

PAPER

Perceptual complexity and form class cues in novel word extension tasks: how 4-year-old children interpret adjectives and count nouns

Catherine M. Sandhofer¹ and Linda B. Smith²

1. Department of Psychology, University of California, Los Angeles, USA

2. Department of Psychology, Indiana University, USA

Abstract

Two experiments examined the role of perceptual complexity, object familiarity and form class cues on how children interpret novel adjectives and count nouns. Four-year-old children participated in a forced-choice match-to-target task in which an exemplar was named with a novel word and children were asked to choose another one that matched the exemplar in either shape or material. In experiment 1, 56 children were provided with lexical form class cues suggestive of adjectives. The results of Experiment 1 showed that perceptual complexity and not object familiarity determined whether children made material or shape matches. In Experiment 2, 56 children were provided with lexical form class cues suggestive of count nouns. The results of Experiment 2 showed that neither perceptual complexity nor object familiarity affected children's selections in the matching task. When provided with lexical form class cues suggestive of a count noun, children selected shape matches. Thus the results suggest that the perceptual properties of the objects presented to children coupled with the particular lexical form class cue determine which features of objects children attend to when interpreting novel words.

Introduction

By most accounts adjectives are hard for young children to learn. Although young children have demonstrated one trial learning of nouns (Woodward, Markman & Fitzsimmons, 1994) and verbs (Tomasello & Kruger, 1992), adjective acquisition is often more difficult. Property terms, such as color, material and texture are difficult for children to learn and not as likely to be applied in fast mapping tasks as other terms, such as shape words (Heibeck & Markman, 1987). And studies designed to train children to use property terms may require as many as 2000 trials to teach three words (Rice, 1980).

However, more recent work has highlighted methods that make it more likely for preschoolers to link adjectives to object properties. In one study, Hall, Waxman and Hurwitz (1993) tested children on a novel adjective extension task. In this task children are shown an exemplar object, hear it labeled with a novel adjective, e.g. 'this is a very wuggish one', and then are asked to select another object that is 'also very wuggish'. The two choice objects

either matched the exemplar in shape (were of the same kind) or matched the exemplar in material (were of the same material kind). Hall *et al.* (1993) found that 4-year-old children were more likely to extend the novel adjective to objects of the same material if children were familiar with the basic level label of the objects. That is, children were more likely to choose objects that matched in material when the novel adjective was applied to an object with which they were familiar, e.g. a plate, than if the novel adjective applied to an object with which they were unfamiliar, e.g. a garlic press. Moreover, the difference in selecting material matches for familiar objects was found only when children were provided with form class cues that suggested adjectives. If the novel word was provided within a form class cue that suggested a count noun, e.g. 'this is a wug', children rarely chose a material matching object.

Children's tendency to make material matches only for familiar objects has been interpreted as evidence for a lexical constraint bias in children's word learning. Specifically, children expect an unfamiliar word to label an

unfamiliar object. If children already know a label for an object, then they expect an unfamiliar word to label some other property or aspect of the object. By this account children are biased to expect that a new word refers to the basic level label of an object, if and only if they do not already know the object's basic level name. Thus children fail to extend novel adjectives to other objects that match in property when provided with an unfamiliar exemplar because children expect the novel word to label the novel object regardless of the syntactic information pointing children towards an adjective interpretation of the novel word.

However Hall *et al.*'s (1993) findings that 4-year-olds can extend novel adjectives to other objects that match in property only when the objects are familiar, conflict with some other results in the literature. Specifically, Smith, Jones and Landau (1992) found that 3-year-olds could extend novel adjectives to other objects that match in a salient property even when using unfamiliar objects, and Landau, Smith and Jones (1992) found that 5-year-olds extended novel adjectives by texture even when they used unfamiliar objects. These results are seemingly at odds with Hall *et al.* (1993) because in each of these studies the objects presented to children were unfamiliar objects and thus by their proposal children should initially interpret the novel words as referring to things of the same shape or object kind.

Our goal in the present study is to provide a unifying account of these two sets of conflicting findings. Thus the central question for the present study is: Why are the 4-year-olds in the Hall *et al.* (1993) study unable to extend novel adjectives by property when presented with unfamiliar objects, but the 3-year-olds in the Smith *et al.* (1992) study and the 5-year-olds in the Landau *et al.* (1992) study are successful with unfamiliar objects? We propose that the discrepancy between the Hall *et al.* (1993) finding that children are unable to extend adjectives with unfamiliar objects and the Smith *et al.* and Landau *et al.* finding that children are able to extend adjectives to unfamiliar objects may be a result of the specific perceptual properties of the stimuli in the two cases. Specifically we suggest that this discrepancy in the literature may be due to differences in the object complexity of the familiar and unfamiliar objects. Both the Smith *et al.* (1992) and Landau *et al.* (1992) studies used very simple-shaped objects in their adjective extension task, for example an inverted U-shape or a circular shape with a wedge cut out. Thus although the objects were unfamiliar to children the shape complexity was relatively simple. The shape complexity of the objects used in Hall *et al.* (1993) is less clear. Several of the familiar objects used in their experiment are clearly simple in shape complexity, for example a plate and a cup, and

several of the unfamiliar objects used in their experiment are clearly more complex than these in shape, for example a garlic press and a set of tongs. It might be the case then, that the average object in the unfamiliar condition may present a more complex shape than the average object in the familiar condition. This is not surprising given that Hall *et al.* sought to control whether children were familiar with the names of the objects and many of the things that children are familiar with and learn to label early refer to relatively simple-shaped objects.

The idea that complexity and not familiarity might control children's patterns of responses in the word extension task is supported by previous findings by Imai and Gentner (1997) that show when Japanese 2-year-olds are presented with simple objects or materials they are likely to extend by material. However, when Japanese 2-year-olds are presented with complex objects they are likely to extend by shape. We ask whether this may be a more general influence. This question is an important one because if children are able to extend adjectives equally well regardless of familiarity as long as complexity is controlled it would mean that the form class cues themselves take precedence in how children map words to categories, rather than as Hall *et al.* (1993) suggest, children's prior knowledge about that specific category.

We test the idea that complex objects foster attention to shape whereas simple objects afford attention to properties other than shape regardless of children's familiarity with the object label by presenting children with objects that are either perceptually simple or complex and objects that are familiar and unfamiliar. If perceptual complexity matters for word extension we would expect children to more readily select objects that match in material when the objects are simple. However, if the perceptual complexity of the objects is unimportant for word learning we would expect to see no differences between the complex and simple objects. In Experiment 1 we use the word extension task using adjective form class cues. In Experiment 2 we present the same stimuli and same word extension task but use count noun form class cues.

Experiment 1

In Experiment 1 we ask whether children are more likely to extend novel adjectives to objects of the same material or shape when the objects are simple or complex and familiar or unfamiliar. We do so by providing children with a novel word in an adjectival syntactic frame. Previous work has shown that when novel words are presented with a form class cue suggestive of an adjective children extend the word to other objects that match by

property (Hall *et al.*, 1993; Landau *et al.*, 1992; Smith *et al.*, 1992).

The design of this study is borrowed and adapted from Hall *et al.* (1993).

Method

Participants

Fifty-six 4-year-olds participated. Half were male and half were female. The 4-year-olds ranged in age from 48 to 59 months with a mean age of 53.8 months. Fourteen children (7 boys and 7 girls) were randomly assigned to each of four conditions. Children were tested individually in their preschools during normal school hours or in the laboratory.

Design and materials

Subjects were assigned to one of four conditions. In each condition the stimuli presented varied in the level of shape complexity (simple vs. complex) and familiarity (familiar or unfamiliar). Simple shapes were defined as objects that were composed of one or two parts whereas complex shapes were defined as objects that were composed of many parts. We assessed the shape complexity of the objects by asking 10 undergraduates to rate each of the 48 objects used in the experiment on shape complexity using a 5-point scale. Objects that were judged as not very complex were given a score of 1 and objects that were judged as very complex were given a score of 5. Table 1 shows the mean complexity ratings for each of the four conditions. As can be seen, objects in the simple conditions were judged as less complex than objects in the complex conditions.

We defined objects as familiar if they were listed on the MacArthur Communicative Development Inventory: Words and Sentences (Fenson, Dale, Reznick, Bates, Thal & Pethick, 1994), a checklist of words known to 50% of all English-speaking children by 30 months of age. However, three words, *dinosaur*, *castle* and *heart* were not included on the MacArthur, but pre-testing indicated that these objects were known by many 4-year-old children. To ensure that unfamiliar objects were truly unfam-

Table 1 Shape complexity ratings for the four conditions

Condition	Rating
Simple familiar	1.41 (.59)
Simple unfamiliar	1.53 (.61)
Complex familiar	3.72 (.97)
Complex unfamiliar	3.94 (.91)

Note: Standard deviations are in parentheses.

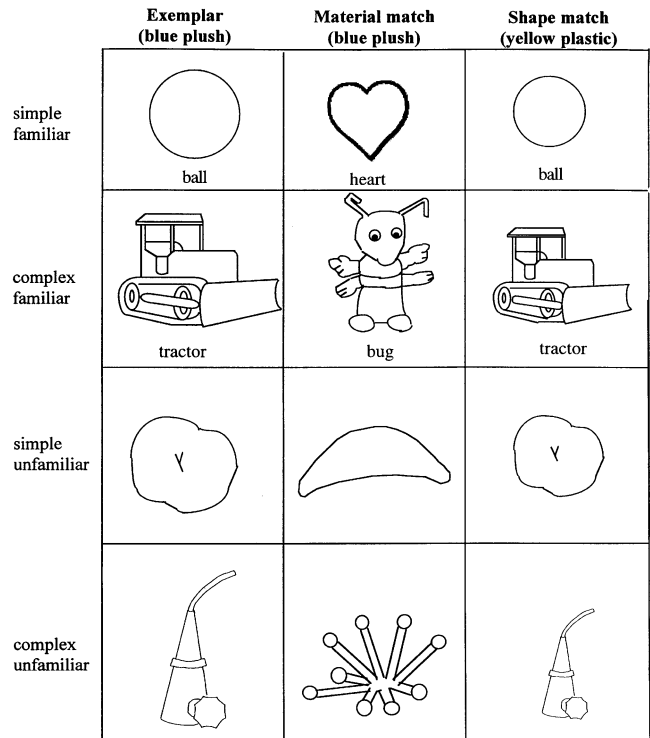


Figure 1 An example of the objects used in the novel word extension triads from each of the four conditions.

iliar to children, the unfamiliar objects were made in the laboratory and did not resemble any nameable objects. The complete description of objects for each condition is listed in the Appendix.

Four triads of objects were used in each condition. In each triad there was a target object, a shape matching object and a material matching object. The shape matching object matched the target in shape and object kind but differed in material kind and related properties such as color and texture. The material matching object matched the target in material kind and related properties but differed in shape and object kind. Figure 1 shows an example of a triad from each of the four conditions.

Procedure

The experiment had two parts. The novel adjective extension trials were always presented first and the familiarity trials were always presented second.

In the novel adjective extension trials, the experimenter presented the child with a target object and labeled it with a novel adjective, 'See this? This is a very wug-ish one.' The child was asked to repeat the novel word. The novel adjective was then repeated at least three times, each time in an adjectival syntax. The two choice objects,

the shape matching object and material matching object, were then placed in front of the child and the target object was placed behind the two choice objects. The child was then asked to 'Show me another one that is very wug-ish.' The novel words used were blick-ish, fep-ish, wug-ish and zav-ish. Both the order of triad presentation and the novel word assigned to each triad were randomly determined for each child.

In order to determine that the objects intended to be familiar to children were indeed familiar and that objects intended to be unfamiliar were indeed unfamiliar, children next participated in a familiarity assessment. The familiarity assessment began with three 'training trials' designed to encourage children to respond 'I don't know' when the object was unfamiliar to them. Children were first presented with a shoe and asked, 'What is this?' When the children responded, 'shoe' they were verbally praised for responding with a correct answer. Children were next presented with two trials of unfamiliar objects and asked, 'What is this?' If children responded, 'I don't know' they were verbally praised. If a child responded with an object name, for example, 'It looks sort of like a mitten', the child was reminded that it wasn't really a mitten and was encouraged to respond 'I don't know' to objects they didn't know a name for; children were then verbally praised for an 'I don't know' response. Children were next presented with the 12 objects from the adjective extension trials, one at a time in a random order. For each object children were asked, 'What is this?' and no feedback was provided.

Results and discussion

We first asked whether the objects we deemed as familiar were indeed familiar to children and the objects we deemed unfamiliar were indeed unfamiliar. Children responded with an appropriate label for the objects in the simple familiar condition 97% of the time on average and for objects in the complex familiar condition 91% on average. In contrast children responded that they did not know the name of the objects in the simple unfamiliar condition 89% of the time on average and for the objects in the complex unfamiliar condition 71% of the time on average. The remainder of responses in the two unfamiliar conditions involved children providing a description of the object, e.g. a green thing, an inappropriate object name, e.g. that looks like a tooth, correctly naming a piece of the object, e.g. it has a ribbon on it, or providing the novel adjective, e.g. wug-ish. Thus, the results of the familiarity trials confirm that the objects in the two familiar conditions were largely familiar to children and the objects in the two unfamiliar conditions were largely unfamiliar to children.

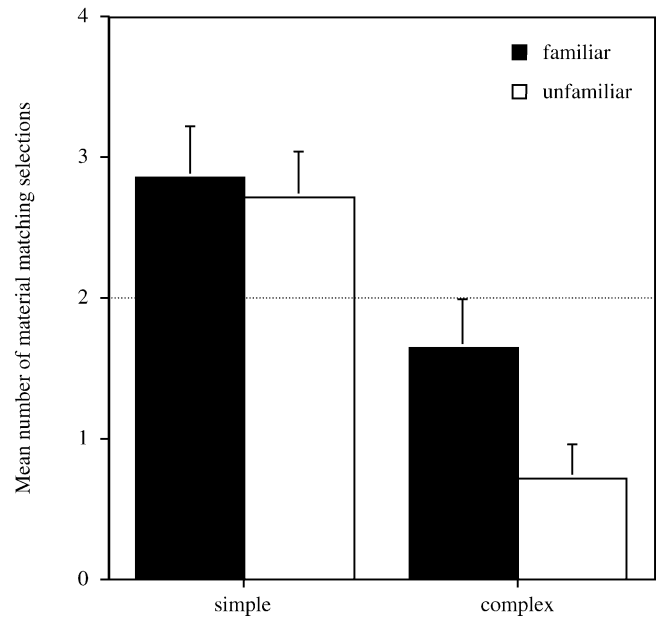


Figure 2 The mean number of material matches made by children in Experiment 1.

We next examined children's performance in the adjective extension trials. Figure 2 shows the mean number of material matching selections children made in each of the four conditions. As can be seen, the number of material choices was higher in the two simple conditions than in the two complex conditions. An ANOVA conducted on the number of material choices confirmed this and revealed a main effect of complexity $F(1, 52) = 25.19, p < .01$, but no effects of familiarity, $F(1, 52) = 2.7$ and no interaction $F(1, 52) = 1.5$. Tukey's HSD revealed no significant differences between children's performance in the familiar simple and unfamiliar simple conditions ($p > .05$) and no significant difference but a marginal effect between children's performance in the familiar complex and unfamiliar complex conditions ($p < .10$). Thus, as a whole the results suggest that the shape complexity of the object affects whether children generalize a novel adjective to a material match or to a shape match.

We next compared children's selections to chance. If children responded randomly they would be expected to make material match selections in two of the four trials. The results showed that children made more material match selections than expected by chance in the simple familiar condition, $t(13) = 2.38, p < .05$, and in the simple unfamiliar condition, $t(13) = 2.22, p < .05$. Children also made less material matches than expected by chance in the complex unfamiliar condition, $t(13) = -5.26, p < .01$. Thus children exceed the number of material matches predicted by chance performance in the two simple conditions, but selected equal to or less material matches

Table 2 Number of children making three or four material kind selections out of four

	Simple	Complex
Experiment 1:		
Adjective:		
Familiar	9**	5
Unfamiliar	9**	1*
Experiment 2:		
Count noun:		
Familiar	0*	0*
Unfamiliar	0*	0*

Note: $N = 14$ per condition.

*Significantly below chance, $p < .05$.

**Significantly above chance, $p < .05$.

than predicted by chance in the two complex conditions. That is, in the complex condition familiarity with the object did not push children toward making material selections, but rather pushed children's performance to chance.

Following Hall *et al.* (1993) we classified children based on their performance on all four trials. We classified children who made three or four material match selections as having made a material interpretation of the novel adjective. Table 2 shows the number of children falling into this classification for each of the four conditions. We then used the binomial theorem to determine whether in any condition more children made a material interpretation of the novel adjective than would be expected by chance. The probability of any one child making three or four material match selections is .3125. For 14 children, if eight or more children made three or more material selections then performance exceeded chance, $p < .05$, and if one or less children made three or more material selections then performance was below chance, $p < .05$. Thus the number of children making material match selections exceeded chance for the two simple conditions and the number of children making material match selections was below chance in the complex unfamiliar condition. Chi-square analyses revealed no significant differences between children's performance in the familiar simple and unfamiliar simple conditions ($\chi^2(1) = 0$) and no significant difference but a marginal effect between children's performance in the familiar complex and unfamiliar complex conditions ($\chi^2(1) = 2.6$, $p < .10$).

Finally we asked whether knowing the object name made individual children more or less likely to match that object by material. One object included in the study made a nice test case for this question. We selected 'sprinkler' as a complex familiar object in part because it was listed on the MacArthur Communicative Developmental Inventory indicating that over 50% of all 30-month-olds had produced the term. Thus we expected that 4-year-

Table 3 Number of material and object selections for children who did and did not produce the label 'sprinkler'

	Produced 'sprinkler'	Did not produce 'sprinkler'
Object match	4	4
Material match	3	3

old children should be able to readily identify the object. However, only seven of the 14 48–60-month-olds were able to appropriately identify the object as a 'sprinkler' or a 'sprayer'. We thus asked whether correctly labeling the object coincided with more or less material choice matches. Table 3 presents the distribution of material and object matches for the seven children who produced 'sprinkler' and the seven children who responded 'I don't know' when asked what the sprinkler was. As can be seen the distributions are exactly equal, suggesting that the ability to produce the basic level object name does not affect whether children are more or less likely to make a material kind selection.

Experiment 2

In Experiment 2 we again ask whether children are more likely to extend novel words to objects of the same material or shape when the objects are simple or complex and familiar or unfamiliar. We do so by providing children with a novel word with a count noun form class cue. If children are able to use the information contained in the form class cues then they should extend the novel word to other objects that match an exemplar in shape. If instead children are relying solely on the perceptual information of the particular objects presented, then we should expect children's pattern of extension to look like that of Experiment 1.

Method

Participants

Fifty-six 4-year-olds participated. Half were male and half were female. The 4-year-olds ranged in age from 48 to 59 months with a mean age of 54.7 months. Fourteen children (7 boys and 7 girls) were randomly assigned to each of four conditions. Children were tested individually in their preschools during normal school hours.

Materials and design

The materials and design were identical to those of Experiment 1.

Procedure

The procedure was the same as Experiment 1 with one important change. The novel adjective extension trials were replaced with novel noun extension trials. In the novel noun extension trials, the experimenter presented the child with a target object and labeled it with a novel count noun, 'See this? This is a wug.' The child was asked to repeat the novel word. The novel noun was then repeated at least three times, each time in a count noun syntax. The two choice objects, the shape matching object and material matching object, were then placed in front of the child and the target object was placed behind the two choice objects. The child was then asked to 'Show me another wug.' The novel words used were *blick*, *fep*, *wug* and *zav*. Both the order of triad presentation and the novel word assigned to each triad were randomly determined for each child.

Results and discussion

To confirm the findings of the first experiment, we again asked whether the objects we deemed as familiar were indeed familiar to children and the objects we deemed unfamiliar were indeed unfamiliar. Children responded with an appropriate label for the objects in the simple familiar condition 97% of the time on average and for objects in the complex familiar condition 91% on average. In contrast, children responded that they did not know the name of the objects in the simple unfamiliar condition 97% of the time on average and for the objects in the complex unfamiliar condition 91% of the time on average. The remainder of responses in the two unfamiliar conditions involved children providing a description of the object, e.g. a green thing, an inappropriate object name, e.g. that looks like a tooth, correctly naming a piece of the object, e.g. it has a ribbon on it, or providing the novel noun, e.g. a wug. Thus, the results of the familiarity trials confirm that the objects in the two familiar conditions were largely familiar to children and the objects in the two unfamiliar conditions were largely unfamiliar to children.

We next examined children's performance in the extension trials. Figure 3 shows the mean number of material matching selections children made in each of the four conditions. As can be seen, children generalized the novel name to the material matching object infrequently in all four conditions. An ANOVA conducted on the number of material choices revealed no main effects and no interactions. Thus, when children are provided with count noun form class cues, neither the shape complexity of the objects nor children's familiarity with the basic level label of the objects affect whether children

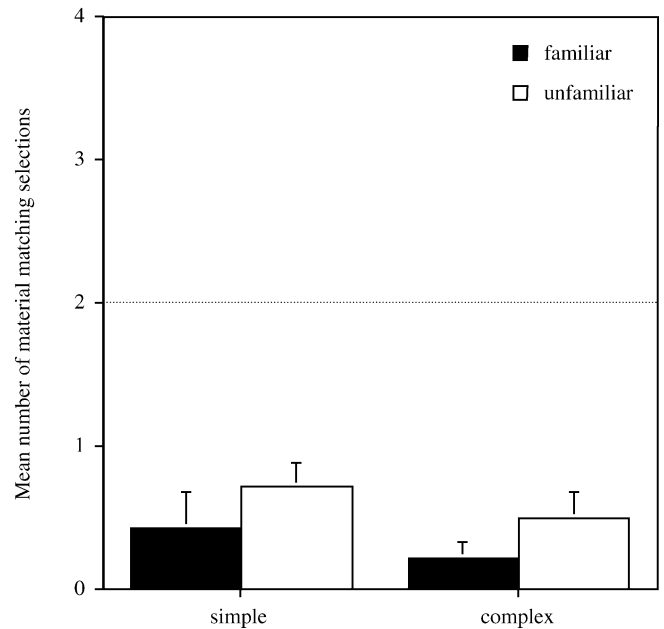


Figure 3 The mean number of material matches made by children in Experiment 2.

generalize a novel count noun to a material match or to a shape match. That is, children generalize by shape regardless of the particular object and its perceptual properties.

We next compared children's selections to chance. If children responded randomly they would be expected to make material match selections in two of the four trials. The results showed that children made less material match selections than expected by chance in all conditions: the simple familiar condition, $t(13) = -6.27$, $p < .01$, the simple unfamiliar condition, $t(13) = -7.87$, $p < .01$, the complex familiar condition, $t(13) = -15.69$, $p < .01$, and the complex unfamiliar condition, $t(13) = -8.63$, $p < .01$. Thus these results confirm that children made less material matches, that is more shape matches, than expected by chance regardless of the particular object condition.

Again, following Hall *et al.* (1993), we classified children based on their performance on all four trials. We classified children who made three or four material match selections as having made a material interpretation of the novel adjective. Table 2 shows the number of children falling into this classification for each of the four conditions. We then used the binomial theorem to determine whether in any condition more children made a material interpretation of the novel adjective than would be expected by chance. The probability of any one child making three or four material match selections is .3125. For 14 children, if eight or more children made three or more material selections then performance exceeded

chance, $p < .05$, and if one or less children made three or more material selections then performance was below chance, $p < .05$. Thus the number of children making material match selections was below chance in all four conditions.

General discussion

These results provide new insight into the circumstances in which children extend novel adjectives and count nouns to objects that match in material or shape. We found that the shape complexity of particular objects and not children's familiarity with the basic level object label affected whether children would extend novel adjectives to objects that matched in material. Thus these findings are consistent with previous results that children can extend novel adjectives to other unfamiliar objects that match in a property as long as the objects are simple (Smith *et al.*, 1992; Landau *et al.*, 1992). However, these results contradict previous findings (Hall *et al.*, 1993; Markman & Wachtel, 1988) that suggest that children's familiarity with the basic level object label is crucial to whether they are able to extend novel adjectives to other objects that match in other properties. We discuss a unifying interpretation of these findings below. In addition we found that when a novel noun is presented within a count noun form class cue, children extend the novel count noun to other objects that match in shape regardless of the shape complexity of the particular objects or children's familiarity with the basic level object label. Thus, this finding suggests that form class cues play an important role in determining children's extensions of new words.

Shape complexity and the perceptual properties of objects

The central question of the present study was why the 4-year-olds in the Hall *et al.* (1993) study were unable to extend novel adjectives by property when presented with unfamiliar objects, but the 3-year-olds in the Smith *et al.* (1992) study and the 5-year-olds in the Landau *et al.* (1992) study were successful when presented with unfamiliar objects. The results of the present experiment suggest that the difference may be due to the differences in shape complexity of the objects between the different experiments. That is, the unfamiliar objects in the Hall *et al.* experiment may have been more complex in shape than were the objects in the Smith *et al.* and Landau *et al.* studies.

Several studies have demonstrated that children respond differently in word extension tasks based on the perceptual information of objects in word extension tasks even

when the form class cues are held constant. For example, Japanese-speaking 2-year-olds extend novel nouns differently for simple and complex objects (Imai & Gentner, 1997). English-speaking children extend novel nouns to solid objects with the same shape, but extend novel nouns to non-solid substances with the same material (Soja, 1992; Dickinson, 1988; Imai & Gentner, 1997). And children can extend novel nouns to objects that share the same function, when the function of objects is demonstrated and made salient (Kemler-Nelson, 1995). Thus the present results are lent support by two previous findings. First, the findings that children use the specific perceptual properties of an object to determine which properties to attend to when choosing other objects that share the same label, and second the finding that Japanese-speaking children extend complex shaped novel nouns differently than simple shaped nouns.

Why might complexity push children's attention to shape – that is, away from making material matches when provided with a novel adjective? We suggest four possible explanations. First, the complex shaped objects may simply be more salient to children in the same sort of way that glowing colors are more salient than non-glowing colors. As a result children would attend to the complex shape more than the simple shape when hearing the novel adjective and thus children would be more likely to map the word to what they are attending to – the shape of the object. Second, complex objects, objects like tractors with multiple parts, may have more distinct features than simple objects, like balls. Importantly, adjectives do *not* refer only to materials or textures. Adjectives may refer to shape, e.g. curvy, round, angular, to featural components, e.g. complex, knobby, sharp, and to evaluative aspects, e.g. nice, important, ugly. Complex objects may foster attention to shape because children are more likely to map the adjective onto the shape based properties of the object when there are more aspects of the object to attend to. Third, structure mapping theory predicts that when the level of surface or perceptual similarity is high, it will lead to a perceptual match (Gentner, 1983; Gentner & Toupin, 1986; Markman & Gentner, 1993). Complex objects have more parts than simple objects, and thus complex objects of the same kind share more alignable parts than simple objects of the same kind. Thus for complex objects with higher surface similarity between two like kinds and more alignable parts, children may be more likely to be led to make a shape match. Fourth, complex objects tend on average to be more distant from other complex objects in similarity space, whereas simple objects, by virtue of being simply shaped tend to group together in similarity space (Colunga & Smith, under review). The nearer in similarity space an object is to a standard the more likely it is that children will

extend a novel adjective or other label to the object (Rosch & Mervis, 1975; Barsalou, 1982; Smith, 1989; Goldstone, Medin & Gentner, 1991; Ratterman & Gentner, 1998; Paik & Mix, under review). Future studies should address how the perceptual properties of an object encourage or discourage adjective extension in children.

Form class cues

The second finding of the present study is that the particular lexical form class cues partially determine whether children will extend novel words to other objects that match in shape or to other objects that match in material. Specifically, when children were provided with form class cues that indicated a count noun, e.g. 'This is a wug', children selected other objects that matched the exemplar in shape. However, when children were provided with form class cues that suggested an adjective, e.g. 'This is a very wuggish one', children's selections varied depending on the perceptual complexity of the exemplar. Thus, form class cues provided children with an important cue as to which features to attend to. This result is supported by previous research (Smith *et al.*, 1992; Hall & Moore, 1997; Hall, Quantz & Personage, 2000; Klibanoff & Waxman, 2000; Waxman & Markow, 1998) showing that preschoolers can distinguish between count noun and adjective form class cues and that in the absence of form class cues perform at chance levels.

However, what remains unclear is how well 4-year-olds actually understand adjective form class cues. The 4-year-olds in the present study were strongly pulled toward objects that matched the exemplar in shape when provided with a count noun form class cue, and in other studies children as young as 2 will extend novel nouns to other objects that match in shape (Woodward *et al.*, 1994). However, the 4-year-olds in the present experiments were swayed by the perceptual features of the objects when provided with adjectival syntax, and numerous studies have documented that when 2- and 3-year-olds are provided with adjective form class cues they do not extend the novel adjective to other objects that match in property (Hall *et al.*, 1993; Hall & Moore, 1997). All together this suggests that even by age 4 – an age at which children are fairly sophisticated language users – children have at best a tenuous understanding of how adjective form class cues map to properties. One reason for this may be that the construction 'This is a very ____-ish one' rarely occurs in input to children versus the count noun construction 'This is a ____'. In other studies where children are given stronger cues to the adjectival status of the novel word by showing the child multiple examples (e.g. here is a modi one, here is another modi one) children are able to extend novel adjectives to

texture, shape and other object properties (Akhtar & Montague, 1999; Klibanoff & Waxman, 2000; Mintz & Gleitman, 2002). These types of studies may more closely match naturalistic situations. By most accounts children are not one trial learners of adjectives (Mintz & Gleitman, 2002; Sandhofer & Smith, 1999; Rice, 1980). This suggests that if given stronger cues as to the adjectival nature of novel words even young children can succeed at extending novel adjectives. Children learning languages that strongly mark the adjective status of words should be more likely to extend the novel word earlier than children learning languages that do not clearly mark the adjective status of words. Support for this idea comes from studies of children learning Japanese, a language in which 'there is no syntactic marker to distinguish names for particular individuals, object kinds, and substances, nor is there normally any singular/plural marking' (Haryu & Imai, 2002, p. 1379). Given familiar objects, Japanese-speaking children do not extend novel words to materially matching objects that differ in shape from a standard (Imai & Haryu, 2001; Haryu & Imai, 2002).

Moreover, even if children can detect that the novel word is meant to be an adjective the properties that accompany an adjective vary greatly. Adjectives can refer to size, material, shape, degree of wetness, etc. And children and adults are more likely to extend novel adjectives to similar objects for some types of adjectives more than others (Graham, Welder & McCrimmon, 2003). Thus even strong form class cues that indicate an adjective are not predictive of a specific property, in the same way that count nouns predict shape matches.

The role of familiarity

The literature on children's word learning widely cites familiarity with the basic level category as an important contributor to helping children learn adjectives. There are three ways that familiarity has been proposed to help learn new words.

First, familiarity with an object could matter in that knowing something about an object should speed learning and create a greater depth of processing. That is, knowing something about jet propulsion engines should speed learning something new about jet propulsion engines and knowing something about elephants should speed differentiating African and Asian elephants. In this way familiarity should help children extend novel words to subordinate categories (e.g. Imai, 1999).

Second, familiarity with an object could constrain children's knowledge about the kinds of properties that are relevant features. That is, knowing about cups and how they are used should make the ability to hold liquid become a more salient property of cups and color

become a less salient property of cups. In this way, familiarity with an object should affect the types of deviations from a standard object children are willing to accept.

But the question being asked in the literature about children's word extensions is whether familiarity with the noun category makes it easier for children to learn some other class of words and thus the third way that familiarity with an object has been proposed to help children is that familiarity with the category's basic level label constrains children from mapping new words onto the basic level category (e.g. Markman, 1989; Markman & Hutchinson, 1984). That is if children know that the basic level object label is cup, on hearing 'it's very daxy' children will abandon the tendency to map 'daxy' onto the cup category since that slot is already filled and instead will look for other likely aspects of the object to which 'daxy' could refer. One potential problem with this account is that being familiar with the basic level category label *does not hinder* children from mapping a novel name onto a familiar object. That is hearing a cup labeled as 'a dax', does not appear to prevent children from mapping the novel word onto by category or shape, as would be expected if children were looking for other aspects of the object as potential referents.

The evidence presented in this study provides at best very weak evidence that familiarity may help children extend novel adjectives when children are presented with perceptually complex objects. And previous studies such as Markman and Wachtel's (1988) landmark study de-

monstrating familiarity effects may have unintentionally confounded perceptual complexity with familiarity as they contrasted children's ability to extend labels for a pair of tongs (unfamiliar but relatively perceptually complex) and a cup (familiar but relatively perceptually simple). However, more clear-cut cases of a familiarity effect have been found for classes of words including subordinates (Imai, 1999), proper nouns (Hall, 1991) and part terms (Markman & Watchel, 1988). As a whole this suggests that familiarity with an object may play some contributory role in helping children extend new words; however, that role may be more limited than previously thought: knowledge about the basic level category may not be critical to adjective learning.

Conclusion

In sum, these findings provide a unifying account of previous discrepant results in the literature. One reason why Hall *et al.* may have found that familiarity with a basic level label is necessary for enabling children to extend novel words by properties other than shape may have had much to do with the particular perceptual properties of the stimuli presented to children. The central finding of the present study is that the perceptual properties of the objects presented to children coupled with the particular form class cue determine which features children will choose to extend novel words.

Appendix

Condition	Exemplar object	Shape match	Material match
Simple familiar	Blue plush ball Natural wood bucket Silver metal spoon Pink paper cup	Yellow plastic ball Brass bucket White plastic spoon Green vinyl cup	Blue plush heart Natural wood apple Silver metal key Pink paper plate
Simple unfamiliar	Blue plush dimple Wood cake flower tool Silver metal elbow pipe Pink paper blob	Yellow plastic dimple Brass cake flower tool White plastic elbow pipe Green vinyl blob	Blue plush slug-shape Wood yin-yang shape Silver metal T-shape Pink paper pac-man
Complex familiar	Blue plush tractor Natural wood house Silver metal sprinkler Paper dinosaur	Yellow plastic tractor Brass house Plastic sprinkler Vinyl dinosaur	Blue plush bug Natural wood bunny Silver metal lamp Paper castle
Complex unfamiliar	Blue plush cone with rings and knob Wood c-clamp shape Silver metal molecule Pink paper child's fortune teller	Yellow plastic cone with rings and knob Brass c-clamp shape White plastic molecule Green vinyl child's fortune teller	Blue plush object with appendages Wood yin-yang shape Silver metal plate hanger Pink paper origami shape

Acknowledgements

This study was supported in part by a National Institute of Mental Health grant F31MH12614 to the first author. Portions of this research were presented at the Twenty-third Annual Conference of the Cognitive Science Society, Edinburgh, Scotland, 2001. We gratefully acknowledge an anonymous reviewer for thoughtful criticism and comments.

References

- Akhtar, N., & Montague, L. (1999). Early lexical acquisition: the role of cross-situational learning. *First Language*, **19**, 347–358.
- Barsalou, L.W. (1982). Context-independent and context-dependent information in concepts. *Memory and Cognition*, **10**, 82–93.
- Colunga, E., & Smith, L.B. (under review). A connectionist account of the object-substance distinction in early noun learning.
- Dickinson, D. (1988). Learning names for materials: factors limiting and constraining hypotheses about word meaning. *Cognitive Development*, **3**, 15–35.
- Fenson, L., Dale, P.S., Reznick, J.S., Bates, E., Thal, D., & Pethick, S. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, **5**, whole serial number 242.
- Gentner, D. (1983). Structure mapping: a theoretical framework for analogy. *Cognitive Science*, **7**, 155–170.
- Gentner, D., & Rattermann, M.J. (1991). Language and the career of similarity. In S.A. Gelman & J.P. Byrnes (Eds.), *Perspectives on language and thought: Interrelations in development* (pp. 225–277). Cambridge: Cambridge University Press.
- Gentner, D., & Toupin, C. (1986). Systematicity and surface similarity in the development of analogy. *Cognitive Science*, **10**, 277–300.
- Goldstone, R.L., Medin, D.L., & Gentner, D. (1991). Relational similarity and the nonindependence of features in similarity judgments. *Cognitive Psychology*, **23**, 222–262.
- Graham, S.A., Welder, A.N., & McCrimmon, A.W. (2003). Hot dogs and zavy cats: preschoolers' and adults' expectations about familiar and novel adjectives. *Brain and Language*, **84**, 16–37.
- Hall, D.G. (1991). Acquiring proper nouns for familiar and unfamiliar animate objects: two-year-olds' word-learning biases. *Child Development*, **62**, 1142–1154.
- Hall, D.G., & Moore, C.E. (1997). Red bluebirds and black greenflies: preschoolers' understanding of the semantics of adjectives and count nouns. *Journal of Experimental Child Psychology*, **67**, 236–267.
- Hall, D.G., Quantz, D.H., & Personage, K.A. (2000). Preschoolers' use of form class cues in word learning. *Developmental Psychology*, **36**, 449–462.
- Hall, D.G., Waxman, S.R., & Hurwitz, W. (1993). How two- and four-year-old children interpret adjectives and count nouns. *Child Development*, **64**, 1651–1664.
- Haryu, E., & Imai, M. (2002). Reorganizing the lexicon by learning a new word: Japanese children's interpretation of the meaning of a new word for a familiar artifact. *Child Development*, **73**, 1378–1391.
- Heibeck, T., & Markman, E. (1987). Word learning in children: an examination of fast mapping. *Child Development*, **58**, 1021–1034.
- Imai, M. (1999). Constraint on word-learning constraints. *Japanese Psychological Research*, **41**, 5–20.
- Imai, M., & Gentner, D. (1997). A cross-linguistic study of early word meaning: universal ontology and linguistic influence. *Cognition*, **62**, 169–200.
- Imai, M., & Haryu, E. (2001). Learning proper nouns and common nouns without clues from syntax. *Child Development*, **72**, 787–802.
- Kemler-Nelson, D.G. (1995). Principle-based inferences in young children's categorization: revisiting the impact of function on the naming of artifacts. *Cognitive Development*, **10**, 347–380.
- Klibanoff, R., & Waxman, S.R. (2000). Basic-level object categories support the acquisition of novel adjectives: evidence from preschool aged children. *Child Development*, **71**, 649–659.
- Landau, B., Smith, L.B., & Jones, S.S. (1992). Syntactic context and the shape bias in children's and adults' lexical learning. *Journal of Memory and Language*, **31**, 807–825.
- Markman, A.B., & Gentner, D. (1993). Structural alignment during similarity comparisons. *Cognitive Psychology*, **25**, 431–467.
- Markman, E. (1989). *Categorization and naming in children: Problems of induction*. Cambridge, MA: MIT Press.
- Markman, E., & Hutchinson, J.E. (1984). Children's sensitivity to constraints on word meaning: taxonomic versus thematic relations. *Cognitive Psychology*, **16**, 1–27.
- Markman, E., & Wachtel, G. (1988). Children's use of mutual exclusivity to constrain the meanings of words. *Cognitive Psychology*, **20**, 121–157.
- Mintz, T.H., & Gleitman, L.R. (2002). Adjectives really do modify nouns: the incremental and restricted nature of early adjective acquisition. *Cognition*, **84**, 267–293.
- Paik, J., & Mix, K. (under review). Preschoolers' use of surface similarity in object comparisons: taking context into account.
- Rattermann, M., & Gentner, D. (1998). More evidence for a relational shift in the development of analogy: children's performance on a causal-mapping task. *Cognitive Development*, **13**, 453–478.
- Rice, N. (1980). *Cognition to language*. Baltimore, MD: University Park Press.
- Rosch, E., & Mervis, C.B. (1975). Family resemblance: studies in the internal structure of categories. *Cognitive Psychology*, **7**, 573–605.
- Sandhofer, C., & Smith, L.B. (1999). Learning color words involves learning a system of mappings. *Developmental Psychology*, **35**, 668–679.

- Smith, L.B. (1989). From global similarities to kinds of similarities: the construction of dimensions in development. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogy* (pp. 146–178). New York: Cambridge University Press.
- Smith, L.B., Jones, S.S., & Landau, B. (1992). Count nouns, adjectives, and perceptual properties in children's novel word interpretations. *Developmental Psychology*, **28**, 273–286.
- Soja, N. (1992). Inferences about the meanings of nouns: the relationship between perception and syntax. *Cognitive Development*, **7**, 29–45.
- Tomasello, M., & Kruger, C.A. (1992). Joint attention on actions: acquiring verbs in ostensive and non-ostensive contexts. *Journal of Child Language*, **19**, 311–333.
- Waxman, S.R., & Markow, D.B. (1998). Object properties and object kind: twenty-one-month-old infants' extension of novel adjectives. *Child Development*, **69**, 1313–1329.
- Woodward, A.L., Markman, E.M., & Fitzsimmons, C.M. (1994). Rapid word learning in 13- and 18-month-olds. *Developmental Psychology*, **30**, 553–566.

Received: 25 February 2003

Accepted: 25 August 2003