.50%), $t(22) = 2.15$, $p < .05$. Thus, it is possible that participants in the complex-first condition, but not the others, used these first few trials to derive a rule (e.g., "There never is another [novel word], so I should always put my sticker on the blank piece of paper"), which led them to select overall more none-of-the-above alternatives and fewer shape and taxonomic alternatives. Children in the complex-first condition did indeed make more none-of-the-above selections overall (collapsing across the two blocks) than children in the simple-first condition (76.00% vs. 38.50%), as shown by a significant effect of block order in a 2 × 2 × 2 mixed ANOVA with shape complexity, context, and block order as variables, $F(1, 20) = 4.62$, $p < .05$. No other significant main effects or interactions were uncovered by this ANOVA.

This result is consistent with studies that suggest that 3- and 4-year-olds have trouble inhibiting prepotent responses and thus tend to perform poorly in tasks that require switching strategies or rules (e.g., Diamond, Kirkham, & Amso, 2002; Munakata & Yerys, 2001; Zelazo, Frye, & Rapus, 1996). More generally, we suggest that perseveration also played a role in the earlier demonstrations of the shape bias. Repeated trials of the same kind, administered with identical instructions and involving very similar types of stimuli, may have induced children to form a sort of problem-solving set (e.g., Luchins & Luchins, 1950) early in the task. Once they figured out a strategy, children probably used it throughout the experiment, especially considering that they were not given any feedback that their responses were incorrect.

To test for generalizability of our results over items, we conducted a 2 × 2 × 2 mixed ANOVA with items, rather than subjects, as a random variable on the shape response data. The factors included were shape complexity (between-items), presence of context, and block order (both within-item). This analysis replicated the significant main effect of block order, $F(1, 6) = 36.93$, $p < .005$. In addition, block order interacted significantly with the context variable, $F(1, 6) = 80.52$, $p < .001$. When the simple-shape items were presented first, adding context increased the number of times shape alternatives were selected from 31.25% to 59.37%; however, when complex-shape trials were administered first, adding context actually decreased the number of shape responses from 25.00% to 14.58%. The number of shape choices when the stimuli were in context and simple-shaped items were presented first (59.37%) was above chance (33.33%), $t(7) = 4.20$, $p < .01$. This preference for shape, as well as the Block Order × Context interaction in the ANOVA by items, was not predicted and cannot easily be explained, either from our theoretical framework or from the viewpoint of the shape bias. Also, note that the interaction was not significant in the ANOVA with subjects as a random variable. Nevertheless, to follow up, we analyzed the responses of the 6 children in the context condition who saw the simple shapes first. On average, these children chose the shape alternative on marginally more trials than expected by chance (59.37% vs. 33.33%), $t(5) = 2.13$, $p < .10$.

Did the differences in background similarity revealed by adult raters affect the pattern of responses? If these differences were to influence responding, we would expect a lower number of shape responses to the four stimulus sets for which the taxonomic alternative was favored by being presented on a background more similar to that of the target than the background of the shape alternative was. Once again, the discrepancy in background similarity ratings between the two groups of stimulus sets had no noticeable impact on the data: The two groups did not differ in terms of either shape selections, $t(6) = 0.58$, $p > .50$, or taxonomic selections, $t(6) = 0.16$, $p > .80$.

To summarize, the introduction of a none-of-the-above alternative in Experiment 2 diminished the number of shape choices even for the simple, stand-alone objects that had induced a shape bias in Experiment 1. In fact, the none-of-the-above option virtually eliminated the shape bias altogether. The only exception was the trend toward a shape bias revealed by the 6 children who saw items in context and were administered the simple-shape trials first. The findings from Experiment 2 are not consistent with the hypothesis that children's word extensions rely solely on shape information. If children treat words as referring to things of the same shape, then adding a none-of-the-above option should not have decreased the number of shape responses, especially not for simple shapes presented in isolation. The results of Experiment 2 support the hypothesis that the bias for stand-alone, simple shapes obtained in Experiment 1 and other similar studies was a result of the confluence of several task and stimulus characteristics, among which the forced-choice aspect was preeminent.

Although these first two experiments provide compelling evidence that children do not have a shape bias in their word extension, they leave open the question of what kinds of information children do pay attention to when learning new words. Following Markman and Hutchinson (1984), we propose that children map words onto *kinds* of objects that have more in common than just shape (see also, e.g., Gelman, 2003; Gelman & Bloom, 2000). We suggest that the taxonomic bias was not evident in the shape-bias studies and the two experiments described here because of the nature of the categories involved: If children cannot generate the relevant superordinate categorical relations—if, for example, they do not realize that an apple and a banana are both kinds of fruit—then they will not be able to apply the strategy of extending new words to objects belonging to a common category. Experiment 3 tests the straightforward prediction that children will respond taxonomically in the presence of a basic-level alternative, even when this alternative is less similar in shape to the labeled target than an out-of-category shape distractor.

## Experiment 3

### Method

#### Participants

Twenty-four 3- to 5-year-old children ($M$ = 4 years 7 months; range = 3 years 5 months to 5 years 4 months) from a university-affiliated preschool participated in this study. Ten of the children were boys, and 14 were girls. Children came from predominantly middle- and upper-middle-class families. Ethnicity information was available for 67% of our participants. Of these children, 63% were European American, 31% were Asian American, and 6% were Hispanic American.

#### Design

The only independent variable included was shape complexity (simple vs. complex; within-subject). Using only the no-context stimuli allowed a conservative test of our hypothesis, as adding context is likely to reduce the number of shape responses. As in Experiment 1, participants were provided with only two answer options: a shape and a taxonomic alternative.

#### Materials

*Experimental stimuli.* Eight sets of color pictures depicting familiar, stand-alone objects were used in this study. Each set consisted of a target, a shape alternative, and a *basic-level* taxonomic alternative. The constraint that the basic-level alternatives be dissimilar in shape to the targets required us to replace most of the stimulus triads used in Experiments 1 and 2: These target objects belonged to basic-level categories that were not heterogeneous enough in shape to allow us to just replace the dissimilar superordinate alternatives with dissimilar basic ones. To take one example, there is not enough shape variability within the basic-level category *apple* to enable us to come up with two exemplars (the target and the taxonomic alternative) that would be judged as dissimilar in shape. In contrast, categories such as *clock* or *shoe* satisfy this constraint and were included in the new set of stimuli. All stimulus triads are shown in the three leftmost columns in Figure 5.

As in the first two experiments, half of the sets consisted of objects with very simple shapes, and the other half consisted of slightly more complex-shaped objects. Each child was tested on both simple- and complex-shaped objects.

Sixteen undergraduate and graduate students rated the stimuli on a scale from 1 to 7. We first tested whether the basic-level taxonomic alternatives were less similar in shape to the targets than the shape alternatives were. Overall, the raters judged the targets to be more similar to the shape alternatives ($M$ = 5.46, $SD$ = 0.54) than to the basic-level category alternatives ($M$ = 2.30, $SD$ = 0.72), paired $t(15) = 19.85$, $p < .001$. This pattern was replicated for each of the individual stimulus triads when these data were analyzed separately (all $p$s $< .05$). Second, the objects we included in the simple stimulus triads were indeed rated to be simpler in shape ($M$ = 2.47, $SD$ = 0.47) than the objects in the complex triads ($M$ = 4.90, $SD$ = 0.59), paired $t(15) = 21.52$, $p < .001$.

*Warm-up stimuli.* We used the two no-context warm-up sets from Experiment 1. All children chose the correct objects on both warm-up trials.

#### Procedure

The procedure was identical to that used in Experiment 1.

### Results and Discussion

Preliminary analyses revealed no significant main effects or interactions involving gender, age, or order of shape complexity blocks. These factors were therefore eliminated from subsequent analyses.

Our main prediction was that children would extend a novel word to a basic-level category alternative even in the presence of an object that is more similar in shape to the labeled target. This prediction was borne out by one-sample $t$ tests against chance (50%): Children selected the taxonomic alternatives more often than expected by chance both for the simple-shaped object trials ($M$ = 71.88%), $t(23) = 3.31$, $p < .005$, and for the complex-shaped object trials ($M$ = 71.88%), $t(23) = 3.49$, $p < .005$. Conversely, and in contrast to Experiment 1, shape responding was below chance ($M$ = 28.12%) for both blocks. See Table 1 for the overall pattern of results.

Individual children's response patterns paralleled these results. In this analysis we counted the number of children who made the same choice, be it shape or taxonomic, for all four trials within a block. The binomial probability of either of these series of responses is .062. There were significantly more children who preferred the taxonomic responses than children who preferred the shape responses both in the block involving simple shapes (11 vs.

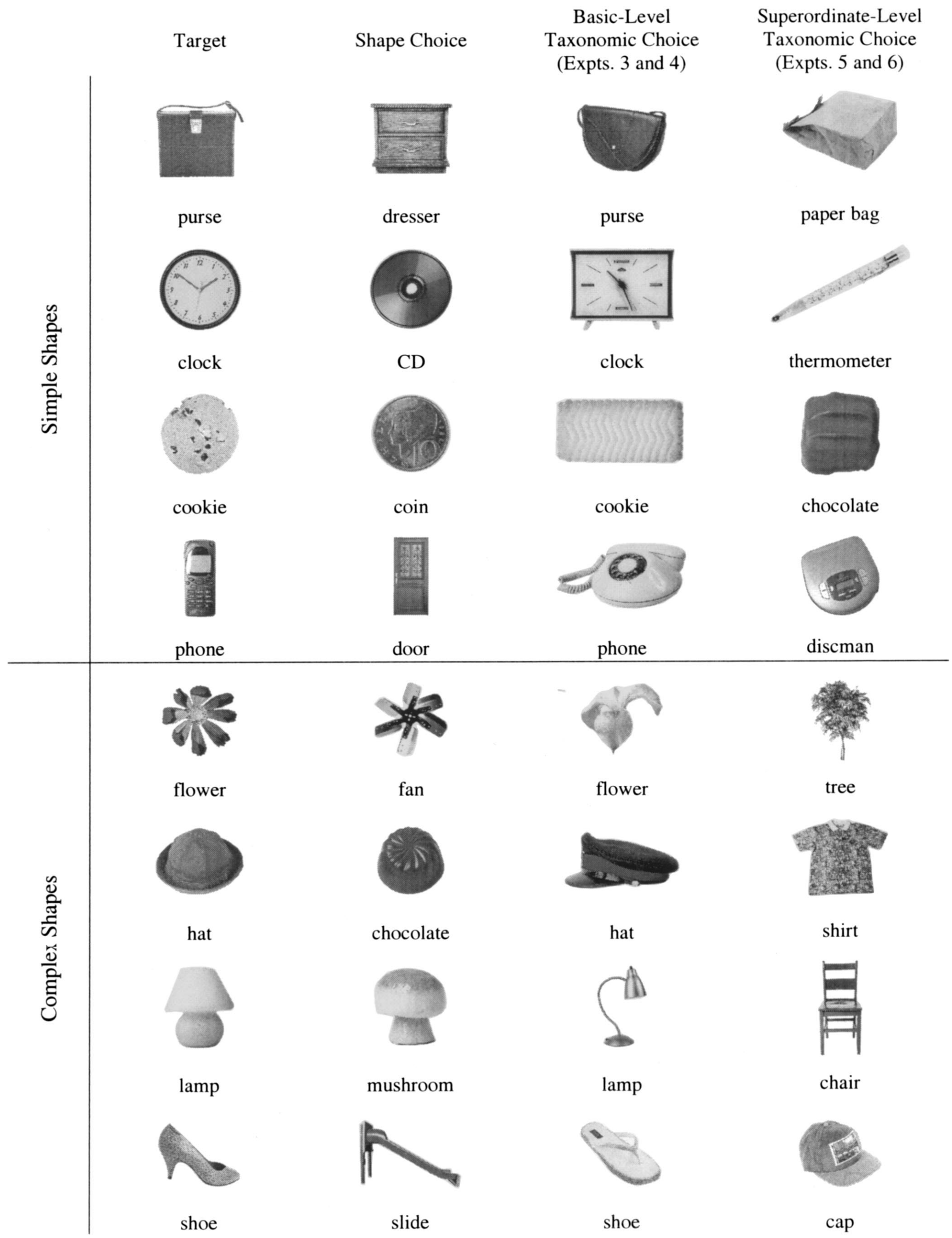


*Figure 5.* Stimuli used in Experiments (Expts.) 3–6.

2), $\chi^2(1, N = 13) = 6.23$, $p < .015$, and in the block with complex shapes (11 vs. 0), $\chi^2(1, N = 11) = 11.00$, $p < .001$.

A repeated measures ANOVA with shape complexity as a factor and subjects as a random variable was conducted on children's shape choices. The main effect of shape complexity was not significant, $F(1, 23) < 1$; the percentage of shape choices was identical for the two blocks (28.12%). This differs from the findings of Experiment 1, where children selected the shape alternative more frequently for the simple-shaped, stand-alone objects (71%) than for the complex-shaped ones (54%). Recall, however, that we argued shape complexity would influence children's behavior when they are forced to choose one of the response options in a situation where they find *neither* to be appropriate. When children cannot identify another referent for the novel label, they are more likely to be swayed by task demands such as the salience of the shape similarity between two of the stimuli (which we claimed was diminished for complex objects). In contrast, whether the shapes of the objects are simple or slightly more complex should matter a lot less when an easily accessible category referent (the basic-level alternative) is included as a response option.

Table 1
*Mean Percentage of Shape, Taxonomic, and None-of-the-Above Responses in Experiments 3–6*

| | Shape | | Taxonomic | | None of the above | |
|---|---|---|---|---|---|---|
| Experiment | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| 3 (basic) | 28.13† | 29.77 | 71.88** | 29.77 | | |
| 4 (basic) | 18.75† | 19.94 | 48.96* | 33.31 | 32.29 | 39.17 |
| 5 (superordinate) | 73.96** | 26.81 | 26.04† | 26.81 | | |
| 6 (superordinate) | 26.56 | 27.41 | 14.58† | 18.67 | 58.85** | 39.95 |

* $p < .05$ above chance. ** $p < .01$ above chance. † $p < .01$ below chance.

To sum up, Experiment 3 strengthens the conclusion that children's word learning is not guided by a shape bias and, in addition, supports the hypothesis that from early on, children believe object labels refer to kinds. Children seek objects of the same kind as the one to which the first instance of the label is applied, but they may not succeed in their search if the kinds involved are as heterogeneous as superordinate categories tend to be. In Experiment 3 we have shown that simplifying the categorical relations that unite the targets and their taxonomic alternatives is accompanied by a substantial increase in the number of categorical choices. More specifically, children chose the taxonomic alternatives more often than expected by chance regardless of whether the shapes of the objects were simple or complex.

A stronger test of the hypothesis that children's word extension is guided by kind membership would consist in adding a none-of-the-above alternative to the response options provided to children in Experiment 3. Recall that in Experiment 2, the introduction of a none-of-the-above option caused shape responding to drop to chance in all conditions, which suggested that children's initial preference for shape alternatives when presented with simple objects in isolation was a task artifact. We predicted that children's selection of the basic-level category alternatives as referents for frog-language labels would be robust enough to withstand the possibility of opting out of extending the label to either of the alternatives.

## Experiment 4

### Method

#### Participants

Twenty-four 3- to 5-year-old children ($M = 4$ years; range = 2 years 9 months to 5 years 3 months) from a university-affiliated preschool participated in this study. Equal numbers of boys and girls were tested. Children came from predominantly middle- and upper-middle-class families. Ethnicity information was available for 88% of our participants. Of these children, 43% were European American, 28% were Asian American, 19% were Hispanic American, 5% were African American, and 5% were Native American.

#### Materials and Procedure

*Warm-up phase.* The warm-up consisted of five trials. The last four were identical to those in the no-context condition of Experiment 2: On two of them, children could find the object the puppet was looking for, and on the other two they could not and had to place their stickers on the white piece of paper. To ensure that children understood thoroughly the function of the none-of-the-above option, we added an extra trial at the very beginning of the session. On this trial, children were asked for *two* things—one that was present and one that was not. Any confusion with regard to the role of the blank piece of paper was cleared before going on to the other four warm-up trials. The stimuli for this additional warm-up trial were a car, a baby bottle, and a butterfly; the experimenter asked the children first to find a butterfly and then to find a fork. Children performed extremely well on the warm-up trials.

*Experimental trials.* A none-of-the-above option was added to the eight stimulus sets from Experiment 3 (with the basic-level taxonomic alternatives). The procedure, however, was identical to that of Experiment 2, where children also had a none-of-the-above option.

### Results and Discussion

Preliminary analyses revealed no significant main effects or interactions involving gender, age, or block order.[1] These factors were therefore eliminated from subsequent analyses.

As predicted, the overall number of taxonomic responses ($M = 48.96\%$) was above chance (33%) even when children had a none-of-the-above option, $t(23) = 2.29$, $p < .05$; see Table 1. Children preferred the basic-level taxonomic alternatives both for simple-shaped ($M = 48.44\%$), $t(23) = 2.23$, $p < .05$, and complex-shaped ($M = 49.48\%$), $t(23) = 2.22$, $p < .05$, objects. In contrast, children made fewer shape responses than would be expected by chance ($M = 18.75\%$), $t(23) = 3.59$, $p < .005$.

Children's preference for the category choices was also reflected in their individual response patterns. Preference for a certain response was defined as making six or more choices of one type across the eight trials of the task. The binomial probability of such a series of responses is .016. As anticipated, there were more children who consistently chose the taxonomic alternatives than children with a preference for shape similarity (8 vs. 0), $\chi^2(1, N = 8) = 8.00$, $p < .005$.

Three repeated measures ANOVAs with shape complexity as a factor and subjects as a random variable were performed on

[1] The only exception was a significant Age Group (younger than 47.5 months vs. older than 47.5 months) × Gender interaction in an ANOVA on children's taxonomic responding. For the younger group, girls had more taxonomic responses than boys (66% vs. 35%), whereas the situation was reversed for the older group (28% for girls vs. 54% for boys).

children's shape, taxonomic, and none-of-the-above responses. Shape complexity did not produce a main effect in any of these analyses, nor did it result in a main effect when items rather than subjects was treated as a random variable (all *p*s $> .10$).

In summary, children's above-chance taxonomic responding in Experiment 4 suggests that their preference stems from their beliefs about what words mean: They persisted in applying the novel labels to objects of the same kind even when they had the option of refusing to extend them. This result also enables us to rule out an alternative explanation for children's chance shape responding in Experiment 2. We argued that the reduction in the number of shape choices relative to Experiment 1 was driven by children's assumptions about object names. Upon hearing each new label, they tried to find an object of the same category as the one labeled; they were unable to do so, so they refused to extend the frog-language name. However, one might argue that the none-of-the-above choice is just too attractive an option. When confronted with a task as challenging as learning words in a foreign language, children will always be more likely to select the safer response and put their sticker on the blank piece of paper. According to this explanation, children in Experiment 2 might still have a shape bias but are unable to show it in their behavior because the none-of-the-above option is too distracting. Taken together, the results of Experiments 3 and 4 do not support this alternative hypothesis. The none-of-the-above option was present in Experiment 4, and yet children were reasonably successful at choosing the same-category alternatives.

We should note, however, that the number of taxonomic responses in this experiment (48.96%) was lower than the corresponding figure for Experiment 3 (71.88%), where children did not have a none-of-the-above alternative. Although there was a reduction in the number of taxonomic responses—probably a consequence of the inherent appeal of an option as "safe" as the none-of-the-above—children still chose the same-category items more often than expected by chance. What's more, the none-of-the-above option had a greater impact on children's preference for shape: Whereas 8 out of 24 children still preferred the taxonomic items after the introduction of the none-of-the-above alternative (Experiment 4), *none* of the 12 children in the simple-shapes/no-context condition, where we had previously found a shape bias, displayed a shape preference when given the none-of-the-above choice (Experiment 2), $\chi^2(1, N = 36) = 5.14$, $p < .05$.

Experiments 5 and 6 were designed to address another potential concern. The shift to basic-level category alternatives in Experiments 3 and 4 required us to replace most of the stimulus sets used in the first two experiments. One could argue that comparing results across experiments whose stimuli were so different is problematic. To facilitate this comparison and also test the generalizability of our results, we substituted superordinate-level alternatives for the basic-level ones in Experiments 3 and 4. In Experiment 5 we again used a forced-choice paradigm and tested the prediction that in the absence of a category alternative they can identify, children will revert to responding on the basis of the demand characteristics of the task. The number of shape choices, however, should fall to chance levels if children are given a none-of-the-above option (Experiment 6).

## Experiment 5

### Method

#### Participants

Twenty-four 3- to 5-year-old children (*M* = 4 years 1 month; range = 3 years 1 month to 5 years 1 month) from a university-affiliated preschool participated in this study. Equal numbers of boys and girls were tested. Children came from predominantly middle- and upper-middle-class families. Ethnicity information was available for 92% of our participants. Of these children, 50% were European American, 32% were Asian American, 14% were Hispanic American, and 4% were African American.

#### Materials and Procedure

The basic-level taxonomic alternative in each of the stimulus sets used for Experiments 3 and 4 was replaced with a superordinate-level alternative (see the rightmost column in Figure 5). Sixteen undergraduate students rated the stimuli on a scale from 1 to 7. Overall, the raters judged the similarity between the targets and shape alternatives ($M = 5.35$, $SD = 1.13$) to be greater than that between the targets and taxonomic alternatives ($M = 2.06$, $SD = 0.56$), paired $t(15) = 10.47$, $p < .001$. This pattern held up for each of the stimulus triads (all *p*s $< .005$, with the exception of the hat/chocolate/shirt set, for which $p = .20$). Second, the raters validated our grouping of the objects with respect to shape complexity by judging the simple triads ($M = 2.81$, $SD = 1.08$) to be indeed simpler in shape than the complex triads ($M = 4.41$, $SD = 0.75$), paired $t(15) = 6.70$, $p < .001$. The procedure was identical to that of Experiments 1 and 3.

### Results and Discussion

Preliminary analyses revealed no significant main effects or interactions involving gender, age, or order of shape complexity blocks.[2] These factors were therefore eliminated from subsequent analyses.

We predicted that children would consistently choose the shape alternatives because (a) they are required to select one of the options; (b) they cannot find an object of the same category as the target; and (c) the shape similarity between the target and the shape distractor is very salient and becomes children's only clue as to what the correct answer should be. Children did indeed make more shape responses than would be expected by chance (73.96% vs. 50%), $t(23) = 7.44$, $p < .001$; see Table 1. Children selected a preponderance of shape alternatives both for the simple-shaped object trials ($M = 71.88\%$), $t(23) = 6.17$, $p < .001$, and for the complex-shaped object trials ($M = 76.04\%$), $t(23) = 7.47$, $p < .001$. Correspondingly, taxonomic responding was below chance for both types of trials.

An analysis of individual response patterns confirmed these results. Recall that a child was categorized as having a response preference if she chose the same option on all four trials within a block. There were significantly more children who preferred the

[2] The only exception was a significant Age Group (younger than 50 months vs. older than 50 months) × Block Order (simple first vs. complex first) interaction in an ANOVA on children's shape responding. (The interaction would also come out significant if the analysis was performed on children's taxonomic responses.) For the younger group, complex-first children had more shape responses than simple-first children (83% vs. 48%), whereas the situation was reversed for the older children (73% vs. 86%).

shape responses than children who preferred the taxonomic responses both in the block involving simple shapes (10 vs. 1), $\chi^2(1, N = 11) = 7.36$, $p < .01$, and in the block with complex shapes (12 vs. 0), $\chi^2(1, N = 12) = 12.00$, $p < .001$.

To make a direct comparison between this experiment and Experiment 3 (with basic-level choices), we ran a 2 × 2 mixed ANOVA with type of response (shape vs. taxonomic) as a within-subject variable, level of the taxonomic alternative (basic in Experiment 3 vs. superordinate in Experiment 5) as a between-subjects variable, and subjects as a random variable. The predicted interaction between type of response and level of the taxonomic alternative was highly significant, $F(1, 46) = 31.40$, $p < .001$. When children were provided with basic-level taxonomic alternatives, they preferred the taxonomic over the shape alternatives (71.88% vs. 28.12%); however, when the basic-level options were replaced with ones at the superordinate level, shape responding was favored by a wide margin (73.96% vs. 26.04%).

A repeated measures ANOVA with shape complexity as a factor and subjects as a random variable revealed no main effect of complexity on the shape choices of children in this experiment, $F(1, 23) < 1$. This result also held up when items rather than subjects was treated as a random variable, $F(1, 6) < 1$. The fragility of the effect of shape complexity, which was present in Experiment 1 but absent in the rest of the experiments, can best be explained by taking a closer look at our stimuli. As we mentioned before, our "complex" objects are really not very complex in shape—at best, they may be slightly less simple than the stimuli we have defined as simple shaped. Confirming this impression, the adults' average rating of our complex items was very close to the midpoint of the scale and only about two points higher than their rating of the simple items. We believe this feature of our stimuli is caused by a real constraint in the way object categories are structured: The more complex the shape of an object, the less likely we are to find another object that has an identical shape but belongs to a different category. Therefore, we could not use truly complex objects and had to restrict ourselves to items we could find out-of-category shape matches for. Such a weak manipulation has less power to detect differences in children's behavior and is more vulnerable to changes in stimulus configuration and experimental procedures.

In Experiment 6, children were again allowed to select a none-of-the-above option. We predicted that this change would cause a considerable reduction in the number of shape choices relative to Experiment 5.

## Experiment 6

### Method

#### Participants

Twenty-four 3- to 5-year-old children ($M$ = 4 years 3 months; range = 2 years 11 months to 5 years 0 months) from a university-affiliated preschool participated in this study. Equal numbers of boys and girls were tested. Children came from predominantly middle- and upper-middle-class families. Ethnicity information was available for 83% of our participants. Of these children, 55% were European American, 20% were Asian American, 20% were Hispanic American, and 5% were African American.

#### Materials and Procedure

The procedure was identical to that of Experiment 4, which also included a none-of-the-above alternative. The stimuli were those used in Experiment 5 (with superordinate-level category alternatives), except that a blank piece of paper standing for the none-of-the-above option was added to each stimulus set.

### Results and Discussion

Preliminary analyses revealed no significant main effects or interactions involving gender, age, or block order. These factors were therefore eliminated from subsequent analyses.

The main prediction tested in Experiment 6 was that shape responses would not occur more often than chance (33%), either overall or within the simple and complex blocks separately. The total number of shape responses children made (26.56%) did not differ from chance, $t(23) = 1.20$, $p > .20$, and neither did the number of shape responses within the complex block ($M$ = 37.50%), $t(23) = 0.53$, $p > .50$. Children chose the shape alternatives on *fewer* occasions than would be expected by chance in the simple block ($M$ = 15.63%), $t(23) = 3.15$, $p < .005$. See Table 1 for the overall pattern of results.

The same pattern of results was evident in individual children's responses. For the purposes of this analysis, a child was defined to have a response preference if she chose the same type of response alternative on six or more of the eight trials in the task. Only 2 out of 24 children in this experiment showed a preference for the shape alternatives; in contrast, 11 children preferred the none-of-the-above option, $\chi^2(1, N = 13) = 6.23$, $p < .015$. The number of children who preferred the shape alternatives in this experiment is also lower than the number of children who preferred the taxonomic alternatives in Experiment 4, in which they were provided with a basic-level category choice (2 vs. 7), $\chi^2(1, N = 9) = 2.78$, $p = .09$.

A full comparison between this experiment and Experiment 4 was carried out in a mixed 3 × 2 ANOVA with type of response (shape vs. taxonomic vs. none-of-the-above) as a within-subject factor, level of the taxonomic alternative (basic in Experiment 4 vs. superordinate in Experiment 6) as a between-subjects factor, and subjects as a random variable. The Type of Response × Level of the Taxonomic Option interaction was again highly significant, $F(2, 92) = 8.15$, $p = .001$. When basic-level category alternatives were available, participants chose them on 48.96% of the trials; however, when the taxonomic alternatives belonged to the same superordinate category as the target, they were chosen on only 14.58% of the trials. This trend was reversed for shape and none-of-the-above choices, which became more frequent when the basic-level alternatives were replaced (18.75% vs. 26.56% for shape responses, 32.29% vs. 58.85% for none-of-the-above responses). The ANOVA also uncovered a main effect of type of response, $F(2, 92) = 4.46$, $p < .05$. Across the two experiments, children chose the none-of-the-above option more frequently than the shape option (45.57% vs. 22.66%), paired $t(47) = 2.66$, $p < .05$. The overall number of taxonomic responses (31.25%) did not differ from the other two measures ($ps > .10$).

A repeated measures ANOVA with shape complexity as a factor and subjects as a random variable revealed a main effect of complexity on the shape choices of children in this experiment, $F(1, 23) = 7.46$, $p < .05$. Surprisingly, there were more shape selections in the complex block than in the simple block (37.50% vs. 15.63%). This result was also replicated in an ANOVA with items as a random factor and complexity as a between-items variable, $F(1, 6) = 37.80$, $p = .001$. However, as pointed out before, the number of shape selections did not exceed chance levels in either block and was much lower than the corresponding number in Experiment 5, in which children were forced to make a choice.

## General Discussion

Six experiments investigated preschoolers' putative shape bias in learning novel words. Experiment 1 manipulated shape complexity and the presence of context and demonstrated that children reveal a shape bias only when the shapes of the objects are simple and when the objects are presented in isolation. More generally, the results of Experiment 1 cast doubt on the very existence of a shape bias in children's word learning. Given that the shape bias is supposed to be a fundamental bootstrapping mechanism—as Imai et al. (1994) claimed, the "early focus on perceptual similarity may help young children learn categories, gradually bootstrapping them to a sense of taxonomic relations that goes beyond perceptual similarity" (p. 45)—it cannot be limited to solitary, simple-shaped objects such as circles or rectangles in isolation. Children rarely see objects whose names they are learning in complete isolation, and only a relatively small proportion of objects whose names they know have shapes as simple as the ones we used in our replication of the shape-bias studies.

The effect of shape complexity, however, was more fragile than anticipated: We were unable to replicate the increase in shape responding for the simple shapes in any of our subsequent experiments. The difficulties encountered in creating our stimulus sets—especially in finding out-of-category shape alternatives for truly complex objects, which led us to use fairly simple shapes for our "complex" sets—are probably responsible for this inconsistent result. Recall that according to our initial account, the simple shapes should have boosted the number of shape-based choices in two complementary ways: by making the similarity of shape stand out and by inducing children to believe they were learning puppet-language names for different shapes. The latter is still plausible, as the shapes of our simple objects (e.g., circle, square) are more nameable than those of our complex objects. On the other hand, given the relative lack of differentiation between our simple and complex objects, the salience of shape similarity was probably equivalent for the two types of items, hence the failure to find an effect of shape complexity in many of our experiments.

Experiment 2, in which a none-of-the-above option was added, further suggests that children's preference for the shape alternatives is not the result of a word-learning principle but rather a consequence of children's being forced to choose one of the alternatives. When children were allowed to decline extending the novel label to either the shape or the taxonomic alternative, the shape bias virtually disappeared.

Although Experiments 1 and 2 discredited the idea of a shape bias in preschoolers' word learning, they did not provide any positive evidence for one of the main hypotheses motivating our research: that from very early on, children's word learning is guided by the assumption that labels refer to kinds of things. Recall that in these two experiments, as well as in Experiments 5 and 6, children selected the superordinate taxonomic alternatives on relatively few occasions. In Experiment 3, however, children preferred the dissimilar *basic-level* taxonomic alternatives to the out-of-category, same-shaped alternatives, thus suggesting that their earlier failure to display a taxonomic bias was in part caused by the use of superordinate categorical relations. Unlike their preference for shape in Experiment 1, children's taxonomic preference in Experiment 3 withstood the introduction of a none-of-the-above alternative (Experiment 4). Even when allowed to select neither the shape nor the taxonomic option, children chose the dissimilar, same-category items more frequently than expected by chance. Experiment 5 further emphasized the role of category level in determining children's responses. Simply replacing the basic-level alternatives with superordinate-level ones produced a complete reversal in children's choices: They now selected the shape alternatives on a majority of trials. Nevertheless, this preference was eliminated in Experiment 6 (much like in Experiment 2) by giving children a none-of-the-above option.

The results of the six experiments reported here make it clear that children do not use words to refer to same-shape objects that cross natural category boundaries. Putting together findings across several different studies, we believe that a simple, coherent picture emerges: In the earlier shape-bias studies (Baldwin, 1992; Golinkoff et al., 1995; Imai et al., 1994), hearing a label caused children to shift away from thematic relations, as Markman and Hutchinson (1984) demonstrated. We argue that this shift suggests that children seek objects of the same kind as the one originally labeled. On their own, however, young children are not always capable of identifying the relevant categories. In particular, superordinate categories are more difficult to grasp for preschoolers than Markman and Hutchinson supposed. Thus, children may seek objects of the same kind but will generalize an object label only when they find an appropriate candidate. Without any other kind of support (such as adult input, for instance), preschoolers are likely to need perceptual similarity in order to identify different members of a kind, and therefore, on their own, they will not consider objects that are too dissimilar to the target as appropriate referents for the novel label. However—and this is key—children will also fail to generalize the term to objects that, though perceptually similar to the target, cross natural category boundaries. They will not, for example, call a carrot and a nail by the same name, despite their perceptual similarity.

On the other hand, children should be able to generalize labels to dissimilar same-category items if the taxonomic relations are easier to grasp—for example, if the targets and the taxonomic alternatives are members of the same basic kinds. In support of this prediction, children showed a taxonomic bias both in Experiment 3 and in Experiment 4, in which they also had a none-of-the-above option. This result replicates and extends that of Golinkoff et al. (1995, Experiment 6), who showed that 4-year-olds succeed in a typical word-extension task when presented with basic-level taxonomic alternatives whose similarity to the target was *matched,* on average, by the shape alternatives' similarity to the target. When perceptual similarity was controlled for, children selected the taxonomic alternatives on a large majority of cases (91.1%). In an unpublished dissertation, Shuff-Bailey (1995) performed a stronger test of this hypothesis by pitting basic-level taxonomic membership against perceptual similarity (similar to our Experiment 3). She showed that 34-month-olds preferred to extend novel labels to the taxonomic alternatives, even though these were significantly less similar to the target than the shape alternatives were.

To clarify, we are not arguing that shape similarity plays no role in the acquisition of object labels. As has been often suggested (e.g., Diesendruck & Bloom, 2003; Rosch et al., 1976), perceptual similarity is often an excellent cue to category membership. In fact, on their own, young children may require substantial perceptual support to recognize objects of the same kind. Shape similarity in particular may be needed for children to independently identify members of a kind. That does not mean, however, that children start learning a language with the expectation that shape similarity alone fixes the extension of words, independent of any information about the named objects' taxonomic categories. In other words, we are claiming not that shape similarity does not matter but rather that it is neither *necessary* nor *sufficient* for word learning. Shape similarity is not necessary for word learning because children give the same name to things that have very different shapes (say, a round clock and a square clock, or a round cookie and a square cookie). Shape similarity is not sufficient because children are not invariably guided by commonality of shape in their word extension—they do not call a coin by the same name as a cookie just because they are both round. Contrary to our view, Imai et al. (1994) maintained that "perceptual similarity—in particular, shape similarity—is an important determinant of young children's word extension" and that "nonobvious but causally deep properties" are not (p. 66). The experiments reported here undermine this conclusion by demonstrating that the results on which it was based do not reflect processes involved in word learning and extension.

Furthermore, young children are indeed capable of extending words on the basis of nonperceptual properties, if these properties are made salient. Shared nonobvious properties (functions, causal powers, intent of the creator, etc.) can be reliable indicators of kind membership, and thus, under the right circumstances, children may make use of them in identifying potential referents for new labels. For example, Gopnik and Sobel (2000) tested whether children could attend to the causal properties of objects in extending words. Children were shown a series of blocks that either did or did not set off a machine that lit up and played music. After placing all of the blocks on the machine (sequentially), the experimenter labeled one of them with a novel word (*blicket*) and asked the children to select another *blicket*. Children were at least as likely to choose the objects that shared the property of setting off the machine as they were to choose objects similar perceptually, even when perceptual similarity conflicted with the shared causal property.

In addition, Kemler Nelson et al. (2000) provided evidence that children as young as 2 years of age extend the name of an unfamiliar artifact with a salient function to other artifacts that share the function, regardless of perceptual similarity. Children were presented with a target artifact that had a distinctive function and was labeled with a novel noun. When tested with items that varied in functional and overall perceptual similarity to the target, children were more likely to extend the previously heard label to an object that had the same function as the target, even when controlling for perceptual similarity between the two. Therefore, function seems to be another nonobvious property that children consider relevant to how an object is named and that they use to guide their naming under favorable circumstances.

Finally, the studies investigating children's inductive projections strengthen the claim that, from an early age, children expect novel labels to map onto kinds. Young children are able to use category labels as signaling category membership even for relatively dissimilar objects (Gelman & Coley, 1990; Gelman & Markman, 1986, 1987; Jaswal, 2003; Jaswal & Markman, 2002; Welder & Graham, 2001). By being open to the information conveyed in the labels, children are able to go beyond the categories they generate spontaneously and thus take advantage of the accumulated knowledge of their culture (see the arguments made by Gelman, 2003; Gentner & Boroditsky, 2001; Jaswal & Markman, 2002; Mervis, 1987; Waxman & Markow, 1995). Children's willingness to incorporate dissimilar objects into the same kind reveals that their categories are not defined by perceptual similarity. From very early on, then, children expect that words map onto kinds whose members share more than appearances.

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Received July 10, 2003
Revision received December 15, 2004
Accepted January 10, 2005 ■