Published in final edited form as:
First Lang. 2013 February 1; 33(1): 3–19. doi:10.1177/0142723711422632.

If it's red, it's not Vap: how competition among words may benefit early word learning

Hanako Yoshida and
University of Houston, USA

Rima Hanania
Indiana University, USA

Abstract

One of the most prominent issues in early cognitive and linguistic development concerns how children figure out meanings of words from hearing them in context, since in many contexts there are multiple words and multiple potential referents for those words. Recent findings concerning on-line sentence comprehension suggest that, within the conversational context, potential referents compete for mappings to words. Three experiments examined whether such competitive processes may play a role in young children's learning of novel adjectives in an artificial word learning task. According to a competitive process view, although young children often mismap adjectives to whole objects rather than the properties of objects, explicitly mentioned familiar words should strongly map to referents consistent with those words and thereby decrease the likelihood of novel words being mismapped to these referents. Experiments 1 and 2 examined the role of the mere mention of familiar words and the role of word order in two year olds' ability to map a novel adjective to a property. Experiment 3 examined these processes in three year olds. The results indicate that lexical competition plays a particularly strong role in helping two year olds map a novel object to a property, whereas syntactic information about form class may also be informative to older children. The results suggest how fundamental processes of lexical competition in on-line word comprehension may give young learners a way to leverage known words in learning new words.

Keywords

early word learning; lexical competition; novel adjective learning

Word learning for novice word learners has often been considered as a mapping problem (Markman, 1989; Quine, 1960). There are words – dog, cat, furry, brown, spotted – and there are meanings or referents and the learner's task is to map the words to their intended meanings in the context. Even when only a single object is in view, a learner cannot know with certainty whether the intended meaning is the object, some properties, or part of the object, or its ongoing activity. From this perspective, word learning for the novice learner is inherently ambiguous, since any context has multiple words and multiple potential referents for those words. Past research on this topic has shown how this ambiguity may be lessened by children's knowledge about the social cues speakers use to indicate referents (e.g. Akhtar, Carpenter, & Tomasello, 1996; Baldwin, 2000), about the kinds of concepts that are

Corresponding author: Hanako Yoshida, Department of Psychology, 126 Heyne Building, University of Houston, TX 77204-5022, USA, yoshida@uh.edu.

A version of this paper was presented at the Society for Research in Child Development meetings in 2007.

lexicalized (e.g. Diesendruck, Markson, Akhtar, & Reudor, 2004; Markman, 1989), and about the linguistic cues within the language being learned (e.g. Gathercole, Thomas, & Evans, 2000; Scofield, Williams, & Behrend, 2007; Yoshida & Smith, 2005).

Developmental theorists of word learning have also suggested that competition among words for meanings may help children with this mapping problem. These ideas are evident in previous proposals including Clark's work (1987, 1997) on competition among developing meanings, in Markman and Wachtel's (1988; also Markman, 1989) research on mutual exclusivity (see also, Markman, 1991; Merriman, 1999), and in Au's (1990) approach to lexical contrast in semantic context. Lexical competition is also important in MacWhinney's (1989, 2004) competition framework and Siskind's (1996) model of statistical word learning. More recently, a growing number of child language researchers have linked these ideas about competition in lexical development to the competitive processes that characterize on-line sentence processing (Halberda, 2009; Hollich, Hirsh-Pasek, Tucker, & Golinkoff, 2000; Horst, Scott, & Pollard, 2010; Smith, Colunga, & Yoshida, 2010). The present study, borrowing ideas from adult studies of on-line sentence comprehension (e.g. Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1996) and more recent study of these processes in children (Barner & Snedeker, in press; Hollich, Jusczyk, & Luce, 2002), examined the role of lexical competition in early adjective learning. We first briefly review the literature on children's adjective learning, and then consider the possible role of competitive processes in this learning.

Adjective learning poses an interesting domain in which to study the role of lexical competition in word learning because adjectives (relative to nouns) are hard to learn and are learned later than nouns (see Gasser & Smith, 1998 for a review). Further, in artificial word learning, tasks in which the to-be-learned word is an adjective, children often interpret the novel adjective as a label for an object (e.g. Markman, 1989; Waxman, 1990; Waxman & Klibanoff, 2000), and their success in mapping the adjectives to the target property has been shown to depend on both the visual context (the objects and properties in the scene) and the lexical context (Mintz & Gleitman, 2002; Sandhofer & Smith, 2007; Waxman, 1990). In the typical artificial adjective learning task, children are presented with an object and it is named with a novel word in a frame consistent with interpretation as an adjective, for example, 'This a *dakish* one.' Children are then presented other objects, which are the same kind or that share the target property, and are asked which of these are also '*dakish*.' In this task, children often err by interpreting the novel word as labeling a noun-like category (or object kind) rather than the property (Au & Laframboise, 1990; Au & Markman, 1987; Clark, 1997; Landau, Smith, & Jones, 1988; Mintz, 2005; Smith, Jones, & Landau, 1992).

Although the frame 'this is a *dakish* one' is ambiguous in multiple ways, including the form class of the novel word (Tare, Shatz, & Gilbertson, 2008), two results using this frame suggest that the child's problem may lie in the unchecked competition among potential referents. Firstly, young children are more likely to correctly map the novel word to the property when the labeled object is a known kind rather than novel (Clark, 1997; Golinkoff, Mervis, & Hirsh-Pasek, 1994; Hall, Waxman, & Hurwitz, 1993; Landau et al., 1988; Mintz, 2005; Smith et al., 1992). Secondly, children do better if the labeled object and test objects are all instances of the same known basic-level category (for example, all ducks, rather than different kinds of animals (Baldwin & Markman, 1989; Hall et al., 1993; Klibanoff & Waxman, 2000; Markman & Hutchinson, 1984; Markman & Wachtel, 1988; Waxman, 1990; Waxman & Gelman, 1986; Waxman & Kosowski, 1990). Both of these results suggest that knowing or being reminded of the known noun category blocks the noun interpretation from winning a competition with the target property as the referent of the novel adjective. In other words, using known objects or objects, all of which are members of the same basic-level category, may inhibit mapping the novel word to the object rather than

the property, because children know the names of those objects. Further evidence indicates that children are more likely to map the novel adjective to the target property when the object's name is explicitly mentioned (Mintz & Gleitman, 2002), as in the construction of 'the *dakish* cup' rather in 'the *dakish* one.' This frame provides clearer information about the form class, which could be beneficial in and of itself. However, in addition, explicit mention of the noun might compete with – and win out over – that interpretation of the novel word as referring to the noun category, thereby leaving the property as the likely referent of the novel adjective.

The idea that the explicit labeling of a potential referent (but not the intended referent) for a novel word helps the mapping of the novel word to the intended target is not a novel one and underlies the earlier proposals of Clark (1987), Markman (1989), and Au (1990) about competition and contrast in early word learning. However, the results and the idea also fit what is known about *on-line* lexical competition in spoken language processing in adults (e.g. Gaskell & Dumay, 2003; Marslen-Wilson, 1987, 1990; McClelland & Elman, 1986; Tanenhaus et al., 1996). The consensus view in that literature is that the listener attempts to build a mapping from a stream of words to the potential referents (and potential meanings) within a current context. Figure 1(a)–(c), using examples from novel adjective learning, illustrates the proposal. Hypothetically, for a novice learner who knows no words, the mappings between all possible meanings might be considered to be equipotential (see Figure 1(a)). However, for young children, all meanings are not equipotential and given no other constraints, there is higher probability of mapping words to the whole object category than to an individual part or property (Markman, 1991). Thus, as shown in Figure 1(b), for a novice learner who knows few words, labels might primarily compete for whole objects as their referents within a context. This is where competition might play a role. The usual assumption about this process is that inhibition is a function of magnitude of activation. Thus in this context, if the child knows – even partially – the dog-DOG mapping, it might work to inhibit a mapping from *stoof* to DOG. These ideas suggest that noun knowledge might help even when the object name is not mentioned if that name is well known (Hall et al., 1993; Waxman & Kosowski, 1990), but these ideas also clearly suggest that the correct resolution of competing referents for the novel adjective would benefit from the explicit labeling – and thus removal from consideration – of those referents.

The method used in the present experiments to test this prediction is based on a specific finding by Mintz and Gleitman (2002), who showed that the explicit mention of known nouns helps children interpret a novel adjective as a property of the named object. Mintz and Gleitman's task (in their Experiment 3) worked like this: the experimenter introduced three familiar toy objects (e.g. an elephant, a fish, and a car) that matched each other only in a salient property and color (e.g. all painted red and having a rough texture). For each object presentation, the experimenter labeled the object with a novel adjective (e.g. *vap*). To test the role of full noun labeling, they contrasted two types of sentences: full noun phrases (e.g. 'this is a *vap* elephant') versus pronoun phrases (e.g. 'this is a *vap* one'). After this labeling, the child was asked to choose between a kind-matching object (e.g. one of those presented objects, such as another elephant having a non-matching property) and a property-matching object (e.g. another rough surface thing). The children performed well – choosing the property-matching object – when the noun was explicitly given, but they performed at chance levels when the modified noun was not overtly expressed (e.g. the case of *one*) – the level of specificity in label changed the interpretation of the novel adjective. As Mintz and Gleitman concluded, the results show that explicit mention of the noun benefits learning. This could be an effect of explicit mention itself, or it could be because the explicit mention of the noun makes the form class of the novel word, that it is an adjective, clear. Mintz and Gleitman interpreted their results in terms of this second possibility.

The experiments that follow use this adjective learning paradigm to test two predictions derived from the competition account. Firstly, if the competition is strictly lexical (and not determined by order information about the form class), then mere mention of the noun should benefit mapping the adjective to the target property, even if the words are not presented in a grammatical string such that the novel adjective modifies the noun. That is, 'elephant *vap*' should benefit learning as well as '*vap* elephant.' This prediction is tested in Experiment 1 with two year olds and Experiment 3 with three year olds. The second prediction is that the number of known words mentioned that can compete for alternative meanings – not only nouns – should help children map the novel adjective to the intended target property. For instance, the task phrase containing a well-known color word as well as the noun (e.g. elephant red *vap*) should be better for mapping *vap* to a textural property than the phrase without the color word (e.g. elephant *vap*), because the mention of red should limit the likelihood of mapping *vap* to RED. This is tested in Experiment 2.

Experiment 2 also examined a possible role for order information in this competition. In an on-line sentence comprehension tasks, adults (e.g. Tanenhaus et al., 1996) and young children (Fernald, Thorpe, & Marchman, 2010) look to potential referents *in the order of their mention*. This suggests that words may be mapped to referents, word by word, with early word-referent pairings limiting interpretations of later words in a spoken utterance. If this is so, then explicitly mentioning known words prior to the unknown word may benefit mapping the unknown word to the correct referent.

Experiment 1

If the initial mapping of a novel word to a target property is the consequence of a strictly lexical competition among potential words and meanings, then it is the words uttered and the potential meanings that matter, not the syntactic structure of the string of the words. Thus, explicit mention of the known name of a potential competitor referent for a novel word might be expected to benefit interpretation of that novel word *even if the known name and the novel word are presented in a list and not in a well-organized sentence.* In Experiment 1, we placed an object on the table; for example, an elephant made of a red and rough (and highly unusual) texture. The experimenter pointed to the elephant and then said (in a list format with intervals) 'elephant-, -red-, -*vap.*' If the spoken words compete for likely referents in a scene (and do so even when presented in the list format), then the child might be able to correctly map *vap* to the unique surface, since 'elephant' would map to the whole elephant and 'red' to its color. If lexical competition alone is sufficient for mapping the novel word to the unmentioned target, then children should succeed in this List condition. This is the main question of the experiment. However, we also included the Standard version of the novel adjective task, which provides no effective lexical competition, but presents the word in a syntactically correct string in which the novel word modified a pronoun – for example, '*a vap one*.' Although this frame, ' a ____one,' is arguably ambiguous on multiple grounds (see Tare et al., 2008), we chose it because it is the highly used standard form in novel adjective learning tasks (Hall et al., 1993; Klibanoff & Waxman, 2000; Markman & Hutchinson, 1984; Mintz & Gleitman, 2002) and is syntactically correct but does not explicit label the potential contending referents for the novel word.

Method

Participants—Thirty-four two year olds (mean age 26.18 months, ranging from 23.39 to 31.70 months; 17 males and 17 females) participated in the study. They were recruited from middle-class families in Bloomington, Indiana and Houston, Texas. The participants were randomly assigned to the Lexical competition or the No-lexical competition conditions.

Stimulus materials—The stimuli were closely modeled on those of Mintz and Gleitman (2002). The stimuli for the six trials and the novel labels are provided in Figure 2. For each set, the three training objects were instances of three different basic-level categories, all the same color and surface texture. The test objects included one category present in the training set but with a different texture and one novel category instance of the same target texture as the training set. Both test objects were the same color as the training objects, and all objects were approximately 10 cm^3 in size. Texture – the intended target property – was chosen to be highly novel and included a star-like pattern; a wire surface; uneven bumpiness; bumpy stripes; Flocking; Velcro surfaces; and holes.

Procedure—On each trial, the child heard three training objects – instances of *different* noun categories but all exhibiting the same property – labeled using either the List or Standard format. Two test objects were then placed on the table, and the child was allowed to play with them to reduce choices based on toy preference. The two test objects were then placed equally distant from the child, and the child was asked to select the named one. This procedure was repeated for the six trials. Children in the List condition heard the training objects labeled with a list of words – the novel adjective, a color word, and a basic-level noun, as in 'This is … an elephant …red …. *vap.*' We included the color word along with the noun to emphasize the list-like structure. In addition, experimenters were trained to use a flat prosody consistent with reading a list. Children in the Standard condition heard each training object labeled with the novel word embedded in a correctly ordered English sentence, but with the adjective modifying a pronoun – for example, 'This is a *vap* one.' On test trials, children in both conditions heard the same test question using the pronoun one, 'Can you get me the *vap* one?'

Results

If competition among lexical competitors helps children resolve the mapping of the novel adjective to the property, then children's choices of the texture-matching test object should be greater in the List condition than in the Standard condition because competing referents for the novel word are explicitly mentioned – and thus by hypothesis blocked – in the List condition, and this is what was found. Children in the List condition mapped the novel word to the target property more ($M = 0.71$, $SD = 0.19$) than those in the Standard condition ($M = 0.55$, $SD = 0.16$; $t_{(32)} = 2.63$, $p < 0.05$;[1] Cohen's $d = 0.90$) In addition, in the List condition, children performed better than chance ($t_{(16)} = 4.48$, $p < 0.001$; Cohen's $d = 1.09$), whereas performance in the Standard condition did not differ from that expected by chance ($t_{(16)} = 1.19$, $p = 0.25$). Performance in the Standard condition is consistent with previous findings showing that children have difficulty in mapping novel adjectives to a property. Children's ability to do this mapping in the List condition suggests that the difficulty does not lie solely in the adjective to property mapping but rather may lie in the other possible referents. The findings support the idea that explicit mention of the other possibilities – mentions that by hypothesis remove those competitors by linking them to other words – benefits the mapping of a novel word to its intended referent. The fact that this effect was obtained despite the mention of the labels in a not syntactically well-formed list suggests that the competition may be strictly lexical – that is, between individual words. We will return to this point in the *General discussion* section.

Experiment 2

Prior work suggests that explicit mention of the modified noun benefits adjective mapping (Mintz & Gleitman, 2002). In the List condition of Experiment 1, the objects were labeled

[1]A non-parametric significance test, the Mann–Whitney *U*-test, confirmed the analysis ($\alpha = 0.006$, two-tailed).

with the noun, a color word, and the novel adjective but in a List format, and we included the color term along with the noun to encourage the interpretation of the utterance as a list rather than a grammatical sentence. However, if the labeling of contending referents with their known labels removes them from contention as referents for the novel adjective, then the number of labeled contenders – not just nouns – should help the mapping problem: known word-meaning pairs (e.g. 'elephant red *vap*') should be better for mapping *vap* to a textural property than 'elephant *vap*,' because the mention of another known word – 'red' – should also limit the likelihood of mapping *vap* to RED in terms of inhibiting competition from novel words to irrelevant properties (e.g. whole object, color). Experiment 2 tests this prediction by manipulating the number of known word-meaning pairs in two trial types: one trial type replicated Experiment 1 (known noun, known color, and a novel adjective – e.g. elephant red *vap*); the other trial type only used the known noun and the novel adjective (no known color – e.g. elephant *vap*).

This experiment also examined the possibility that the order of mention of the novel and known words matters. Within a lexical competition process, known pairs might be effective in terms of inhibiting competition from novel words to the wrong referents (e.g. whole objects, color) when the known words are presented first. That is, mapping the novel word, *vap*, to a texture might actually be harder given *vap* elephant (which is syntactically correct in English) than elephant *vap.* We test these two predictions by manipulating word order (novel→known versus known→novel).

Method

Participants—Thirty-four two year olds (mean age of 28.20 months, ranging from 22.61 to 32.42 months; 17 males and 17 females) participated in the study. They were recruited from middle-class families in Bloomington, Indiana, and in Houston, Texas. None of the participants had participated in Experiment 1.

Procedure—The two trial types that differed in the number of competitors mentions were tested as a within-subject variable. Half of the trials, the +color trials, were identical to the List condition in Experiment 1, which include explicit naming of color in the phrase (e.g. 'This is an elephant red *vap*'); the other half, the −color trials, did not include a color (e.g. 'This is an elephant *vap*'). The order of the +color and −color trials was randomized across children, and there were three trials for each trial type. Randomly selected participants were tested in either the novel→ known word order condition (e.g. for +color trials, 'This is a *vap*, red, elephant,' and for −color trials, 'This is a *vap* elephant') or the known→ novel word order condition (e.g. for +color trials, 'This is an elephant, red, *vap*' and for −color trials, 'This is an elephant, *vap*'). Note that the competition process view predicts that known→novel word order is more effective, although this word order is less like the syntactically correct construction in English than is the novel→ known construction. All other aspects of the procedure were the same as in Experiment 1.

Results

As can be seen in Figure 3, children's successful novel adjective mapping depended – as predicted – on both the number of competitors and whether the known words were mentioned prior to the novel adjective. Mean proportion of correct texture-match test object choices were submitted to a 2 (word order: known→novel versus novel→known) × 2 (number: +color versus −color) mixed analysis of variance (ANOVA), with repeated measures on the latter factor. There was a significant interaction between the number and word order; $F_{(1, 32)} = 7.11$, $p < 0.05$, $\eta^2 = 0.182$. Neither the main effect of number nor of word order approached significance.

When words are presented in known→novel word order, mentioning the color clearly mattered: children mapped the novel word to the texture more in the +color ($M = 0.69$, $SD = 0.30$) than in the −color trials ($M = 0.46$, $SD = 0.29$; $t_{(16)} = 2.02$, $p < 0.05$),[2] Cohen's $d = 0.79$. Children performed at above-chance levels in the +color trials ($t_{(16)} = 2.57$, $p < 0.05$, Cohen's $d = 0.65$) but not in the −color trials ($t_{(16)} = -1.00$, $p = 0.33$). These results thus replicate the findings in Experiment 1 and provide additional support for a role of lexical competition in disambiguating possible referents in context by showing that labeling more of the competitors with their known labels is better for the disambiguation process than explicitly labeling fewer. When words were presented in novel→known word order, although the order aligns with English syntactic order, performance was weaker. Children's performances appear to be slightly better in the −color ($M = 0.60$, $SD = 0.16$) than in the +color trials ($M = 0.41$, $SD = 0.30$); however, the difference was not significant and the performance level did not differ reliably from chance in either condition. These results from the novel→known word order condition suggest that for young children, prior mention of known noun facilitates the competition process even though the word order is not conventional for the English language. The word order is conventional for some languages, such as French; this raises the interesting question of whether young children learn adjectives more readily in such languages.

Critically, the results of this experiment suggest that it is not just the explicit mention of words that helps children learn novel adjectives; rather the role of known words is most beneficial when known words are presented prior to novel words. This may be because this prior mention removes competing interpretations ahead of the encounter with and thus interpretation of the novel word.

Experiment 3

Experiments 1 and 2 used List-like presentations of novel and known words and, thus, the beneficial effects of explicitly labeling potential competitors to the intended referent for the novel word appear to be due to *lexical* competitions. As each word is heard it activates potential referents in the scene with strong links between a heard word and a referent inhibiting other potential links to the referent, leaving the unknown word to be mapped to the non-mentioned referent. The effect is stronger when the known words are mentioned first, which suggests that the conventionalized word order in English works against early adjective learning. However, as children learn their language one might expect conventional word order to play a stronger role, and perhaps to be more important than lexical competition alone. To address this, Experiment 3 tests the role of word order with three year olds. If children are more knowledgeable of the adjective-noun order that characterizes English, then they should succeed with the novel→known phrasing, which fits the adjective-noun structure of English more than with the known→novel word order, as shown in Experiment 2.

Method

Participants—Forty-five three year olds (mean age of 37.06 months, ranging from 32.8 to 45.8 months; 21 males and 24 females) participated in the study. They were recruited from middle-class families in Bloomington, Indiana, and in Houston, Texas.

Procedure—The three-year-old participants were randomly assigned to one of three conditions; the List of words Incorrect word order, the List of words Correct word order, and the Standard condition. In the List Incorrect condition, the ordering of the list of words was

[2]A non-parametric significance test, the Wilcoxon matched-pairs signed-ranks test, confirmed the analysis ($\alpha = 0.02$, two-tailed).

identical to the List condition in Experiment 1 (e.g. 'This is an elephant, red, *vap*'). In the List Correct condition, the order was identical to the novel→known condition (with the +color trials) (e.g. This is a *vap*, red, elephant) in Experiment 2. Both List conditions were stated by trained experimenters in a list-like flat prosody. We also included the Standard – and grammatical – phrasing used in Experiment 1 with the novel adjective modifying the pronoun 'one' (e.g. This is a *vap* one). All other aspects of the procedure were the same as in Experiment 1 and Experiment 2.

Results

The results suggest that these older children mapped novel adjectives to texture-matched target properties equally well regardless of the three conditions. Mean proportions of texture-match test object choices from the three conditions – the List Incorrect, the List Correct, and Standard phrasing condition – were submitted to a one-way ANOVA, which yielded no effect of condition, $F_{(2, 44)} = 1.75$, $p = 0.19$. Post-hoc analysis confirmed that there are no differences among these conditions: between the List Correct and List Incorrect conditions, $p = 0.70$, between the List Correct and Standard, $p = 0.16$, between the List Incorrect and Standard, $p = 0.55$ (Tukey, $\alpha = 0.05$). The key question for the experiment was whether children's successful novel adjective leaning is more pronounced when correct syntactic structure is given in the task. This does not appear to be the case, although these older children's performances were not hurt by the novel adjective-known noun order, as were their younger counterparts in Experiment 2. One sample *t*-tests comparing children's performance to that expected by chance indicate that when older children were presented with the phrases containing two known words, they performed at above-chance level both in the List Correct ($M = 0.69$, $SD = 0.20$; $t_{(14)} = 3.52$, $p < 0.01$, Cohen's $d = 0.95$) and in the List incorrect ($M = 0.63$, $SD = 0.19$; $t_{(14)} = 2.46$, $p < 0.05$, Cohen's $d = 0.68$), but not in the Standard condition ($M = 0.54$, $SD = 0.23$; $t_{(14)} = 0.73$, $p = 0.47$), where there is no known words (besides *one*) supporting the competition process.

These results suggest that older children with a longer history of language exposure benefit from both syntactic information *and* the mention of known words to home in on the intended referent of a novel word. They also underscore the ambiguity of the standard carrier phrase for experiments on novel adjective learning in children learning English.

General discussion

The three experiments provide strong support for the role of lexical competition in early word learning. The explicit labeling of potential competitors for the referent of an unknown adjective appears to remove those competitors and in so doing enables the learner to map the novel adjective to the intended referent. The fact that explicit mention of known words aids the correct mapping even when the known and novel words are presented in list form suggests that the underlying mechanism is one of *lexical* competition. The findings that explicit mention of more rather than fewer known words and the finding that a known-novel order of mention benefits the correct mapping also support the lexical competition hypothesis. The results replicate the findings of Mintz and Gleitman (2002) by showing that explicit mention of the noun supports adjective learning, but the present results also extend those earlier findings by showing that the benefit of explicit mention does not depend on the syntactical structure of the sentence: the labeling of the object helps novel adjective mapping even when the words are not presented in a well-formed English order. Indeed, violating the English adjective-noun order is particularly beneficial to two year olds' mapping of the adjective to the intended property. This advantage is not seen in three year olds who – given a list-like presentation – succeed as well given the conventional English order as with the known-novel order. These findings are relevant both to general mechanisms of word learning and also more specifically to adjective learning.

Many theories of early word learning have posited competition-like processes to explain how children use known words in a context to figure out the relevant interpretation of a novel one. These include the mutual exclusivity assumption (Markman, 1989, 1991; Merriman, 1999) and proposals about the role of contrast (Au, 1990). These earlier proposals were not explicit about the underlying mechanisms and they were often presented as generalized constraints on early word learning. However, a growing body of work has begun to re-examine these ideas in relation to on-line processes of word comprehension (see Gershkoff-Stowe, 2002; Hollich et al., 2002; Swingley, 2005). The general idea of this newer work is that processes of on-line lexical competition may underlie such phenomena as mutual exclusivity (see Markman, 1989) and young children's general bias to map novel words to novel referents (Mervis & Bertrand, 1994). These novel word-novel object phenomena may emerge in real time and within a context as the listener attempts to understand a spoken utterance, with the excitatory and inhibitory processes of lexical activation strongly constraining a one word–one meaning *in the context*.

We know that on-line lexical competitions are a core mechanism in spoken language comprehension by adults (Tanenhaus et al., 1995), and growing evidence is demonstrating these same processes in very young language users (Barner & Snedeker, in press; Fernald et al., 2010; Hollich et al., 2002). These studies of on-line processing in both adults and children often continuously track eye gaze and they consistently show that listeners fixate potential referents of heard words as they are heard. These looks to potential referents may be both essential to disambiguating words in contexts and they may also be automatic. For example, when adults are presented with a visual display, they show clear evidence of attempting to establish reference on-line, in immediate response to incoming speech input. In one study by Eberhard, Spivey-Knowlton, Sedivy, and Tanenhaus (1995), adults were presented with a sentence (e.g. 'Touch the starred yellow square') in a computer display containing relevant objects and their eye gaze was measured. Upon hearing the instruction with only one starred object on the display, adults' onset of eye movements to the target emerged right after the word 'starred.' However, when presented the same sentence instruction with a display that contained multiple candidates (e.g. more than one) starred objects, participants delayed eye movements until more disambiguating information was provided, as if on-line sentence comprehension attempts to disambiguate potential meanings by binding heard words to the objects and events in the immediate context (see also, Sedivy, Tanenhaus, Chambers, & Carlson, 1999; Trueswell, Sekerina, Hill, & Logrip, 1999). The automaticity of the looks to potential referents is suggested by findings that adults fixate potential referents in a scene when word is mentioned, even when the objects in the scene are explicitly not being referred to and are unrelated to the task at hand. In particular, Huetting and Altman (2007) found that adult participants automatically fixated on a picture of a rope on the display upon hearing the word 'snake,' suggesting that words automatically direct attention to possible referents.

The central hypothesis behind the present experiment is that these processes that support spoken language comprehension are also helpful in the earliest stages of word learning and may underlie the many general principles of contrast (Au, 1990; Clark, 1997; Markman, 1991; Merriman, 1999) that have been documented in early word learning. This is an interesting possibility on a number of grounds. Firstly, such a mechanism might be expected to become available to young learners early in word learning, once children know just enough words for there to be some amount of lexical competition. Given some known words, an unknown word, and a cluttered context with many potential meanings, very early learners – perhaps before they know much about language other than a few words and referents – could use the competition inherent in on-line comprehension to map the novel word to unmentioned referents. This solution to referential uncertainty requires that the learner know some words (to create sufficient competitions) and that word-referent

activations compete in working memory, but it does not require robust knowledge of referential rules, syntactic categories, different kinds of meaning, nor linkages between syntactic categories and kinds of meanings. Accordingly, an important next step is to more precisely determine the nature of these competitive processes and their development in early word learners. Research by Jusczyk and Hohne (1997) suggests that infants comprehend at least some common nouns by eight months or even earlier (e.g. see also Tan & Schafer, 2005, for the relation between early known object names and novel word learning). Just how many nouns are needed – and how well to they need to be known – to set up the helpful competitions is an unknown but theoretically important question. Evidence from Waxman and Markow (1995) on novel adjective learning using a preferential looking paradigm in infants suggests that these processes might work from a very early age (see also Booth & Waxman, 2009).

The developmental differences suggested by the performances of the three year olds in Experiment 3 versus the performances of the two year olds in Experiments 1 and 2 suggest a possible developmental shift from primary dependence on lexical-based competition to the use of structural information about language-specific word order. Three year olds' successful performances in both the List Correct and List Incorrect conditions could mean that a known-novel word order does not matter so much to older children's lexical competition processes or it could reflect the use of two different kinds of processes for figuring out a novel word meaning – lexical competition in the incorrect word-order condition and knowledge about English word order, adjective-modified noun, in the correct word-order condition.

The importance of the known-to-novel word order for younger children (and its less importance for older children) may indicate changes in children's ability to maintain several active possibilities as candidates prior to settling on one potentially wrong candidate, or in the ability to revise a prior interpretation given later information in the utterance. These possibilities need to be tested in methods that provide a finer grained measure of the temporal course of disambiguation, such as momentary eye gaze to an object in a scene while listening to an utterance.

Alternative accounts of the present results are possible. For example, instead of on-line competitions among activated words and meanings, children might have been reasoning about possible intended meanings. Such an account might be able to explain why the number of labeled contenders matters, but it seems unlikely to explain why order of mention matters and why younger children do better with a word order contrary to the language they are learning, and such an account would not suggest the use of a list-like format to enable better mapping over the grammatically correct and commonly used phrase of 'a *vap* one.' However, in a deep way, reasoning and lexical competition may not truly be opposing hypotheses. As far as we know, no one has proposed that children are consciously deliberating about the potential meanings of these words. Instead, their cognitive systems are combining and integrating information across words and scenes. Some of this integration is through the competitive processes of lexical activation and, as such, these processes effectively make inferences about underlying meanings that align with fundamental aspects of language.

In sum, given the evidence concerning competitive processes in lexical access and spoken language comprehension in the adult literature (Gaskell & Dumay, 2003; Gaskell & Marslen-Wilson, 1999; Luce & Pisoni, 1998; Magnuson, Dixon, Tanenhaus, & Aslin, 2007; Marslen-Wilson, 1987, 1990; McClelland & Elman, 1986; Norris, 1994; Tanenhaus et al., 1996; Vitevitch & Luce, 1998) and the growing evidence in the developmental literature for these same processes (Barner & Snedeker, in press; Hollich et al., 2002; Swingley, 2005),

the potential role of these processes in word learning itself is an important new area for research. The present results contribute by showing how lexical competition may help children home in the intended meaning of a novel word and by providing a mechanistic hypothesis about why lexical contrast may be so important to early word learning.

Acknowledgments

We wish to thank Linda Smith for research support and preparation of this manuscript. We especially wish to thank Lauren Menifee for intensive data collection, and the families who participated in this study.

Funding

This research was supported by Indiana University, University of Houston, a National Institutes of Health grant [R01 HD058620], the Foundation for Child Development, and the University of Houston's Grants to Enhance and Advance Research (GEAR) program.

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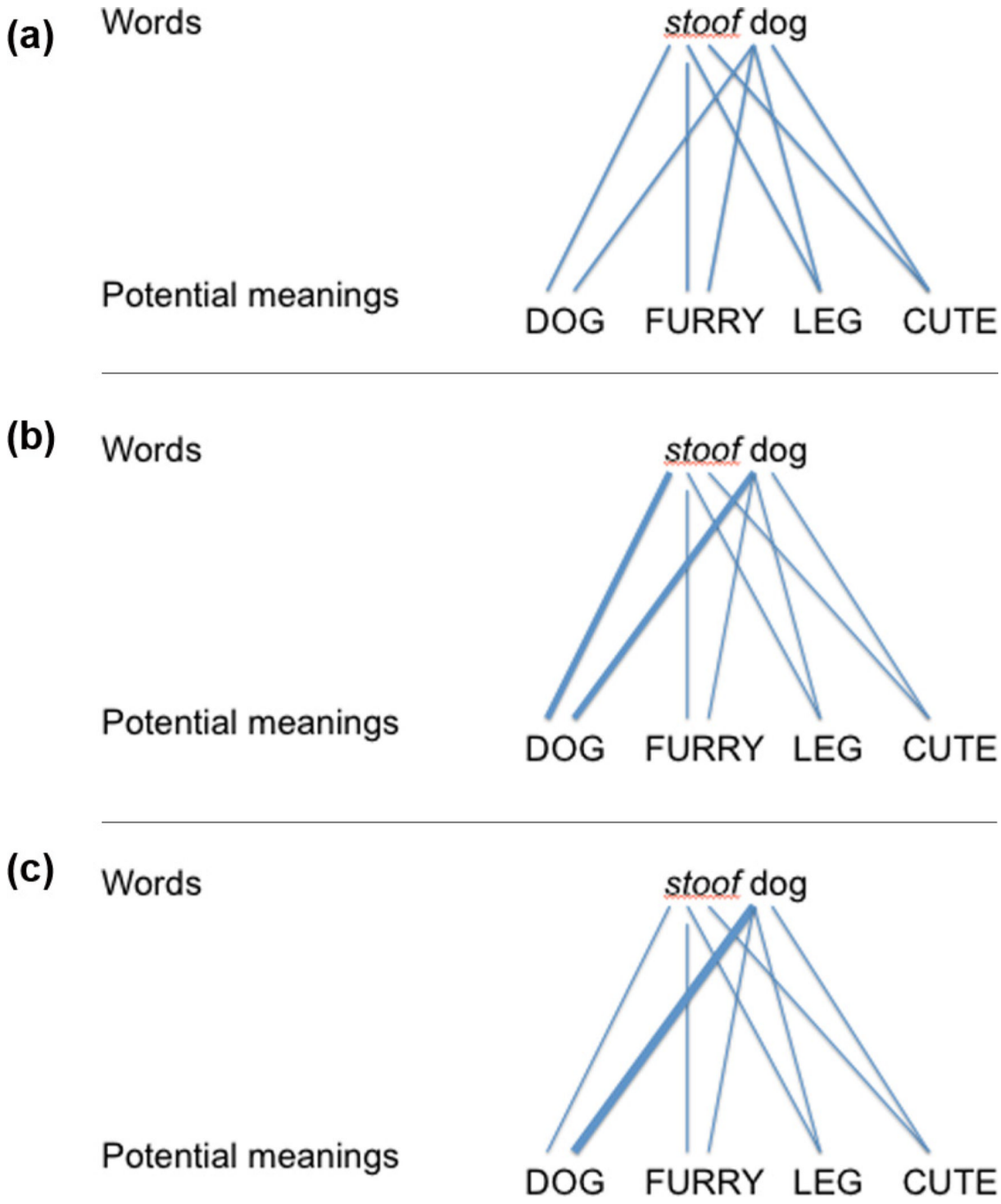

Figure 1.
Illustrations of the idea how the positive effect of knowledge of the noun category on the adjective learning may be understood in terms of the competition process

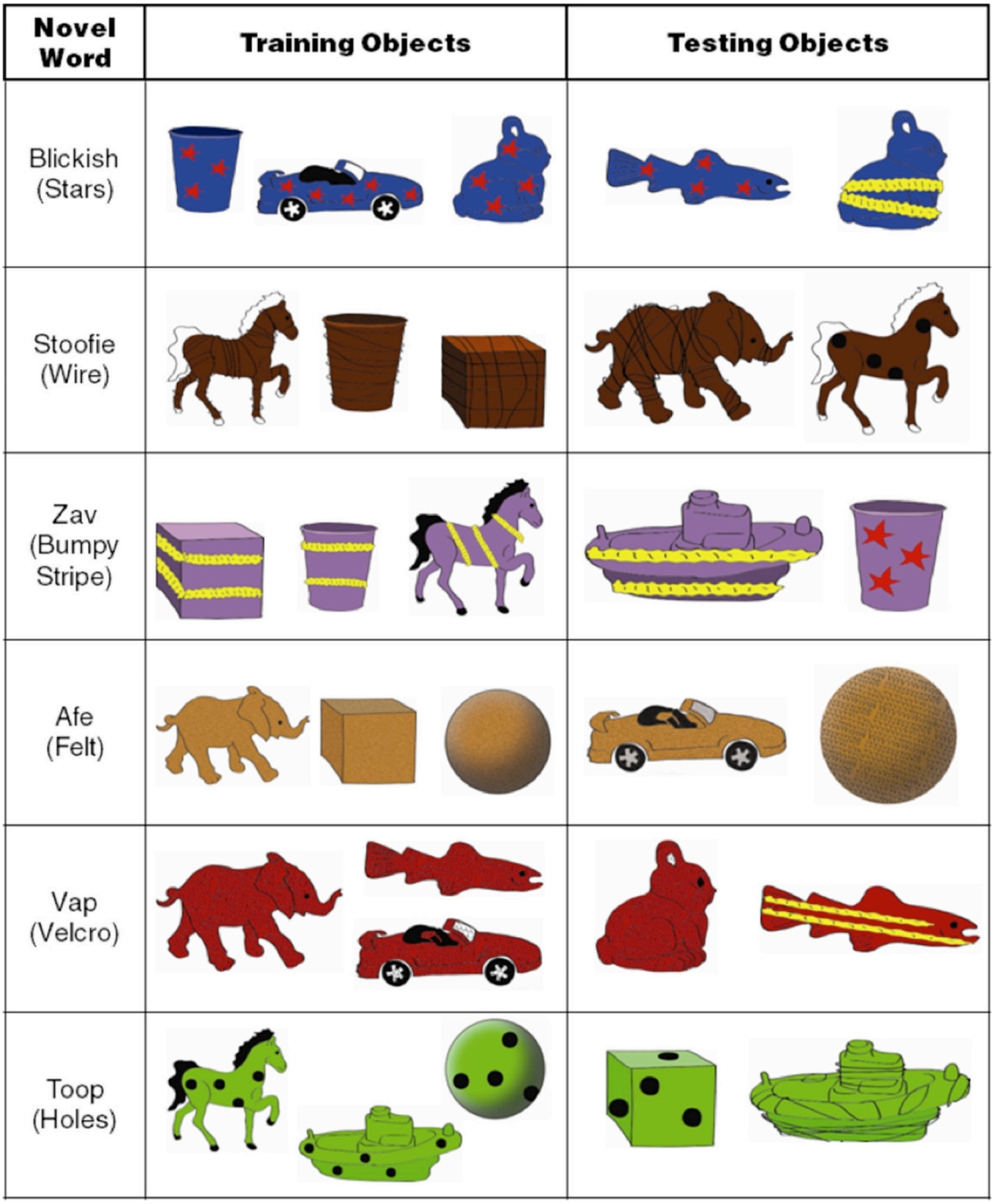

Figure 2.
Illustrations of all stimulus objects and a list of the novel adjectives used in each set

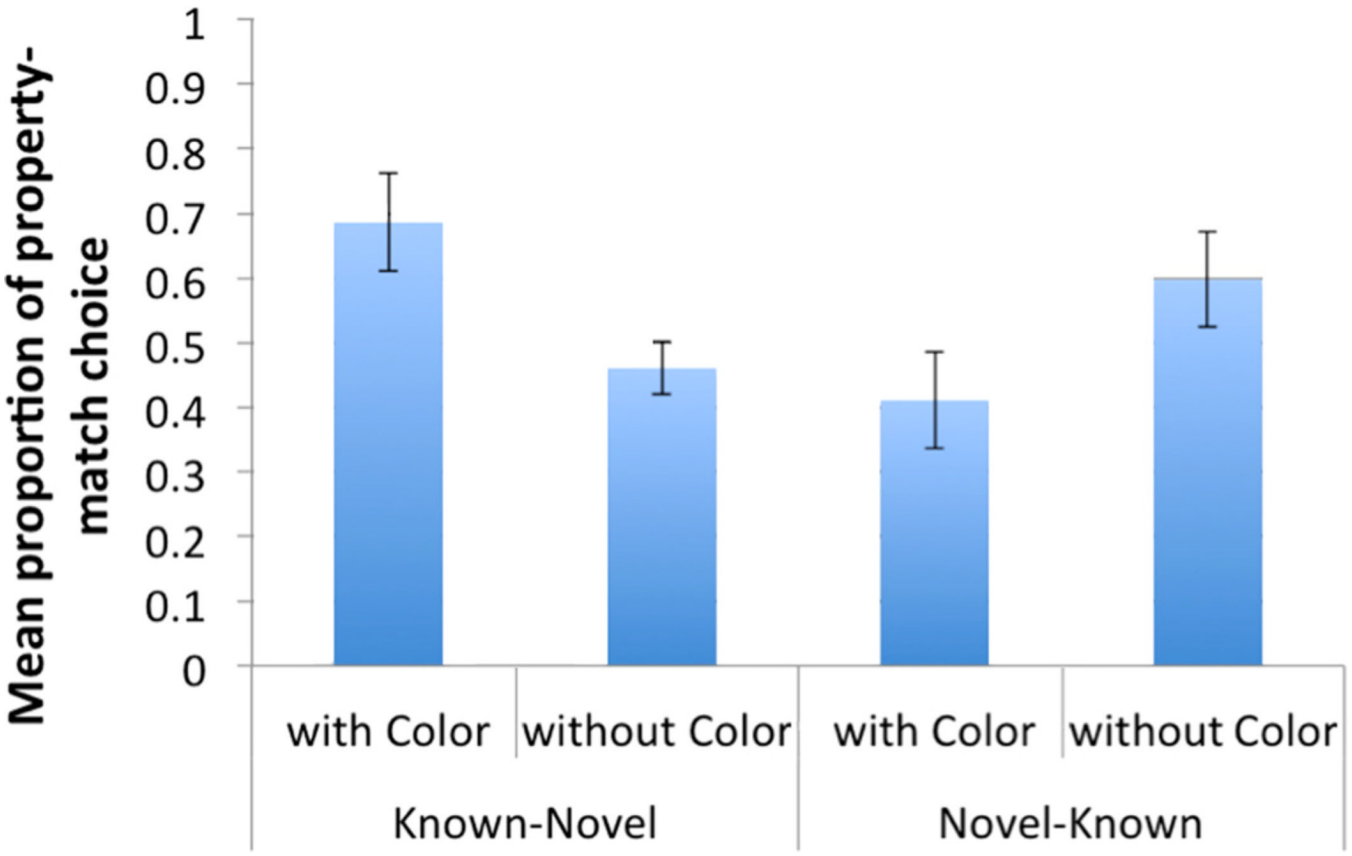

Figure 3.
The proportion of texture-match choices (property-matched test-object choices) made in the +color and −color trials for the novel→ known condition and the known→ novel condition (Experiment 2).