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It's Taking Shape: Shared Object Features Influence Novel Noun Generalizations

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SHARED OBJECT FEATURES INFLUENCE GENERALIZATIONS

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Abstract

Children's early noun vocabularies are dominated by names for shape-based categories. However, along with shape, material and color are also important features of many early categories. In the current study, we investigate how the number of shared features among objects influences children's novel noun generalizations, explanations for these generalizations and spontaneous speech. Preschool children and adults were presented with test objects that shared only one feature (e.g., shape) or that shared two features (e.g., material and color). After each trial, participants were asked, "how did you know that was your [novel name]?" Adults and 4-year-old children consistently attended to shape. Three-year-old children also attended to shape, however this bias reduced if the other objects had more features in common. Children's explanations of their choices reflected an understanding that shape was guiding their responses, however, there explanations were not as concrete as adults' explanations. Finally, children's spontaneous speech was dominated by references to the objects' shapes. Overall, these data demonstrate that preschool children and adults attend exclusively to shape when encountering novel object categories.

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It's Taking Shape: Shared Object Features Influence

Novel Noun Generalizations and Explanations

Young children are experts at generalizing names from one category member to another. For example, when presented with a peanut-butter treat labeled *cookie* they generalize the name to new cookies, when presented with an opaque, brightly-colored drink labeled *juice* they generalize the name to new opaque drinks, and when presented with a novel object they generalize its name to other objects that share the same shape—a behavior known as the *shape bias* (Landau, Smith, & Jones, 1988).

For typically developing children learning English, the shape bias emerges early during language acquisition, when children have acquired approximately 50 nouns or 150 words (Gershkoff-Stowe & Smith, 2004; Samuelson & Smith, 1999). In contrast, late talkers (children whose productive vocabularies are in the bottom 30th percentile for their age) do not attend to shape as reliably as their age-matched peers (Jones, 2003; Jones & Smith, 2005). Importantly, children's early noun vocabularies support the development of the shape bias: the first 300 words children learn are predominately count nouns for solid objects from shape-based categories (Samuelson & Smith, 1999). This early noun vocabulary, therefore, contains the statistical regularity that supports the development of the shape bias. Training studies demonstrate that teaching children real nouns that follow this statistical regularity leads to a precocious shape bias (Samuelson, 2002; Smith et al., 2002; Perry et al., in press). Specifically, the vocabulary of children receiving such training dramatically increases as compared to their peers who did not receive such training (e.g., Samuelson, 2002). Clearly, then, children learn from the statistical regularity in their early, shape-dominated vocabularies.

Numerous labs have replicated children's shape bias and shed light on its development (e.g., Booth & Waxman, 2002; Imai & Gentner, 1997; Soja, Carey, & Spelke,

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1991; Samuelson & Smith, 2000; Landau, Smith & Jones, 1992). Children's shape bias is very robust and can withstand changes to object rigidity (Samuelson & Smith, 2000), object size (Landau, et al., 1988) and the syntax used when objects are named (Soja, et al., 1991). However, recent studies suggest that the shape bias is also susceptible to task effects. For example, children's shape bias is weaker if they are presented with yes-no questions, rather than forced choices (Samuelson, Schutte, & Horst, 2009), non-named exemplars, rather than named exemplars (Diesendruck & Bloom, 2003; Samuelson & Smith, 2000), or task-relevant instructions that specifically downplay the importance of shape (Diesendruck, Markson, & Bloom, 2003).

Recent evidence also suggests that the shape bias is susceptible to changes in stimuli. For example, children's shape bias is weaker if they are presented with deformable objects (Samuelson, Horst, Schutte, & Dobbertin, 2008), or objects that have animate features likes eyes (Jones, Smith, & Landau, 1991) or shoes (Jones & Smith, 1998). Recently, Samuelson and Horst (2007) presented 2-year-old children with a novel noun generalization task which included both solid object and nonsolid substance trialsas well as stimuli presented as both whole objects/single globs or as pieces/multiple globs. Analyses of individual differences revealed that children's shape bias on solid object trials was increasingly disrupted as a function of how many solid-pieces trials they had just experienced. Taken together, these and similar findings demonstrate that while the shape bias is generally robust, it is a product of children's prior knowledge, just-previous experience and the current task. That is, children's shape bias emerges in the moment as a dynamic interaction of what the child knows about object categories, what the child has just seen, what the child is currently seeing and what he or she is asked to do (see also, Samuelson & Horst, 2008 for a similar argument).

Children's ability to generalize novel names on the basis of other object features (e.g., material, color) may also be susceptible to task effects. For example, Sandhofer and Doumas

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(2008) taught 2-year-old children three color words (red, yellow, green) and varied both order of presentation (massed or distributed) and test object similarity. At test, children were presented with the three training exemplars (memory test) and three color swatches (posttest) and were asked "show me [color]." Children's recall was significantly better in the memory test if they had been trained with a massed presentation. Children's performance on the posttest was significantly better if they had encountered highly similar training objects whose color similarity decreased incrementally across training. That is, both trial order and stimuli are important when learning names for non-shape object features.

Similarly, Samuelson and Horst (2007) found that 2-year-old children only demonstrate a material bias in a two-alternative forced choice task if the material matching test stimuli share more than one feature with the named exemplar. In that study, children were more likely to choose a shape match when shown a purple hair gel U (exemplar) and presented with a beige facial scrub U (shape match) and pink hair gel globs (material match). In contrast, children were more likely to choose a material match when shown a purple hair gel U and presented with a beige facial scrub U and purple hair gel globs. It appears, then, that the number of features the test stimuli share with the exemplar influences whether children demonstrate a shape bias or a material bias. However, Samuelson and Horst (2007) only varied the number of shared features between subjects and only manipulated one match (material-only matches vs. material-and-color matches). Thus, the primary goal of the current study is extend these findings by systematically investigating how the number of shared features among objects influences children's novel noun generalizations.

In the current study, we investigate how the number of shared features between the exemplar and test objects influences children's behavior in three aspects of the novel noun generalization task. First, we test whether the number of shared features impacts on the strength of children's shape bias. Specifically, we present children with test objects that either

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share only one feature with the exemplar (i.e., shape-, material- and color-matches) or test objects that share two features with the exemplar (e.g., shape-and-color matches). This is the first study to systematically manipulate the number of shared features between the exemplar and test objects in a novel noun generalization task.

Second, we explore whether children use other features (e.g., material, color) when reasoning on novel noun generalization trials. Specifically, after each trial, we ask children "how did you know that was your [novel name]?" Previous research in other domains has included such questions, particularly in the literature exploring children's arithmetic strategies and understanding of balance (e.g., Messer, Pine, & Butler, 2008; Pine, Lufkin, & Messer, 2004; Siegler & Chen, 2008; Siegler & Jenkins, 1989). For example, Siegler and Stern (2008) presented 8-year-old children with both standard problems (e.g., 2 + 4 – 3 = ?) and inversion problems"(e.g., 2 + 4 – 4 = ?) and asked "how did you figure out the result?" after each problem. Children were able to demonstrate that they use a variety of strategies in such tasks. Recently, Florez-Romero and colleagues (2006) questioned 3-4-year-old children in a linguistic task. An experimenter read a story containing several grammatical, semantic and phonological errors and demonstrated that children were able to accurately point out these errors. Thus, in the current study we test 3- and 4-year-old children, as this is the youngest age at which children have been shown to understand such abstract questions. Importantly, this is the first study to explore whether children can accurately reflect on their own reasoning in a word learning task (but see, Farrington-Flint, Vanuxem-Cotterill, & Stiller, 2009 on reading and spelling strategies with elementary school-aged children).

Finally, we explore whether children attend to multiple features of novel categories, in general. Specifically, we examine children's spontaneous speech before each novel noun generalization trial, during the phase where children are exploring the objects. Previous research on children's spontaneous speech in novel noun generalization tasks has determined

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that 17-28-month-old children's spontaneous comments predominantly refer to the objects' shapes (Samuelson & Smith, 2005). However, the young children in that study may not yet have had a sufficiently large vocabulary of color and texture words at their disposal, thus it is important to replicate this finding with older children with larger productive vocabularies.

Method

Participants. A total of 32 monolingual, English-speaking children and 16 adults from the university community participated. None of the participants had any family history of colorblindness. Sixteen 3-year-old children (mean age = 36 months 27 days, *SD* = 59 days, range = 33 months 26 days to 39 months 9 days, 9 girls), 16 4-year-old children (mean age = 48 months 5 days, *SD* = 50 days, range = 44 months 26 days to 50 months 70 days, 8 girls) and 16 adults (mean age = 25 years 6 months, *SD* = 9 years, range = 19 years 1 month – 48 years 9 months) participated. Data from two additional 4-year-old children and one adult were excluded from the analysis due to experimenter error. Children received a small gift for participating and parents were reimbursed for travel costs. Adult participants received course credit or £5 for participating.

To our knowledge, the main experiment is the first study on children's shape bias in a non-American-English-speaking population. Thus, it was important to first determine that British children's early noun vocabularies are also dominated by count nouns for solid objects from shape-based categories. To this end, we ran a replication of Samuelson and Smith (1999). Thirty-six undergraduate students received course credit for rating the 304 nouns on the UK adaptation of the MacArthur-Bates Communicative Development Inventory: Words and Sentences (Klee & Harrison, 2001) according to whether each noun was a count noun or mass noun (syntax condition), solid or nonsolid (solidity condition) or from a shape-, material- or color-based category (category condition). Overall, the same pattern of results as those reported by Samuelson and Smith (1999) were found. That is,

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British children's early noun vocabularies are largely comprised of solid objects from categories organized by shape named with count-noun syntax. Further, there were no differences in the number of solid, shape-based, count nouns, $X^2(2) = 1.03$, *ns*, between the American and British versions.

Stimuli. Six sets of novel objects were created for this experiment. Each set contained an exemplar and four test objects (see Figure 1). Three sets included test objects that shared one of three features (shape, material or color) with the exemplar. The *tanzer* set included two test objects that matched the exemplar in shape (but not material or color) and two that matched in material (but not shape or color). The *lorp* set included two test objects that matched the exemplar in color (but not shape or material) or shape (but not material or color). Note, in order to ensure that children encountered every possible combination of feature matches and encountered each feature equal number of times (see procedure below), the *glark* set did not include any shape-matches; instead it included two test objects that matched the exemplar in material (but not shape or color) and two that matched in color (but not material or shape). The other three sets included test objects that shared either one or two features with the exemplar. The *tife* set included two test objects that matched the exemplar in shape and color (but not material) and material (but not shape or color). The *chatten* set included two test objects that matched the exemplar in shape and material (but not color) and two test objects that matched the exemplar in color (but not shape or material). The *ratch* set included two test objects that matched the exemplar in shape (but not material or color) and two objects that matched the exemplar in both material and color (but not shape). Novel stimuli were approximately the same size (M = 8.8cm x 9.0cm x 2.0cm, range = 0.5 cm to 15.2 cm).

Six familiar objects were used during the warm-up phase. One set included two identical blue, plastic sunglasses and a ring of toy keys. The other set included two identical

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black-and-white baby shoes and a brown cow. Stimuli were presented on a white 46 cm x 24 cm wooden tray divided into two halves.

Procedure and Design. Parents accompanied their children at all times, and were asked not to refer to the shape, color, texture or material of the items presented. The experimenter used neutral syntax throughout the experiment to avoid biasing participants to either shape or material choices (see, Gathercole, Cramer, Somerville, & Dehaar, 1995).

Training Trials. Children and adults were first presented with two training trials with familiar objects. Children were given all three objects to play with for up to 30 seconds while the experimenter encouraged them to touch each of the objects. Adults were told they could touch the objects if they wished. Then, the experimenter placed the identical match and other object on the tray and held up the exemplar and asked for the identical match, e.g., "See this? This is my little shoe. Can you show me your little shoe?" Next, the experimenter slid the tray forward. If children did not choose an object, the experimenter repeated the question up to three times. Correct responses were praised enthusiastically. All children completed the training trials with at least one correct response. After participants made their choices, the experimenter took the chosen object and replaced it on the tray, and asked "How did you know that was your little shoe?" This question was also repeated up to three times. The second training trial proceeded in the same manner. Which training set was presented first was counterbalanced across participants at each age. Participants were presented with the identical match once on the left and once on the right.

Test trials. Test trials immediately followed the training trials and proceeded in the same manner with the exception that no feedback was given. Each participant saw each exemplar twice and each test object once across a total of twelve trials. That is, for each set the exemplar was presented on two consecutive trials: once with one pair of test objects and once with the other pair. For example, a participant might see the *tanzer* exemplar presented

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first with the black shape-match and the white material-match and then with the gold shape-match and the brown-material match. Again, after participants' choices, the experimenter took the chosen object and replaced it on the tray and asked "How did you know that was your [novel name]?" Within each block, trial order and pairing of test objects were counterbalanced across participants using a Latin Square design. Further, left-right positioning of test objects alternated across trials: half of the participants started with the shape-match (or material-match for the *glark* set) on the left and the other half on the right.

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Previous research on the robustness of children's shape bias demonstrates that what children see on one trial may significantly influence their choices on following trials (e.g., Samuelson & Horst, 2007). We attempted to minimize trial order effects in two ways. First, test trials were always presented in two blocks. The three sets presented in the first block included test objects that shared only one feature with the exemplar. The three sets presented in the second block included test objects that shared either one or two features with the exemplar. Block order was fixed to ensure that test objects that shared two features did not subsequently bias children's choices and explanations on trials in which each test object only matched the exemplar in one feature. Second, we included the *glark* set. Without the *glark* set, children would have seen four shape-matches but only two material-matches and two color-matches during the first block. That is, they would have encountered shape-matches at a ratio of 2:1 to either material- or color-matches. Clearly, this statistical regularity in the input could have unduly influenced children's subsequent choices. Thus, the *glark* set was included to avoid biasing children to attend to any one feature. We were also curious about how children would behave in this arguably unexpected situation. Because more studies on children's shape bias include material matching test objects than color matching test objects, we present the results for this set in terms of proportion of material choices.

Coding. The mean proportion of shape choices (and material choices for the *glark* set) were calculated for each child as the total shape choices out of the total number of trials children answered for each set (see also, Samuelson et al., 2008). Participants' choices on the forced-choice trials were coded online by the experimenter. Picking up, touching or pointing to a novel object was considered a response. If a child failed to make a clear response this was coded as a "non-response." This occurred on one trial for one 3-year-old child and two trials for one 4-year-old child. A second coder, naïve to the experimental hypotheses, coded 25% of the sessions for each age group. Inter-coder agreement was high, *M* = 97.3%, *SD* = 5.21%, range = 0.86 – 1.00. Disagreements were resolved via discussion.

Verbal explanations. Table 1 provides example of utterances made by children during the task. Overall, children provided 147 explanations when asked "how did you know that was your [novel name]?" and made 365 spontaneous comments about the novel objects and the objects' features during the familiarization phase, before each trial. To establish whether children's comments referred to objects' shape, material/texture or color, 28 undergraduates rated children's explanations and spontaneous comments for course credit. Both children's explanations (e.g., "because it has pointy bits") and spontaneous comments (e.g., "looks like a whale tail") were presented as a list on a computer screen and adults clicked a button to indicate if an utterance was "shape-based," "material/texture-based," "color-based" or "ambiguous." As in Samuelson & Smith's (1999) study, raters could choose more than one response. No additional information about the utterances beyond "these were things children said in an experiment" was provided. If at least 85% of raters agreed, utterances were classified as shape-, material/texture-, or color-based. As in Samuelson & Smith's (1999) study, if fewer than 85% of raters agreed, utterances were classified as "ambiguous" and were not used in the subsequent analyses.

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Adults provided explanations on all trials. Adults' explanations were not presented to the raters because they were very explicit (e.g., "same shape"). Eighteen adult explanations were not included in the analyses because they were non-feature specific (e.g., "[because] they are the same" (n = 3, all in response to shape-matches) or referred to two features, which children never did (n = 15). These explanations were "[…] the same shape and color" (n = 13, all in response to shape-and-color matches on *tife* trials), "[…] the same shape and material" (n = 2, two participants both in response to a shape-and-material match (*chatten* trial). This resulted in 174 explanations by adults.

Results

First, we report participants' choices on the novel noun generalization task. Then, we analyze participants' explanations that immediately followed these choices. Finally, we present the data on children's spontaneous comments. No trial order effects were found for any of these analyses.

One shared feature. Figure 2 depicts participants' proportion of shape choices (and material choices for the *glark* set) for trials in which the test objects each shared a single feature with the exemplar. Overall, 3-year-old children demonstrated a shape bias at levels significantly greater than expected by chance (.50) when asked to generalize novel names on the basis of shape or material ($t(15) = 2.15$, $p < .05$, $d = 0.54$) or on the basis of shape or color ($t(15) = 4.57$, $p < .001$, $d = 1.14$, see white bars in Figure 2). These data are consistent with the numerous studies demonstrating a robust shape bias in preschool children (e.g., Landau et al., 1988). When asked to generalize names on the basis of material or color, these children demonstrated a material bias ($t(15) = 4.03$, $p < .01$, $d = 1.01$).

Similarly, 4-year-old children also demonstrated a strong shape bias when asked to generalize novel names on the basis of shape or material ($t(15) = 4.04$, $p < .01$, $d = 1.01$) or on the basis of shape or color ($t(15) = 3.90$, $p < .01$, $d = 1.15$, see gray bars in Figure 2).

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However, when asked to generalize novel names on the basis of material or color, 4-year-old children did not generalize names on the basis of material at levels different from chance ($t(15) = 1.07$, $p = .30$, $d = .27$). That is, these children did not demonstrate any bias in their novel noun generalizations when shape was not an option.

Overall, adults demonstrated the same pattern of results as the 3-year-old children. Specifically, they generalized names on the basis of shape when asked to generalize a novel name on the basis of shape or material ($t(15) = 15.00$, $p < .001$, $d = 3.33$) or on the basis of shape or color ($t(15) = 7.00$, $p < .001$, $d = 1.53$, see black bars in Figure 2). They also demonstrated a material bias when asked to generalize a novel name on the basis of material or color ($t(15) = 2.41$, $p < .05$, $d = .50$). Overall, then, as in previous studies, preschool children and adults demonstrated a strong shape bias when presented with objects that shared a single feature with the exemplar.

One versus two shared features. Figure 3 depicts participants' proportion of shape choices for trials in which the test objects either shared a single feature or two features with the exemplar. Overall, 3-year-old children demonstrated a strong shape bias when asked to generalize novel names on the basis of shape-and-material or color ($t(15) = 8.06$, $p < .001$, $d = 2.02$) and shape-and-color or material ($t(15) = 5.20$, $p = .001$, $d = 1.30$, see white bars in Figure 3). However, when asked to generalize novel names on the basis of shape or material-and-color, 3-year-old children did not demonstrate a shape bias ($t(15) = 1.70$, *ns*, $d = .42$). That is, when asked to choose between an object that shared the same shape and an object that shared two other features with the exemplar, young children's shape bias was disrupted.

Overall, 4-year-old children demonstrated a robust shape bias when asked to generalize novel names on the basis of shape-and-material or color ($t(15) = 5.20$, $p = .001$, $d = 1.30$), shape-and-color or material ($t(15) = 5.98$, $p < .001$, $d = 1.49$) and shape-only or material-and-color ($t(15) = 2.15$, $p < .05$, $d = 0.54$, see gray bars in Figure 3).

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Similarly, adults also demonstrated a robust shape bias when asked to generalize novel names on the basis of shape-and-material or color (M = 1.00) shape-and-color or material (M = 1.00) and shape-only or material-and-color ($t(15) = 7.33$, $p < .001$, $d = .92$, see black bars in Figure 3). These data again suggest that the shape bias increases in strength with development.

Verbal explanations. Data from eight 3- and 11 4-year-old children are included in this analysis. An additional four 3- and three 4-year-old children responded, but never said anything about the objects. These children either said "I don't know" (three 3- and two 4-year-old children) or "because I know," (one 3-year-old child) or "because it is" (one 4-year-old child) every time they responded. An additional four 3- and two 4-year-old children did not provide any verbal explanations. Like Samuelson and Smith (2005), although some children did not contribute data, we felt it was important to analyze these data.

The number of verbal explanations that referred to objects' features is provided in Table 2. Participants sometimes provided verbal explanations that were inconsistent with their choices (e.g., explaining "because it was blue" after choosing a material-match). Thus, explanations that matched the choices are underlined. Note, these data only include references to object features (i.e., shape, material, color), thus there was a one in three chance that raters would agree that an explanation was about a particular feature (e.g., shape). Thus, the binomial tests were calculated with $p = .33$.

As can be seen from the table, 3-year-old children frequently provided shape-based explanations for their choices. Specifically, 52.94% of children's explanations referred to the objects' shapes, compared to only 14.71% that referred to the objects' materials or textures and only 32.35% that referred to the objects' colors. This suggests that young preschool children attend to shape when reasoning on novel noun generalization tasks. When children provided explanations after choosing shape-matches, they were significantly more likely than

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chance to refer to shape (exact binomial, $p < .05$). No further systematicity was found in the other explanations. When children provided explanations after choosing the material-matches, they were more likely to refer to either shape or color than material. Young children also provided several color-based explanations, but not often after choosing color-matches. Overall, 3-year-old children's explanations were moderately consistent with their choices (Cohen's $\kappa = .50$), however, because so few 3-year-old children provided shape-, material- or color-based explanations it is difficult to draw any strong conclusions.

Similarly, 4-year-old children frequently provided shape-based explanations. Specifically, 51.16% of children's explanations referred to the objects' shapes, compared to only 17.44% that referred to the objects' materials or textures and only 31.40% that referred to the objects' colors. This pattern of responses is similar to that of the younger children. Like the younger children, when 4-year-old children provided explanations after choosing shape-matches, they were significantly more likely than chance to refer to shape (exact binomial, $p < .05$). However, unlike younger children, 4-year-old children were also significantly more likely than chance to refer to shape after choosing objects that matched the exemplar in shape and another feature (shape-and-material, exact binomial, $p < .01$, shape-and-color, exact binomial, $p < .05$). This is particularly interesting because these objects shared more than one feature with the exemplar, thus referring to shape or the other feature would have consistent with children's choices. Based on children's explanations, however, they appeared to ignore the other feature. Older children also provided several color-based explanations, but not often choosing color-matches. Overall, 4-year-old children's explanations were consistent with their choices, Cohen's $\kappa = .57$.

Finally, adults' explanations followed the same pattern of results. That is, like children, adults frequently referred to objects' shapes when explaining their choices. This was the case after choosing the shape-matches (exact binomial, $p < .001$), the shape-and-material-

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matches (exact binomial, $p < .001$), and the shape-and-color-matches (exact binomial, $p < .001$). However, unlike children, adults explained their material choices on the basis of material (exact binomial, $p < .001$) and their color choices on the basis of color (exact binomial, $p < .01$). Overall, adults' explanations were highly consistent with their choices, Cohen's $\kappa = .95$.

Spontaneous Comments. Data from 12 3- and 10 4-year-old children are included in this analysis. An additional four 3- and six 4-year-old children did not spontaneously comment on the stimuli or spoke too quietly to allow transcription.

Feature-Specific Spontaneous Comments. Overall, 3-year-old children made 146 feature-specific comments. Children made 1.59 (SD = 1.27) feature-specific comments per trial. As can be seen in Figure 4, 3-year-old children frequently provided shape-based comments. Overall, children made noticeably more shape-based comments (45.45%) than material- (26.02%) or color-based (29.45%) comments. A χ^2 analysis revealed a Main Effect of Feature, $\chi^2(2) = 8.48$, $p < .05$, further suggesting that children were spontaneously attending to shape.

Of 3-year-old children's 146 comments 107 comments referred to only one object (e.g., "it's the footprint of a chicken" in reference to a material-match), 26 referred to two objects (e.g., "two puzzle pieces" in reference to an exemplar and a shape-match) and 13 referred to all three objects (e.g., "tower" in reference to all three) for a total of 198 references (see Table 3). At the level of references, children's comments were also predominately shape-based, $\chi^2(2) = 17.85$, $p < .001$. When children referred to the exemplars, they also referred significantly more to their shapes than materials or colors, χ^2 (2) = 7.14, $p < .05$.This is particularly strong evidence for children's spontaneous attention to shape as the exemplars always shared at least one other non-shape feature (e.g., material) with another object that was present.

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Overall, the 4-year-old children made 153 feature-specific comments, Children made 2.21 (SD = 1.19) feature-specific comments per trial. No effect of trial number was found. As can be seen in Figure 4, 4-year-old children also frequently provided shape-based comments. Again, children made more shape-based comments (60.13%) than material- (22.22%) or color-based (17.68%) comments. A χ^2 analysisrevealed a Main Effect of Feature, χ^2 (2) = 49.92, $p < .001$. This suggests that 4-year-old children were spontaneously attending to shape.

Of 4-year-old children's 153 comments 107 comments referred to only one object, 41 referred to two objects and five referred to all three objects (see Table 3). Again, At the level of references, children's comments were also predominately shape-based, χ^2 (2) = 75.26, $p <$ .001. When children referred to the exemplars, they also referred significantly more to their shapes than materials or colors, χ^2 (2) = 17.85, $p < .001$. The same pattern was observed for references to the shape-, material-, color- and shape-and-material-matches, all ps< .05. This suggests that 4-year-old children's primary interest lay in objects' shape rather than objects' material or color.

Discussion

The primary goal of the current study was to systematically investigate how the number of shared features among objects influences children's novel noun generalizations. We examined the effect of shared features in three tasks with 3- and 4-year-old-children and adults. Specifically, we tested participants in a forced-choice novel noun generalization task, and asked participants to explain their choices and examined children's spontaneous speech. All age groups showed a strong shape bias when choosing between test objects that matched exemplars in shape (or shape and another feature) versus either material only or color only. However, the shape bias in 3-year-old children was disrupted when they were asked to choose between objects that matched the exemplar in shape only or that matched the

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exemplar in two features (material and color). In contrast, 4-year-old children and adults generalized novel names by shape even when the other test objects had more features in common with the exemplar.

Explanations for novel noun generalization choices were dominated by shape for all age groups. Younger children's responses often described the shapes rather than explicitly noting "shape." For example, one 3-year-old child explained, "because it's got those bits." Older children were also likely to describe the shapes but also noted the sameness, for example, one 4-year-old child explained, "it's got the same bits, like a wheel." However, when objects matched in shape and another feature (e.g., shape and color), both 3- and 4-year-old children only ever provided one feature as an explanation for their choices. That is, children did not appear to take the co-occurrence of another feature into account when generalizing novel names. This is consistent with previous developmental research that suggests children perceive object similarity holistically and cannot separate dimensions (Kemler & Smith, 1978). In contrast, adults are able to attend to multiple commonalities between objects at the same time. Indeed, when objects matched in shape and another feature adults provided explanations for more than one feature (e.g., "it's the same shape and color"). That is, participants' explanations became more abstract and sophisticated across development.

Children's spontaneous comments were also predominately about objects' shapes. Interestingly, children made predominantly more shape-based comments to each of the test objects, including the exemplars. This is particularly notable because the exemplars shared either two or three features with the other objects present. Thus, children should have been just as likely (or even more likely) to spontaneously comment on the non-shape features of the exemplars (i.e., material and color). In addition, the significant number of shape-based spontaneous comments in reference to the exemplars suggests that preschool children attend

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to objects' shapes without any prompting (see also, Samuelson & Smith, 2005). Clearly, however, preschool children do sometimes generalize novel names on the basis of function rather than appearance (Kemler Nelson, Frankenfield, Morris, & Blair, 2000), particularly when function is clearly related to object properties. Nevertheless, because the majority of children's spontaneous comments were explicitly about the objects' appearances, including comparing them to artifacts, these data suggest that children were more interested in what objects looked like rather than their possible functions.

This paper makes several important contributions to the extant word learning literature. Specifically, this study is the first to systematically vary the number of features shared among test stimuli. Building on research by Samuelson & Horst (2007), we systematically manipulated whether the shape-matches as well as the other test objects shared one or two features with the exemplar with the same participants. Like Samuelson and Horst (2007), we found that children's novel noun generalization behavior was influenced by the number of features shared between the test objects and exemplars. As such, this paper adds to our growing understanding of the importance of stimuli effects in early word learning tasks (see also, Jones & Smith, 1998; Jones, et al., 1991; Samuelson & Horst, 2007). For example, when asked to generalize a novel name to objects that matched the exemplar only in shape or to objects that matched the exemplar in both material and color, 3- but not 4-year-old children generalized to the object that shared more properties. This suggests that the shape bias is stronger in 4-year-old children. When asked to generalize a novel noun to objects that matched the exemplar in material only or color only, 4- but not 3-year-old children stopped behaving systematically. Again, this suggests that 4-year-old children may rely so heavily on shape when generalizing novel names that they have no other features to fall back on when shape is removed from the equation.

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Second, this is the first study to explore children's explanations for their behavior in a novel noun generalization task. Previous research has explored children's explanations in other tasks, for example, 4-5-year-old children's use of the "min strategy" for arithmetic problems (e.g., Siegler & Jenkins, 1989), 5-year-old children's strategies for connecting the dots (e.g., Winsler&Naglieri, 2003), 5-9-year-old children's understanding of balance-scale problems (e.g., Pine, et al., 2004) and 7-9-year-old children's understanding of water displacement (e.g., Siegler & Chen, 2008). Such research has provided important insights into children's cognitive development. For example, children understand that strategies make tasks easier, such as grouping familiar items (e.g., sets of clothes and sets of toys) improves recall for individual items (Carr & Schneider, 1991). However, very little research has explored children's recollection of strategy use in language tasks (but see Farrington-Flint, Vanuxem-Cotterill and Stiller, 2009 on reading and spelling). The current study is the first to demonstrate that preschool children can also reason about their own behavior in word learning tasks. As in other tasks, children were able to provide task-relevant responses for their explanations (e.g., describing the objects' shapes). What remains unclear, however, is whether children were simply aware that they had chosen the shape-match or whether they were explicitly aware of the overall importance of shape in object naming. This study takes a first step toward understanding children's emerging understanding of their word learning strategies, but additional research is needed to explore the depth and complexity of children's understanding of their own word learning biases.

Finally, we extend the previous research on toddlers' spontaneous comments to novel objects to preschool children (cf. Samuelson & Smith, 2005). Specifically, we demonstrate that preschool children's spontaneous comments about novel objects are predominantly shape-based, even when objects share multiple features with other objects present. This is an important extension of the work by Samuelson and Smith (2005). As the authors point out in

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their discussion, their young subjects may have provided predominantly shape-based comments because of their relatively small productive vocabularies. For example, they likely did not produce some of the non-shape words our subjects used such as “fluffy,” “sparkly,” “scratchy” and color terms. Children in the current study could produce these words (they sometimes did) yet the majority of their comments referred to the objects’ shapes. Samuelson and Smith (2005) also noted that they used a relatively small number of novel objects (five in Experiment 1, 12 in Experiment 2) and that a replication with more objects was needed. In the current study we obtained spontaneous comments for 30 novel objects. Importantly, with older children and more objects we replicated the same general shape-dominated spontaneous speech observed by Samuelson and Smith (2005).

Overall, the current data illustrate that attention to shape dominates children’s and adults’ behavior in several word learning situations: how they generalize novel names, how they explain how they generalize novel names and their spontaneous speech. On the one hand, these data demonstrate that children’s shape bias is incredibly robust. It persists in a variety of tasks. On the other hand, these data indicate that children and adults become so fixated on shape that they appear to stop attending to and using other object features (e.g., color), even when these features perfectly co-occur with shape. Taken together, then, these findings provide novel insight into how both children and adults weigh multiple, shared features when encountering novel object categories.

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Table 1. Example utterances by type.

Type of Utterance	Example Utterance
Shape	These are legs, forgot the body. Got teeth. Look, it's a round hook.
Material	These are fluffy things. Feels like paper. Let me have the squidgy one.
Color	It's a green one. The black one. This is the same pink.
Non-feature-specific	That one's the same as that one. I like this one. Oooh, these are cool!

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Table 2. Verbal explanations as a function of object chosen. Underlined numbers indicate verbal explanations that matched the object chosen. *p < .05, **p < .01, ***p < .001.

Age	Shared feature	Verbal responses			
		Shape	Material	Color	Total
3 yrs	Shape	9*	3	3	15
	Material	3	2	3	8
	Color	2	0	1	3
	Shape & material	2	0	3	7
	Shape & color	2	0	1	4
	Material & color	n/a	n/a	n/a	n/a
4 yrs	Shape	17*	10	8	35
	Material	3	4	6	13
	Color	2	0	3	5
	Shape & material	9**	0**	4	13
	Shape & color	10*	1*	5	16
	Material & color	3	0	1	4
Adults	Shape	82***	2***	0***	84
	Material	1**	22***	1**	24
	Color	3	0*	8**	11
	Shape & material	29***	0***	2**	31
	Shape & color	19***	0***	1**	20
	Material & color	0	2	2	4

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Table 3. Number of Children's Spontaneous Comments by Feature and Referent Type.

Age		Referent	Feature-Based Comments Shape-Based	Material-Based	Color-Based	Total
3 yrs	Total Comments		65	38	43	146
	Total References		94	53	51	198
		Exemplar	31	16	16	63
		Shape-Match	14	7	10	31
		Material-Match	20	8	7	35
		Color-Match	12	8	5	25
		Shape-Material Match	8	4	7	19
		Shape-Color-Match	9	7	3	19
		Material-Color-Match	0	3	3	6
4 yrs	Total Comments		92	34	27	153
	Total References		126	45	33	204
		Exemplar	40	12	11	63
		Shape-Match	28	10	7	45
		Material-Match	18	8	6	32
		Color-Match	19	6	3	28
		Shape-Material Match	10	2	0	12
		Shape-Color-Match	5	5	1	11
		Material-Color-Match	6	2	5	13

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Figure 1. Stimuli used in the current experiment.

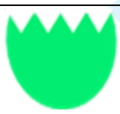
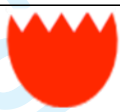
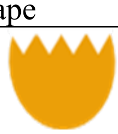
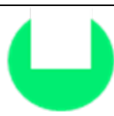
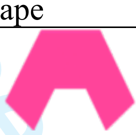
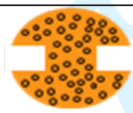
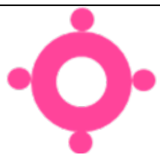
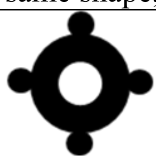
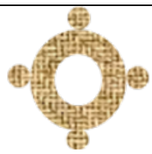
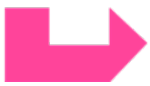
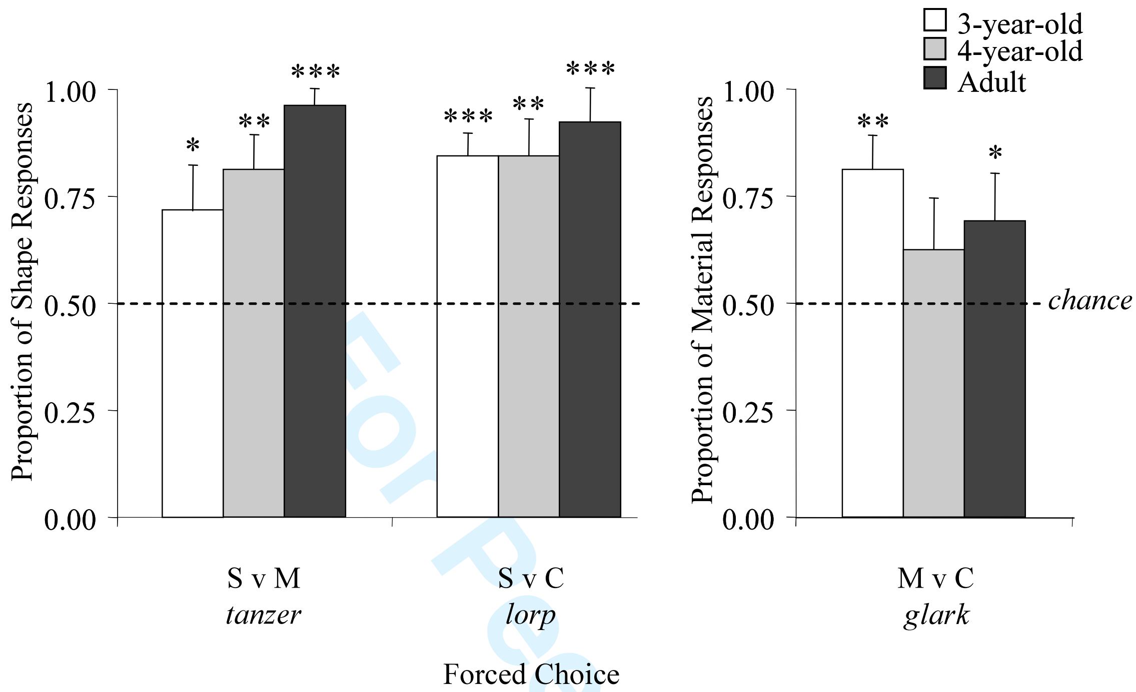
Set	Exemplar	Test Objects		Test Objects	
Tanzer	 Beige wood	 Black rubber	Gold scourer	 White wood	 Dark brown wood
		same shape		same material	
Lorp	 Green paper	 Red cardboard	 Tan bumpy clay	 Green felt	 Green fabric
		same shape		same color	
Glark	Yellow Sponge	 Blue sponge	 Pink sponge	Yellow polystyrene	Yellow plastic
		same material		same color	
Tife	 Orange cork	 Orange mesh	 Orange bumpy felt	 Purple cork	 Grey cork
		same shape, same color		same material	
Chatten	 Blue clay	 Red clay	 Black clay	 Blue foam	 Blue towel
		same shape, same material		same color	
Ratch	 Pink fluffy fabric	 Black wool	 Beige carpet	 Pink fluffy fabric	 Pink fluffy fabric
		same shape		same material, same color	

Figure 2. Proportion of shape responses (left panel) and material responses (right panel) for trials in which test objects shared one feature with the exemplar (Block 1).



Dotted line represents chance (.50). Error bars are one standard error from the mean. $^*p < .05$, $^{**} p < .01$, $^{***} p < .001$.

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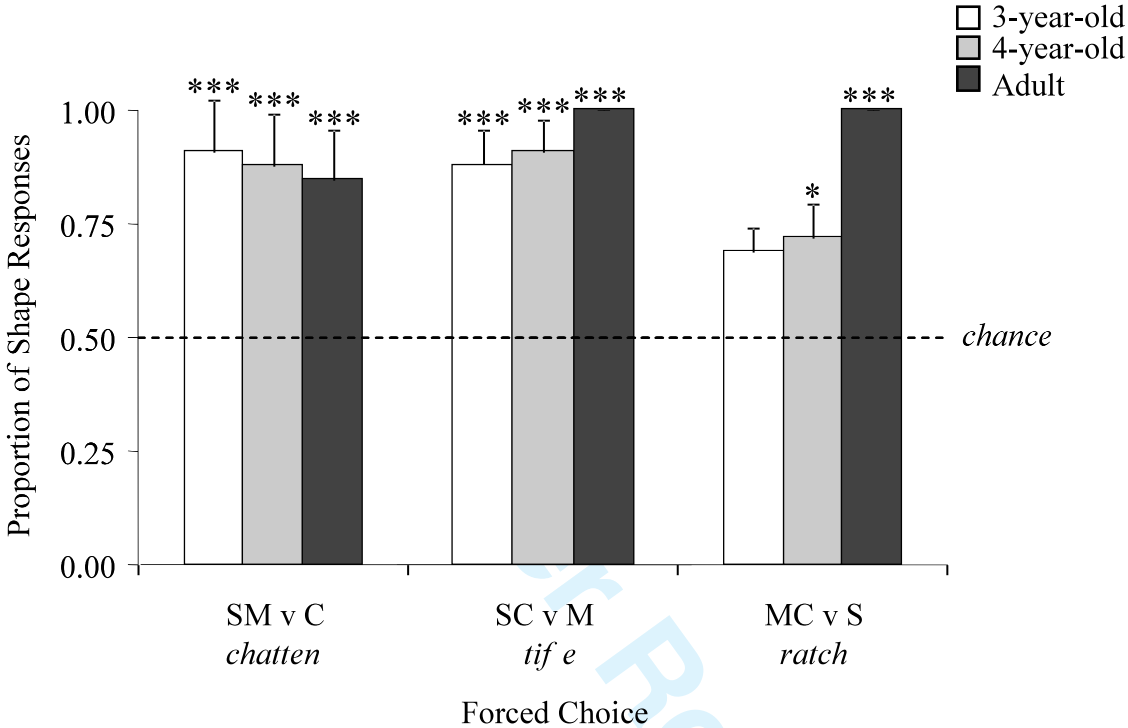
Figure 3. Proportion of shape responses for trials in which test objects shared one or two features with the exemplar (Block 2).



Dotted line represents chance (.50). Error bars are one standard error from the mean. * $p <$ .05, ** $p < .01$, *** $p < .001$.

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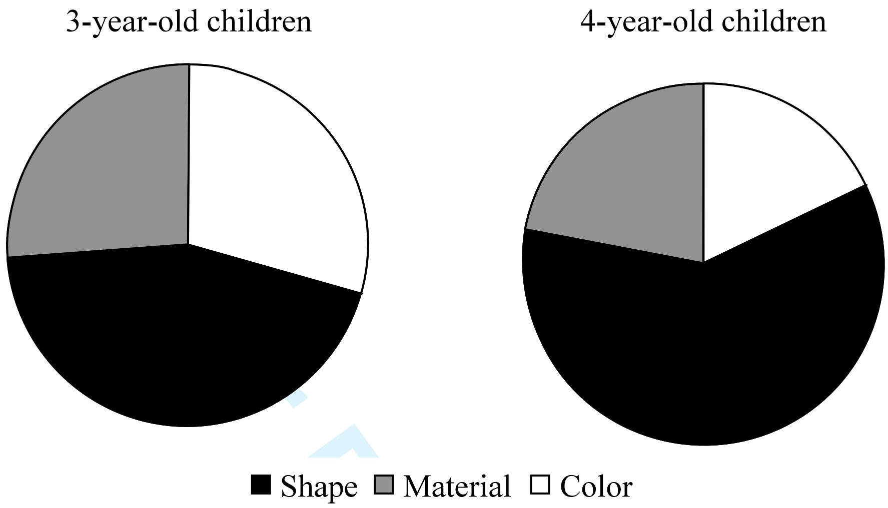
Figure 4. Proportion of children's spontaneous utterances by utterance type.



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