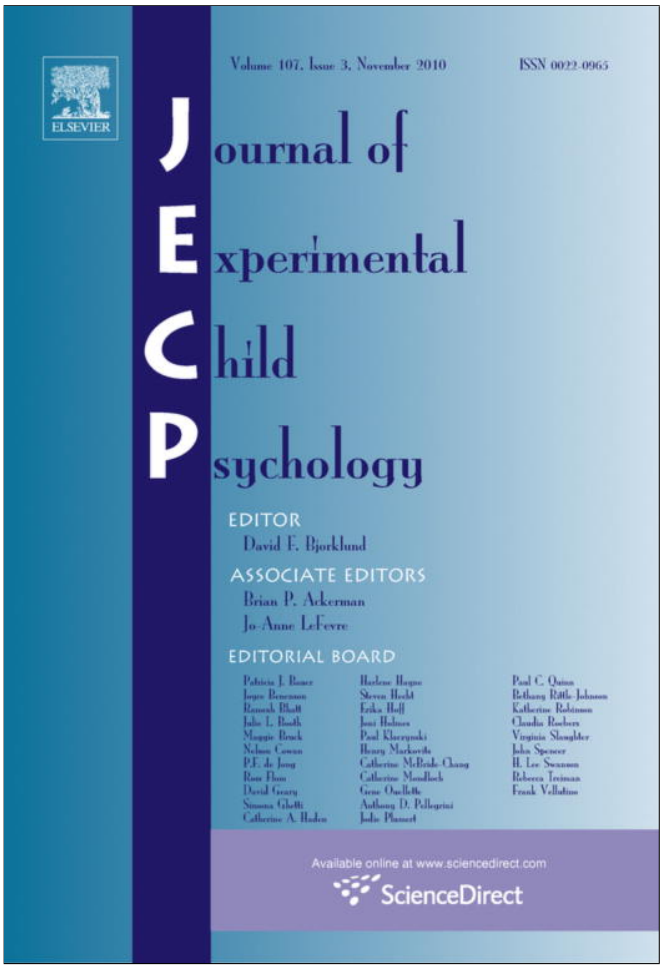

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The role of comparison in preschoolers' novel object categorization

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ABSTRACT

We examined the role of the comparison process and shared names on preschoolers' categorization of novel objects. In our studies, 4-year-olds were presented with novel object sets consisting of either one or two standards and two test objects: a shape match and a texture match. When children were presented with one standard, they extended the category based on shape regardless of whether the objects were named. When children were presented with two standards that shared the same texture and the objects were named with the same noun, they extended the category based on texture. The opportunity to compare two standards, in the absence of shared names, led to an attenuation of the effect of shape. These findings demonstrate that comparison plays a critical role in the categorization of novel objects and that shared names enhance this process.

Introduction

Grouping objects together into categories enables children to make sense of the vast diversity of objects and entities in their environment. A large body of research has been devoted to examining the types of information children may rely on to form categories of objects (for reviews, see Madole & Oakes, 1999; Mandler, 1998; Quinn, 2002; Rakison & Oakes, 2003). Other research has examined the factors that influence children's attention to various object characteristics when categorizing objects (e.g., Blair & Somerville, 2009; Diesendruck, Hammer, & Catz, 2003; Hammer & Diesendruck, 2005; Imai, Gentner, & Uchida, 1994; Keates & Graham, 2008; Waxman & Namy, 1997; Welder &

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Graham, 2006). For example, studies have demonstrated that preschoolers will categorize on the basis of conceptual similarities in some circumstances (e.g., Diesendruck & Bloom, 2003; Gelman & Markman, 1986), whereas in other circumstances they will ignore such similarities and categorize only on the basis of shape (e.g., Landau, Smith, & Jones, 1988, 1998). Here we report the results of three experiments that examined whether the opportunity to compare objects influenced how children categorize novel objects. In particular, we examined how the comparison mechanism may assist preschoolers in focusing on less obvious properties of objects when forming novel categories and whether providing labels can enhance the comparison effect.

As a general learning mechanism, comparison can provide a highly efficient means for learning about the world. Indeed, a burgeoning body of research has documented the benefits of comparison on learning in a number of different realms for both children and adults. For example, comparison fosters both adults' and children's acquisition of relational concepts and language (e.g., Christie & Gentner, in press; Gentner, Anggoro, & Klibanoff, in press; Gentner, Loewenstein, & Thompson, 2003; Loewenstein & Gentner, 2001; Wang & Baillargeon, 2008). Similarly, the opportunity to compare facilitates children's acquisition of verb meanings (Childers, 2008; Childers & Paik, 2009; Childers & Tomasello, 2001; Haryu, Imai, & Okada, in press; Piccin & Waxman, 2007) and spatial terms (Casasola, 2005). More broadly, comparison has been shown to facilitate children's ability to generalize algebraic equations (Rittle-Johnson & Star, 2007), computational estimations (Rittle-Johnson & Star, 2009; Star & Rittle-Johnson, 2009), and linear scales (Thompson & Opfer, in press).

With particular reference to the categorization of objects, Gentner and Namy have shown that comparison processing may lead children to notice commonalities between objects that are not noticed when the objects are examined in isolation (Gentner & Namy, 1999, 2004; Namy & Gentner, 2002; Namy, Gentner, & Clepper, 2007; see also Gentner, 2003; Gentner & Medina, 1998). That is, the act of examining two or more things in conjunction allows children to assess commonalities and differences that do not involve highly salient features. In particular, 4-year-olds, when provided with the opportunity to compare two exemplars of a category, categorized familiar objects based on conceptual similarities (i.e., belonging to the same kind) despite having differing perceptual properties. When not provided with the comparison, 4-year-olds grouped the same objects together based on similar perceptual properties – primarily shape – even though it meant crossing ontological boundaries (i.e., grouping an apple with a balloon) (Gentner & Namy, 1999).

Namy and Gentner (2002) further found that providing shared names for objects to be compared enhanced the comparison effect, possibly by increasing the likelihood that children would engage in comparison (Gentner & Namy, 1999), whereas providing conflicting labels decreased the effect. These findings are consistent with research indicating that names increase the likelihood of cocategorization in infants (e.g., Waxman & Markow, 1995) and young children (Gelman & Markman, 1986; Gentner et al., in press; Markman, 1989).

Other studies have also demonstrated the benefits of comparison on preschoolers' and infants' formation of categories. For example, Oakes and Ribar (2005) found that infants form more differentiated categories when they are given pairs of exemplars than when they experience the same exemplars one at a time. Other research has demonstrated that adults and children 6 years of age or older will use comparison to extract a categorical relation for novel objects (Hammer, Diesendruck, Weinshall, & Hochstein, 2009). Extant research, however, does not provide insight into the role of comparison in preschool-age children's categorization of *unfamiliar* objects. Yet this mechanism would be highly useful during development when so many objects are unfamiliar from a child's perspective.

In the current studies, we explored 4-year-olds' use of comparison when categorizing novel objects. The logic of our studies is based on the findings just reviewed that the comparison mechanism focuses children on commonalities between the objects compared, even initially nonsalient features. We took as a starting point children's reliance on a well-established feature, namely object shape. A large body of research has demonstrated that infants and preschoolers show a strong reliance on object shape for word learning and categorization tasks (e.g., Baldwin, 1989, 1992; Graham & Diesendruck, 2010; Graham, Kilbreath, & Welder, 2004; Graham & Poulin-Dubois, 1999; Graham, Williams, & Huber, 1999; Imai et al., 1994; Landau, Smith, & Jones, 1992; Landau et al., 1988; Smith, Jones, & Landau, 1992), although there is considerable debate around the underlying nature of this shape bias (see the special issue of Samuelson and Bloom (2008) for an in-depth review of the debate). Rather than

attempting to clarify why children rely on shape for categorization, our focus was on whether, given the high attentional weighting afforded by shape, providing children with the opportunity to compare objects would lead preschoolers to rely on a less obvious perceptual property of objects (i.e., texture) to group novel objects together even when a shape match was available.

In addition to examining the role of comparison in preschoolers' categorization of novel objects, we also examined how providing labels for objects can enhance the comparison effect. A large body of research has demonstrated that labeling objects can play a potent role in guiding infants' and preschoolers' categorization (e.g., Fulkerson & Waxman, 2007; Gelman & Coley, 1990; Gelman & Markman, 1986, 1987; Keates & Graham, 2008). Studies with familiar objects have documented that providing labels for objects to be compared enhanced the comparison effect (Gentner & Namy, 1999). In the current studies, we sought to extend this finding by examining whether providing shared labels for novel objects would facilitate preschoolers' comparison and subsequent categorization of those objects.

In Experiment 1A, we examined whether providing children with the opportunity to compare objects and a shared name for objects would lead preschoolers to rely on a less obvious property of objects (i.e., texture) to group novel objects together even when a shape match was available. In Experiment 1B, we examined children's use of texture as a basis for categorizing in the absence of comparison. In Experiment 2, we examined whether children would spontaneously engage in the comparison process without being directed to do so. In particular, we tested the proposal that simply providing a common label for two different objects prompts children to compare them and thereby discover their commonalities (Gentner, 2003; Gentner & Namy, 2006).

Experiment 1A

In Experiment 1A, 4-year-olds were presented with novel object sets in one of four groups: Comparison/Word, Comparison/No Word, No Comparison/Word, and No Comparison/No Word. Each object set consisted of one standard (No Comparison) or two standards that shared the same texture (Comparison) and two test objects. One test object matched one standard in shape only, and one test object matched one standard in Texture Only. For children in the Word groups, the standard(s) was named with the same novel count noun. Following presentation of the standard(s), children were invited to extend the category (No Word groups) or the name (Word groups) to the test objects.

We predicted that when shown only one standard (No Comparison groups), children would choose a test object matched on shape because shape is a dominant basis for categorization. However, we predicted that when shown two standards that share a common texture but differ in shape (Comparison group), children would compare the objects for similarities and would choose the test object matched on texture. Finally, we predicted that providing common labels for the standards would enhance the comparison effect.

Method

Participants

Participants were 128 preschoolers, with 32 children randomly assigned to each group: Comparison/Word (mean age = 4.57 years, *SD* = 0.34, range = 3.75–5.17), Comparison/No Word (mean age = 4.57 years, *SD* = 0.31, range = 4.08–5.17), No Comparison/Word (mean age = 4.56 years, *SD* = 0.34, range = 3.83–5.17), and No Comparison/No Word (mean age = 4.60 years, *SD* = 0.27, range = 4.08–5.25). Equal numbers of boys and girls participated in each group. Children were from homes in which English was the primary language spoken.

Materials

Four sets of objects, consisting of two standards and two test objects, were created (see Fig. 1). In the No Comparison groups, one standard was presented, followed by two test objects. One test object shared the same texture as the standard but differed in color and shape. The other test object shared the same shape as the standard but differed in color and texture. In the Comparison groups, two standards that shared the same texture but differed in color and shape were presented, followed by the

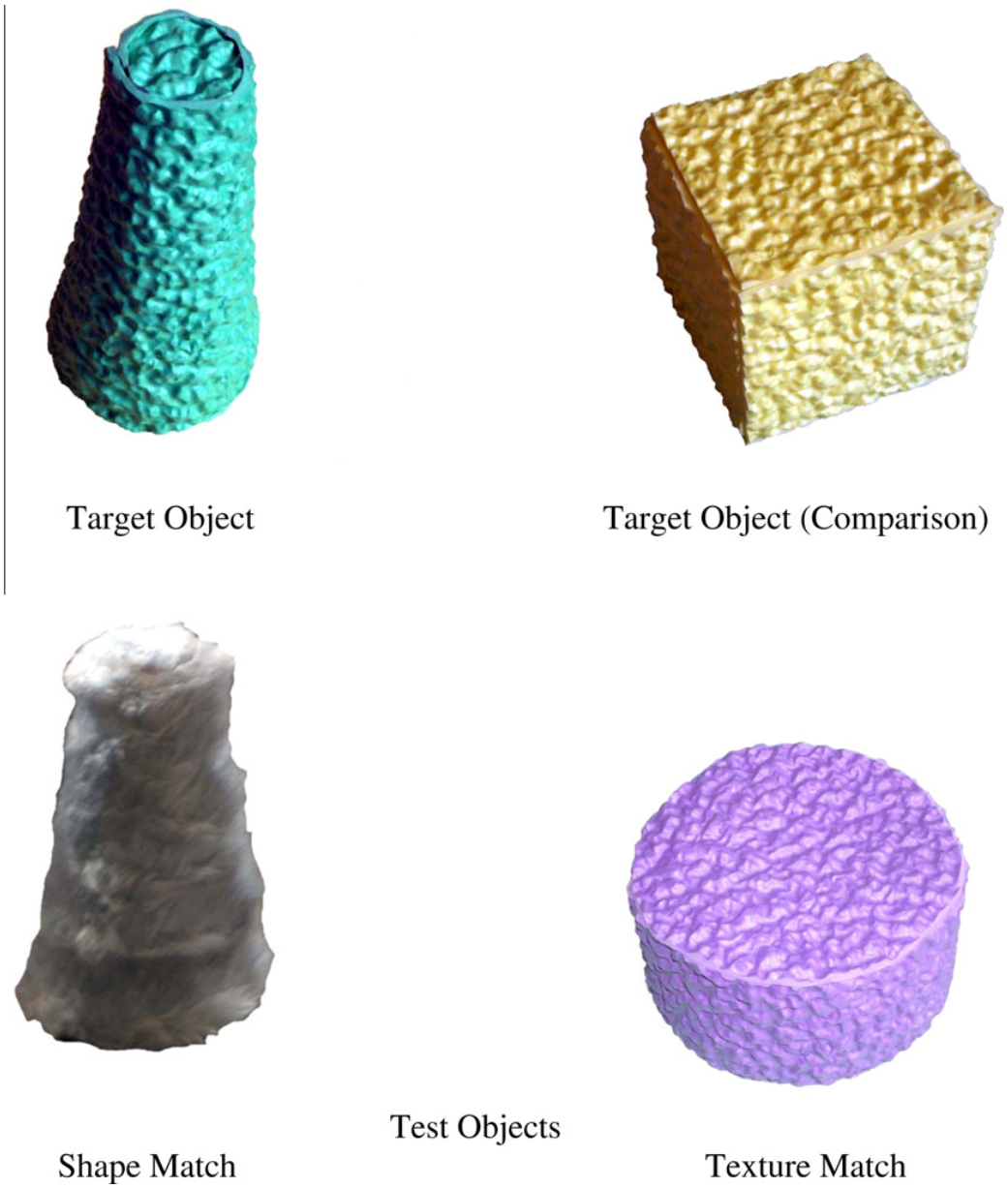

Fig. 1. Example object set.

same test objects used in the No Comparison groups. Note that when objects differed in shape, all of the shapes used were distinct (i.e., hybrids were not used). The labels *blick*, *flum*, *modi*, and *wug* were randomly assigned to each object set.

Procedure

To familiarize children with the procedure, each child was first presented with two practice trials followed by the four test trials. On each test trial, the standard(s) was presented, followed by the two test objects. The standard(s) was left within the child's view throughout the trial. For children in the No Comparison/Word group, the standard was presented and labeled with a novel count noun ("This is a *blick*"). When presented with the test objects, the child was asked to indicate which of the two objects was also a referent of the novel word ("Show me another *blick*"). This same procedure was followed for children in the Comparison/Word group with one exception: two standards were presented, and both were labeled with a novel count noun ("This is a *blick* and this is a *blick* too; see how these are both *blicks*").

In the No Comparison/No Word group, the standard was presented with a general attention phrase ("This is one"). The child was then shown the two test objects and asked, "Show me another one that is

the same kind of thing". This same procedure was followed for children in the Comparison/No Word group with one exception: two standards were presented ("See this one and this one too; see how these are both the same kind of thing").

The experimenter recorded children's responses on each trial. A second coder, unaware of the hypotheses of the study, attended 20% of the testing sessions ($n = 29$) to obtain a measure of interrater reliability. The two coders were in perfect agreement (kappa = 1.00).

Results

The number of texture choices across the four trials was summed and converted to a percentage. See Table 1 for the mean percentage of texture choices for children in each group. Children in the Comparison/Word group chose the texture match significantly more often than expected by chance (50%), $p < .001$. Children in the Comparison/No Word group chose the texture match at chance levels, $p = .51$. Children in No Comparison/No Word group and the No Comparison/Word group chose the texture match significantly less often than expected by chance, ps < .05.

To directly examine the effects of comparison and naming, a 2 (Comparison) × 2 (Word) analysis of variance (ANOVA) was conducted. This analysis yielded main effects of comparison, $F(1, 124) = 125.19$, $\eta^2 = .50$, $p < .001$, and word, $F(1, 124) = 17.69$, $\eta^2 = .13$, $p < .001$. These main effects were qualified by a comparison by word interaction, $F(1, 124) = 24.24$, $\eta^2 = .16$, $p < .001$. Using independent t tests with a Bonferroni correction and corrected for unequal variances where applicable, we followed up on those effects of interest. In both the No Word and Word conditions, children in the Comparison group chose significantly more texture matches than children in the No Comparison group, $t(47.84) = 3.91$ and $t(45.27) = 13.48$ for the No Word and Word conditions, respectively, both ps < .001. Although the effect of comparison was evident for both the Word and No Word conditions, children in the Comparison/Word group made significantly more texture choices than children in the Comparison/No Word group, $t(57.88) = 5.16$, $p < .001$. In contrast, children in the No Comparison/Word and No Comparison/No Word groups chose the texture matches at similar levels, $p = .44$. Thus, adding a common label by itself does not appear to change children's responding, although it does appear to augment the effect of comparison in shifting children toward the texture response.

In the next set of analyses, the number of children who consistently chose a texture match object as a function of condition was examined. A child was defined as a consistent texture chooser if he or she chose the texture match object on at least three of the four trials. A chi-square analysis indicated that there was a significant difference in number of consistent texture choosers across the groups, $\chi^2(3) = 64.24$, $p < .001$. More children in the Comparison/Word group ($n = 25$) consistently chose the texture match object than children in the Comparison/No Word group ($n = 8$), the No Comparison/Word group ($n = 0$), and the No Comparison/No Word group ($n = 1$).

Discussion

When children did not have the opportunity to compare objects, they showed a strong preference to group objects based on shared shape regardless of whether or not the objects were named. When

Table 1
Mean percentages of texture choices by group and experiment.

	Group	Mean percentage of texture choices	Standard deviation
Experiment.1A	Comparison/Word	77.34*	26.46
	Comparison/No Word	37.50	34.78
	No Comparison/Word	7.03*	13.07
	No Comparison/No Word	10.02*	18.90
Experiment 1B	Texture Only/Word	84.38*	23.55
	Texture Only/No Word	68.75*	33.60
Experiment 2	Comparison/Word	78.12*	31.45
	Comparison/No Word	46.88	32.75

* Significantly different from chance (50%).

children were provided with two standards but the standards were not labeled, they showed evidence of a shift away from shape toward texture. Thus, the opportunity to compare the objects led to an attenuation of the shape effect, although not to a significant preference for texture. When children were given the opportunity to compare objects and the objects were named with a common label, they were more likely to group objects based on similar texture than on similar shape. This finding provides clear support for the claim that common labels serve as an implicit "invitation to compare". That is, a common label for two different things prompts children to compare them and thereby discover their commonalities (Gentner, 2003; Gentner & Namy, 2006). Note that the results also demonstrate that providing a label alone did not influence preschoolers' categorization in our studies. Children in the No Comparison/Word group, like those in the No Comparison/No Word group, predominantly chose shape matches. Thus, we found that adding a common label by itself does not appear to change children's responding, but it does appear to augment the effect of comparison in shifting children toward the texture response.

Experiment 1B

One question that arises from the first experiment concerns whether children's reliance on comparison to identify a texture match indicates that the texture match in our materials can be gleaned only following comparison or whether texture would serve as an available basis for categorizing in the absence of comparison. In Experiment 1B, we sought to examine this issue by evaluating children's tendency to categorize objects on the basis of shared texture when it was the only basis for similarity between the standard and choice objects (i.e., when there was no competing same shape match). We presented 4-year-olds with novel object sets that consisted of one standard and two test objects. One test object matched the standard in Texture Only, and one test object was unrelated to the standard (i.e., did not match the standard on any dimension). Children were tested in one of two groups: Texture Only/No Word and Texture Only/Word. For children in the Word group, the standard and test objects were named with the same novel count noun.

Method

Participants

The sample consisted of 64 preschoolers, with 32 children randomly assigned to each group: Texture Only/Word (mean age = 4.46 years, *SD* = 0.57, range = 3.50–5.25) and Texture Only/No Word (mean age = 4.38 years, *SD* = 0.49, range = 3.58–5.25). Equal numbers of boys and girls participated in each group. Children were from homes in which English was the primary language spoken.

Materials

Four sets of objects, consisting of one standard and two test objects, were created from the same objects used in Experiment 1A. One test object shared the same texture as the standard but differed in color and shape. The other test object shared no similarity with the standard. The same labels used in Experiment 1A were randomly assigned to each object set.

Procedure

The same general testing and coding procedures used in Experiment 1A were used in Experiment 1B with one exception: children were presented with only one standard in the Texture Only/Word and Texture Only/No Word groups.

Results and discussion

See Table 1 for the percentage of texture choices for each group. Children in both the Texture Only/Word and Texture Only/No Word groups chose the texture match significantly more often than expected by chance (50%), $p < .01$. Thus, when presented with only one object in the array that matched the standard, children relied on texture to group objects together. Interestingly, the presence of a label

enhanced children's attention to shared texture as a basis for categorization. An independent groups *t* test indicated that children in the Texture Only/Word group chose significantly more texture matches than children in the Texture Only/No Word group, $t(62) = 2.15$, $p < .05$.

Using the same criteria identified in Experiment 1A, we examined the number of children who consistently chose a texture match object across both groups. A chi-square analysis indicated that the number of consistent texture choosers did not differ across the two groups, $p > .08$. Thus, similar numbers of children in the Texture Only/Word group ($n = 27$) and the Texture Only/No Word group ($n = 21$) consistently chose the texture match object across trials.

The results of Experiment 1B demonstrated that children will rely on texture to categorize novel objects when texture is the only basis of similarity, indicating that texture is indeed an available basis for categorizing in the absence of comparison. This result serves to benchmark the findings of Experiment 1A by suggesting that comparison is acting to increase the salience of texture (and decrease the salience of shape) as a relevant basis for categorization.

Experiment 2

In Experiment 2, we examined whether children would use the opportunity to compare the objects to discover similarities without being explicitly directed to do so by the experimenter (i.e., when a less directive dialogue was used). That is, the experimenter simply presented the standards to children and did not provide instructions that encouraged them to discover similarities between the objects.

Children were tested in the Comparison/Word and Comparison/No Word groups using the same object sets used in Experiment 1A. Direct comparison with the results of Experiment 1A allowed for the assessment of children's ability to engage spontaneously in comparison. That is, if the comparison process is evoked without explicit direction from the experimenter, the results should parallel the results from those two groups in Experiment 1A. The elimination of the explicit invitation to comparison in the instructions also allowed us to test the "common labels invite comparison" proposal (Gentner & Namy, 2006). That is, if providing common labels without an explicit "Do you see why these are both X?" instruction continues to lead children to extend on the basis of texture relative to the No Word condition, this would provide support for the hypothesis that common labels invite comparison.

Method

Participants

A total of 32 preschoolers were tested, with 16 children randomly assigned to each group: Comparison/Word (mean age = 4.63 years, $SD = 0.40$, range = 4.17–5.25) and Comparison/No Word (mean age = 4.84 years, $SD = 0.34$, range = 4.17–5.33). Equal numbers of boys and girls participated in each group. Children were from homes in which English was the primary language spoken.

Materials and procedure

The same material and general testing procedures used in Experiment 1 were used in Experiment 2 with the exception of the dialogue used to introduce the objects. In the Comparison/Word group, the standards were presented and labeled with a novel count noun ("This is a *blick* and this is a *blick* too"). In the Comparison/No Word group, the standards were presented with the following dialogue, "This is one and this is one too". Thus, the experimenter did not explicitly encourage preschoolers to discover similarities between the objects.

Interrater reliability for 20% of the data ($n = 7$) indicated that the coder and the experimenter were in perfect agreement (kappa = 1.00).

Results and discussion

See Table 1 for the percentage of texture choices for each group. Consistent with the findings of Experiment 1A, children in the Comparison/No Word group chose the texture matches at chance levels, $p > .70$, whereas children in the Comparison/Word group chose the texture matches significantly

more than would be expected by chance, $p < .05$. An independent t test indicated that children in the Comparison/Word group chose significantly more texture matches than children in the Comparison/No Word group, $t(30) = 2.75$, $p < .01$.

The number of children who consistently chose a texture match object as a function of group was examined using the same criteria outlined in Experiment 1A. More children in the Comparison/Word group ($n = 12$) consistently chose the texture match than children in the Comparison/No Word group ($n = 5$), $\chi^2(1) = 6.15$, $p = .013$.

Cross-experiment comparisons

The mean percentages of texture choices for the two less directive dialogue groups were compared with those of the more directive dialogue groups (Comparison/Word and Comparison/No Word) to assess whether the more explicit invitation to compare in Experiment 1A led the children to heightened engagement during the comparison process. Independent t tests indicated that there were no significant differences between the Comparison/Word more directive and Comparison/Word less directive groups, $p = .93$, or between the Comparison/No Word more directive and Comparison/No Word less directive groups, $p = .47$.

The results of Experiment 2 parallel the findings of Experiment 1A, indicating that the tendency to engage in the comparison process was not a function of the directions used to introduce the objects. When presented with two similar objects simultaneously, children will engage in the comparison process spontaneously without the guidance of the experimenter. Moreover, labeling the objects continued to enhance the comparison effect, providing support for the notion that shared labels serve as an invitation to compare.

General discussion

The starting point for these experiments was the striking finding that the opportunity to compare objects leads preschoolers to categorize on the basis of conceptual, rather than perceptual, features (Gentner & Namy, 1999; Namy & Gentner, 2002). We sought to extend this research by examining the role of the comparison process and names in guiding preschoolers' categorization of novel objects. When children were presented with only one standard, they overwhelmingly grouped objects together based on shared shape regardless of whether or not the objects were named and even though shared texture was an available basis for categorization. In contrast, children were more likely to categorize objects based on similar texture when they had the opportunity to compare two objects that shared texture, especially when common labels were also provided. Children who were provided with only the opportunity to compare objects showed a movement away from shape similarity as a basis for categorization but did not reliably extend the category to include the texture match as did those who also heard a label. That shape apparently remained a significant draw for children in the Compare/No Word condition is striking given that the shape match matched only one of the two standards. These findings suggest that comparison will elevate common properties, even nonsalient ones, over noncommon properties, even salient ones such as shape. However, only when a shared name is also provided are children more likely to form a category of objects based on other, perhaps more subtle and less conventional, similarities such as similar texture.

When considered in conjunction with research by Gentner and Namy (1999); see also Namy and Gentner (2002), our findings offer insight into both the nature of the comparison process and the circumstances that elicit this process. First, our results indicate that comparison can play a critical role in preschoolers' novel object categorization as well as in the categorization of familiar objects, suggesting that this mechanism can play a powerful role in development as well as in word learning (Gentner & Namy, 2006). Second, our findings demonstrate that the comparison process was more pronounced when the objects were labeled with a shared name. Thus, we suggest that common labels enhance preschoolers' tendency to compare two objects to extract similarities. Finally, our results indicate that the presentation of two objects simultaneously is sufficient to lead preschoolers to compare objects. This suggests that the comparison process is evoked and that explicit instructions are not necessary.

However, before embracing these conclusions, an alternate possibility must be considered. That is, it is possible that the labels in our experiments, rather than highlighting commonalities between objects, elicit a shift toward the texture match by overshadowing differences among the objects (Sloutsky & Robinson, 2008). However, when carefully considered, it is clear that auditory overshadowing cannot account for our findings for the following reasons. First, we note that recent research on auditory overshadowing during infancy has indicated that words may overshadow visual processing at 10 months of age; however, only nonspeech sounds attenuate visual processing at 16 months of age and words do not (Sloutsky & Robinson, 2008; see also Robinson & Sloutsky, 2007). In our studies, we used words, which interfere with visual processing far less than other sounds, and the 4-year-old age range in our studies is well past the age (10 months) at which sizable auditory overshadowing has been found for words. Second, our results indicate an effect of comparison even in the absence of a label; auditory overshadowing cannot account for those effects. Finally, auditory overshadowing cannot explain why children in the No Compare/Word condition display a systematic shape bias given that both choice objects share a common property with the standard.

The current results add to a growing body of research that demonstrates how children's categorical decisions shift based on the context of presentation (e.g., Blair & Somerville, 2009; Booth & Waxman, 2002; Booth, Waxman, & Huang, 2005; Diesendruck & Bloom, 2003; Diesendruck et al., 2003; Graham, Welder, Merrifield, & Berman, in press; Imai et al., 1994; Kotovsky & Gentner, 1996; Namy & Gentner, 2002; Trauble & Pauen, 2007; Waxman & Namy, 1997). For example, Hammer and Diesendruck (2005) specifically demonstrated that when contextual factors led objects' functions to be more distinctive, children extended a standard's name to a test object with the same function. In contrast, when contextual factors led objects' physical appearances to be more distinctive, children extended a standard's name to the physically more similar test object. Our studies add significantly to this research by elucidating the role that comparison can play in preschoolers' novel object categorization.

Our findings also suggest a number of important directions for future research. In the current studies, only perceptual features were contrasted. Thus, an important extension of this work is to examine the use of comparison when categorizing *novel* objects based on nonperceptual similarities. Gelman, Raman, and Gentner (2009) demonstrated that when comparing familiar kinds, comparison highlights deep conceptual structure for both adults and children. Another avenue to explore is the developmental course of comparison, including examination of whether the process of comparison is present during early development and how the process might change with linguistic and cognitive development. As these questions are explored, the conditions under which children engage in the comparison process will be clarified, thereby offering important insights into preschoolers' categorization.

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