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Abstract

Learning new words involves decoding both how a word fits the current situation and how it could be used in new situations. Three studies explore how two types of cues— sentence structure and the availability of multiple instances-- affect children's extensions of nouns and verbs. In each study, 2½-year-olds heard nouns, verbs or no new word while seeing the experimenter use a novel object to perform an action; at test, they were asked to extend the word. In Study 1, children hearing nouns in simple sentences used object shape as the basis for extension even though, during the learning phase, they saw multiple objects in motion; children in the other conditions responded randomly. Study 2 shows that by changing in the type of sentences used in the noun and verb conditions, not only is the shape bias disrupted but children are successful in extending new verbs. In a final study, access to multiple examples was replaced by a direct teaching context, and produced findings similar to those in Study 2. An implication of this result is that seeing multiple examples can be as effective as receiving direct instruction from an adult. Overall, the set of results suggests the mix of cues available during learning influences noun and verb extensions differently. The findings are important for understanding how the ability to extend words emerges in complex contexts.

Young children are amazingly adept word learners. This ability is particularly impressive given that children not only have to solve the initial problem of mapping new words to referents, but also need to develop strategies for extending words to new instances. Researchers often examine word learning and extension by examining a single grammatical category, most often nouns (e.g., Booth & Waxman, 2002; Graham, Williams & Huber, 1999; Imai, Gentner & Uchida, 1994; Landau, Smith & Jones, 1988, 1998) but at times, verbs (e.g., Forbes & Poulin-Dubois, 1997; Gropen, Pinker, Hollander & Goldberg, 1991; Huttenlocher, Smiley & Charney, 1983; Maguire, Hirsh-Pasek, Golinkoff & Brandone, 2008). However, a few recent studies have investigated both noun and verb learning and

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[1]As these stimuli include novel verbs, they were not directly modeled after verbs children comprehend or produce at this age. However, in comparing these actions to verbs listed on the MacArthur Communicative Development Inventory, all actions are similar to verbs most children comprehend around this age (e.g., in Set 1, *brush ground*/dax = *sweep* on the CDI; in Set 2, *pick up*/gep is similar to *push* on the CDI). Thus, children at this age should be able to process these actions and learn these similar verbs.

extension in the same study (e.g., Kersten & Smith, 2002), and the present paper contributes to this emerging set of studies. Studies including multiple word types are important because in the laboratory, decisions about stimuli are likely influenced by whether the study concerns noun *or* verb learning whereas in everyday environments, children are learning both nouns and verbs presumably from the same overall scenes or "stimuli".

In our research, the process of designing conditions under which children could learn nouns and verbs equally well led us to consider the important roles of two key cues. One set of cues to which children could attend is the linguistic information provided by an adult, which the syntactic bootstrapping view (e.g., Gleitman, 1990) suggests should contribute importantly to verb learning, and which also could influence noun learning. A second cue is the availability of multiple instances that can be compared. The present studies add to a small set of studies examining both nouns and verbs, and they extend this approach by exploring attention to these cues and their interactions.

Previous studies of noun and verb learning and extension

Few previous studies have examined noun and verb learning in the same experiment, and these studies have revealed somewhat conflicting results. Of the few studies that have been conducted, two studies do not show a difference between noun and verb learning, with Oviatt (1980) showing a similar ability to learn nouns and verbs in one year olds, and Tomasello and Akhtar (1995) finding that 2-year-olds could learn both nouns and verbs with enough exposures. Two other studies show that children learn nouns more easily than verbs, with Schwartz and Leonard (1984) finding that toddlers taught 16 new nouns and verbs learn more nouns, and Childers and Tomasello (2002; 2006) showing that children produce more nouns than verbs under similar exposure conditions (this was despite an overall tendency to remember non-verbal actions particularly well). These studies are important because they examine noun and verb learning in controlled experimental contexts, but they do not explore how particular cues may influence noun or verb learning or how children go beyond an initial learning context and extend nouns and verbs to new contexts, a hallmark of a productive speaker.

More recent studies have begun to focus on children's ability to *extend* words, and how this may vary across word type. In Kersten and Smith (2002), children (3 ½- to 4-year-olds) and adults were shown animated events with novel insect-like objects performing novel motions, and were asked to learn new nouns or verbs and extend these words to new instances. Word extension was assessed by showing new instances and asking participants to say whether the just learned nouns or verbs should be extended to them (e.g., "Is this a zeebee?" or "Is this one morping?"). They found that, for nouns, both children and adults were willing to accept a similarly shaped object as an example of a new noun while ignoring its motion. However, unlike adults, children were reluctant to accept an event as an example of the verb if either the object or its motion was changed. Instead, children were as likely to extend the verb to an object match as they were to a motion match, and they were better at ignoring object properties and focusing on actions if shown familiar objects (see Kersten, Smith & Yoshida, 2006, for similar results in Japanese).

Kersten and Smith's (2002) results suggest that having to attend novel objects interferes with the ability to extend a new verb, while having to attend to new motions does not interfere with the ability to extend new nouns. Thus, a specific property of the scene, at least in terms of the novelty or familiarity of the entities, was a key cue and verb learning appeared to be more vulnerable to this cue than was noun learning. At the same time, while the two aspects of events that were manipulated (movement patterns of objects and direction of motion) are both aspects that are important to consider when learning new verbs, the

events themselves were not prototypical causative events in which an animate agent causes a salient change in an inanimate patient (Slobin, 1981; 1985). Thus, children may be more successful in a verb condition if shown prototypical causative events. In addition, because the nouns were presented in relatively simple frames (e.g., “This is a zeebee”) while the verbs were heard in several tenses (e.g., “This one is morping. This one’s gonna morp. He morped!”), the ease of learning the nouns and verbs could have been influenced by this difference in syntactic complexity.

A second previous study also found differences in children’s ability to extend nouns and verbs (Imai, Haryu & Okada, 2005). In their study, Japanese-speaking 3-year-olds, 5-year-olds and adults were shown a video of a person engaging in a repeated action using a novel object, and heard new nouns or verbs. At test they saw two scenes at the same time and were asked to point to one: one showed the same agent and action but a new novel object, and the other showed the same agent and object but a new novel action. Children were able to generalize a new noun to a scene showing the same object undergoing a different motion as opposed to a scene with a new object undergoing the same motion. However, only 5-year-olds could generalize new verbs to scenes with new objects and similar motions. Thus, again, verb extensions were easier to disrupt than were noun extensions, and the familiarity of the objects was a key cue. A follow-up study (Study 3) showed that 3-year-olds could generalize newly learned verbs but only to scenes in which the object and action were the same as in the target scene and only the agent varied. Interestingly, both Kersten & Smith (2002) and Imai et al. (2005) included events in which a main object or agent produced fairly large body movements (in Imai et al., while holding a second object); how children would respond to events in which an agent causes a salient change in a second object (i.e., a prototypical causative event) is unclear.

In contrast to these two studies which suggest noun extension occurs earlier or is more robust than is verb extension, Waxman, Lidz, Braun and Lavin (2009) recently reported equivalent learning of new nouns and verbs by 24-month-old English-speaking toddlers from a single set of stimuli. Children in this study saw dynamic video events with an agent performing an action with an inanimate patient (e.g., a man waving a balloon) (though again, the action was focused on a fairly large movement of one main entity or agent). For each word learned, four events were shown that could be compared (i.e., the man was shown waving four different balloons with varying shapes), and two more events were shown providing contrastive information before test (i.e., the man was shown playing a saxophone and shown waving a previously presented balloon). At test, children saw the man waving the familiar balloon or performing a different action with it (e.g., tapping the balloon).

Two studies show that with access to both comparison and contrast, toddlers were able to learn nouns and verbs equally well. They were able to resist extending the new verb to a new non-relevant action (tapping vs. waving in Study 1), but looked equally at the same action at test with two different objects (Study 2). Children also could resist extending the new noun to a new object (a rake vs. the balloon in Study 2) but could extend the noun to a scene with the same object undergoing a different motion (Study 1). A strength of this study is that the new nouns were embedded in longer sentences (e.g., noun condition: “The man is waving the larp.”; verb condition: “The man is larping the balloon”), and this study included 24-month-olds, while the other two studies did not include children younger than three years. A question that remains is whether the contrast phase, the comparison phase or both are equally important for noun and verb learning, and what the children learns from each phase.

Our study

The present paper adds to this small set of studies investigating noun and verb learning by including prototypical causative events. In addition, we examined children's attention to two cues that have not received much attention: sentence structure and access to multiple examples. As in Kersten & Smith (2002), in Study 1, we used stimulus sentences that were similar to those commonly used in noun learning studies (e.g., "It's a danu."; e.g., Landau et al., 1998) and verb learning studies (e.g., "Look! I'm meeking it."; e.g., Behrend & Scofield, 2006). However, comparisons of noun and verb studies are difficult because the level of syntax used in the sentences often varies (Childers & Tomasello, 2006). We predicted that stimulus sentences that are relatively complex should benefit verb learning because longer sentences would provide more syntactic information to the child, while making noun learning more difficult than is typically reported because children would need to locate the nouns in the more complex sentences. In addition, we considered how the syntactic structure of sentences in the learning phase of the study fit the structure of test sentences. We manipulated the types of sentences heard, using one set of sentences in Study 1 and a second set of sentences in Studies 2 and 3.

A second potential support for word learning is access to multiple exemplars to compare. Multiple examples could be especially helpful to children learning new verbs because verbs often refer to events that unfold over time. In addition, there are a variety of ways in which events can be parsed or construed, and there is a greater freedom in the ways languages refer to relations between objects as compared to references to the objects themselves (Gentner & Boroditsky, 2001). As a consequence, it may be more difficult for infants and young children to learn verbs (or other relational words) than it is for children to learn and extend words that refer to concrete objects (Gentner, 1982; Gentner & Boroditsky, 2001). In fact, across a variety of languages, children often produce more nouns than verbs before the age of 2 years (e.g., Au, Dapretto & Song, 1994; Bornstein, Cote, Maital, Painter, Park, Pascual, Pêcheux, Ruel, Venuti & Vyt, 2004; Jackson-Maldonado, Thal, Marchman, Bates, & Gutierrez-Clellen, 1993; Tardif, Gelman & Xu, 1999; Tardif, Shatz & Naigles, 1997), suggesting that children should have more experience extending new nouns than verbs. This common pattern in production further supports the noun/verb studies that have suggested more difficulty in verb than noun learning (e.g., Kersten & Smith, 2002; Imai et al., 2005; Childers & Tomasello, 2002, 2006).

Given the difficulty of learning words that refer to relations, verb researchers have discussed the necessity of attending to cues across situations (e.g., Behrend, 1995; Fisher, Hall, Rakowitz & Gleitman, 1994; Pinker, 1989). Cross-situational information could be useful because it allows the observer to compare two or more events that co-occur with the same verb, which would reveal aspects of those events that are likely to be central to that verb's meaning (similarities) and aspects that are free to vary (differences). New research suggests that comparison processes are useful in categorization (Gentner & Namy, 2000; 2006; Kovack-Lesh & Oakes, 2007; Namy & Gentner, 2002) and, more specifically, that the comparison of multiple events contributes to verb extensions in children as young as 2 1/2 years learning English (Childers, in press; Maguire et al., 2008; Scott & Fisher, 2009) or Korean (Childers & Paik, 2009). We compared children's responses after seeing multiple events (Study 2) with their responses after receiving a direct demonstration by the experimenter (Study 3). This allowed us to explore the unique contribution comparison may play.

A final main goal was to examine noun and verb extensions using a live interactive task in which concrete objects were shown in motion. In the research published to date, children have been asked reveal their verb extension decisions through looking time (Waxman et al.,

2009), pointing (Imai et al., 2005), or verbal responses (Kersten et al., 2006). In the present studies, children were given a chance to see events unfold live before them and to interact with objects they could hold in their hand (which may be especially important for 2-year-olds). In all conditions, at test they were asked to perform the same response which was to choose one object from an array. Although this response in the verb condition does not conclusively demonstrate that children can extend the meaning of a new verb, it has been used in previous studies (e.g., Childers & Tomasello, 2002), and we designed the study in this way so that there would be equivalent task demands across word conditions. If children did not attend to possible actions related to particular objects, there would be no reason for them to make consistent choices across trials. If we had asked children to move the objects only in the verb condition, and then found that children's verb learning was perhaps less robust or consistent than noun learning, the difference in dependent response would be an uninteresting possible reason for the outcome. At the same time, because the inclusion of nouns and verbs in these studies necessitated this common dependent variable, further studies in which children hearing verbs are asked to demonstrate actions are needed to more conclusively examine verb extension.

Earlier research on noun extensions suggests that children have a fairly strong shape bias (e.g., Graham et al., 1999; Landau, et al., 1988; Landau et al., 1998). However, in the few studies in which children were able to ignore shape and attend to function, the objects the new nouns referred to had complex functions that appeared to be very salient, complex and led to a noticeable result (e.g., creating lines on a page) (e.g., Kemler Nelson, 1995, 1999; Kemler Nelson, Russell, Duke & Jones, 2000). Thus, in the noun condition in Study 1, we presented children with sentences that were similar to other noun learning studies that have revealed a 'shape bias' (e.g., Landau et al., 1988; 1998), but we presented those sentences with more complex moving objects. In addition, because we predicted that having multiple instances to compare would be important for word extension, we included additional examples in Study 1. Children at this age often have difficulty extending new verbs (e.g., Huttenlocher et al., 1983; Roberts, 1983; Tomasello, 1992, 2000), and a key cue that could help with verb extension is comparison information. Because comparison events were included in this study, we predicted that children would successfully extend verbs.

Study 1

Method

Participants—Thirty-six 2 1/2-year-old children (M = 2 years, 8 months; range = 2;4–2;10) participated, with 11 girls and 25 boys (see Table 1). Most participants lived in middle-class or upper-middle-class families in a major city in the south central US. Twenty-one of the participants were Caucasian, eight were Hispanic or Latino, five self identified as more than one race/ethnicity including Hispanic or Latino, one was Caucasian and Asian, and one did not report ethnicity.

Participants were scheduled to participate in an on campus laboratory or were recruited through local day care centers. All parents who brought their child to the on campus laboratory reported that s/he was predominately exposed to English. In addition, we had these parents describe their children's language abilities using portions of the MacArthur-Bates Communicative Development Inventory: Words and Sentences (Fenson, Dale, Reznick, Bates, Thal, & Pethick, 1994); these children could produce 76 verbs on average (range: 21–103; n = 28). Parents also listed three of the longest sentences they had heard from their child; the mean length of longest sentence was 6.7 words (range: 3–13 words; n = 26). Children in day care centers were not recruited for the study if their teachers reported that they were bilingual or had a marked speech delay.

In the on campus laboratory, a direct mail marketing company provided names of potential families, who were then sent an introductory letter and contacted by phone. Participants who were seen at day care centers were asked to return a signed consent form to their teacher. These participants were taken individually to a quiet room to participate. In this study, children were excluded from the final data set for failing to complete all four trials (six), extreme distraction during the study (three), experimenter error (five), and failing to answer any practice questions correctly (one).

Materials—Twenty-eight novel objects were designed for this study and divided into four sets, each including one target object, four objects for the comparison phase, and two test objects. The comparison objects included two objects that had shapes that matched the target but were shown using different actions, and two objects that were shown with similar actions as the target but had different shapes. The test objects consisted of one object that had a shape that matched the target but which could perform a different action, and one object which could perform a similar action to the target but had a different shape. Each set was assigned a novel name (*gep*, *blick*, *dax*, and *koob*) and placed in its own box.

For example, in one set (*gep*), the target consisted of a ball embedded in a bowl that was pressed down onto a metal disk and could pick it up. The target and shape objects had a spaceship-like shape. The shape comparisons were twisted in a circle on the ground and the shape test choice could not pick up the metal disk (no magnet). The action objects were pressed to the ground (comparisons) and could pick up a metal disk (test); these objects did not have a spaceship-like shape. At test, children could choose a new spaceship-shaped object (shape choice) or a soft object that could pick up the metal disk (action choice, see Figure 1 and Appendix for a complete list).

Every experiment also began with a practice trial that included four familiar toys: a small Elmo, a stuffed pig, a toy motorcycle, and a toy helicopter.

Design—Participants were randomly assigned to one of three conditions (Noun, Verb, No Word), with 12 participants per group. Sets were presented in a random order and the order in which the objects were presented within each object set (e.g., shape objects first) was counterbalanced.

Procedure

Practice Trials: The experimenter began by demonstrating four familiar actions with four familiar objects. During demonstration with two of the four objects, the experimenter labeled the objects by name (e.g., “Look! It’s a helicopter.”) and with the other two objects, the experimenter labeled the objects’ actions (e.g., “Look! Elmo’s laughing.”). The experimenter then placed all of the familiar toys before the child and asked for one of the objects by referring to its action (verb question: e.g., “Which one was laughing?”) and another by name (noun question, e.g., “Where’s the helicopter?). The order in which questions were asked (noun or verb first) was counterbalanced across children, and the two objects requested at test were randomly selected.

Introduction to the Target: The experimenter then randomly selected one of the identical boxes containing a stimulus set. The experimenter first presented the target with a specific action while producing a noun (e.g.,”Look. It’s a <*novel wd* >. See? It’s a <*novel wd* >.”), verb (e.g., “Look, I’m going to <*novel wd* > it. See? I’m <*novel wd* >-ing it.”) or general language phrase (e.g., “Look. See? Wow.”) (see Table 2).

Presentation of Shape and Action Comparisons: After the introduction to the target object, the experimenter presented two objects that shared the same shape as the target and two objects that could perform the same action. Based on the procedures used in other studies of comparison (e.g., Gentner & Namy, 2006), the comparisons were always presented in pairs, with the two shape objects presented together and the two action objects presented together. The order of the presentation of shape or action comparison objects was counterbalanced both within each participant (shape objects were presented first half of the time for each participant) and across participants (particular sets were presented with shape objects first half of the time). Each object was shown in motion twice and language phrases were used to comment on it with different phrases used in each language condition. In the Noun condition, during the comparison phase children heard, "See? Look at this one. Wow.", in the Verb condition, children heard, "See? Look what I can do with this. Wow.", and in the No Word condition children heard, "See? Look. Wow.". In order to keep the procedure from becoming too lengthy, children were discouraged from exploring the comparison objects. However, in cases in which children persisted in their requests, the experimenter ensured that the child explored one item of each set (one shape and one action object).

Exploration of the Test Objects: After the comparison objects were shown, the experimenter brought out the test objects and encouraged the children to explore them using phrases that could draw attention to both objects and their potential actions ("See? Look at these. What can you do with these?"). Children who played exclusively with one object were encouraged to explore the other object. This interaction with the test objects was the only opportunity children had to explore the properties of the test objects, particularly their potential actions.

Test: Following presentation of the two test stimuli, the experimenter reintroduced the target, producing the same language phrases that had been used to initially. The experimenter then removed the target and retrieved the two test objects. In a forced-choice trial, the experimenter prompted the child to extend the label to only one of the objects, saying "Give me the <*novel wd* >. Where's the <*novel wd* >?" in the Noun condition or "Give me the one that <*novel wd* >-s. Which one can <*novel wd* >?" in the Verb condition. In the No Word condition, the child was simply asked for one of the objects ("Give me one. Which one?"). The test phase for the set ended when the child made a choice. Following the test phase, the procedure was repeated with the other three sets.

Coding—Each of the child's choices at test was coded as a shape choice or action choice. Each experimental session was coded live by an observer who was present in the room. This record was used in the final analysis if the session could not be coded from videotape (n = 3 in this study). Responses were coded from videotape by a second observer who had not seen the original experimental session and did not have access to the original coding sheets. A third observer then coded a random sample of 22% of the participants from tape (n= 8). Interrater agreement between the second and third coders was found to be 100% with a Cohen's kappa = 1.0.

Results

A univariate ANOVA with Word Type (3: Noun, Verb, No Word) as a between subjects factor and the mean number of shape choices as the dependent variable revealed a main effect of Word Type, $F(2, 35) = 6.59$, $p < .01$ (see Table 3). Tukey HSD post-hoc tests showed that the Noun condition differed significantly from the Verb condition, $p < .01$, and differed from the No Word condition, $p < .02$. A one sample t-test comparing the number of shape choices in the Noun condition to chance also was significant, $t(11) = 4.17$, $p < .01$.

Discussion

In this study, children in the noun condition exhibited a clear shape bias. A univariate ANOVA showed a significant difference between the three word conditions, and post-hoc tests revealed that the noun condition differed significantly from the other conditions and from chance. Although many other studies have shown this bias, it is somewhat surprising here because the objects were shown within a dynamic event in which actions led to a clear result. In addition, in this study, children saw multiple examples of objects and actions that could be compared. We predicted that access to comparison events could weaken a shape bias because it could draw children's attention away from shape and towards action, but that did not occur.

We also predicted that seeing multiple events would help children extend verbs, but the results showed that children in the verb condition still had difficulty. In thinking about this result, we began to consider whether something about the stimulus sentences was working against children's verb extension ability. Specifically, the verb test question in Study 1 (e.g., "Give me the one that <*novel wd* >-s? Which one can <*novel wd* >?") focuses on the object undergoing the action while the introductory sentences focus on the agent ("I'm <*novel wd* >-ing it"). Thus, in Study 2, we changed the sentences used to introduce the new verbs in object-focused sentences (e,g., "Look! The toy <*novel wd* >-s. See? The toy can <*novel wd* >.") to more closely match the test question we had been using (e.g., "Give me the one that <*novel wd* >-s?"). And, to maintain a balance between the noun and verb conditions, we changed the noun sentences so that the nouns would appear in more complex sentences and would be embedded within the sentence (e.g., "Look what the <*novel wd* > does?") (see Table 2). Thus, in the Noun condition, children heard a novel noun and a familiar verb, and were asked to extend the novel noun, and in the Verb condition, children heard a familiar noun and a novel verb, and were asked to extend the verb.

Study 2

Method

Participants—42 2 1/2-year-old children (M = 2 years, 8 months; range = 2;4–2;11) participated, with 24 girls and 18 boys. Most participants lived in middle-class or upper-middle-class families in a major city in the south central US. Sixteen of the participants were Caucasian, 15 were Hispanic or Latino, two were Black or African-American, seven self identified as Hispanic or Latino and one or more additional categories including Caucasian, Asian, Black or African-American, and American Indian or Alaskan Native.

Participants were recruited for the study using the same procedures as had been used in Study 1 (see Table 1). Parents in this study reported 73 verbs produced on average (range: 17–103; n = 35), and a mean length of longest sentence on the MCDI of 5.9 words (range: 2–14 words; n = 34). Participants in day care centers were screened as described in Study 1. Additional children participated but were excluded for failing to complete all four trials (six), being extremely distracted during the experiment (four), experimenter error (thirteen), or failing to pass the practice trials (one).

Materials—The same four object sets used in Study 1 were used in this study (see Appendix).

Design—Participants were randomly assigned to one of three conditions (Noun, Verb, No Word), with 14 participants per group. As in the previous studies, the sets were presented in a random order and the order in which the objects were presented within each set (e.g., shape objects first) was counterbalanced.

Procedure

Practice Trials: The practice trials were presented in the same way as in Study 1.

Introduction to the Target: This phase of the procedure was the same as had been used in Study 1 but included different sentences (see Table 2). In the noun condition, instead of "Look, it's a <*novel wd* >" children heard "Look what the <*novel wd* >does. See what the <*novel wd* >can do?". In the verb condition, instead of "I'm going to <*novel wd* >it" children heard, "Look, the toy <*novel wd* >-s. See? The toy can <*novel wd* >.". The no word condition was unchanged.

Presentation of Comparisons: The comparison phase of the experiment was conducted in the same way as in Study 1 except that the sentences heard in the Verb condition were changed from "Look what I can do with this" to "Look what this toy can do."

Exploration of the Test Objects: After the comparison objects were shown, the experimenter brought out the extension objects and encouraged the children to explore them (e.g., "Look at these. What can these do?").

Test: The test phase was exactly the same as in Study 1, with the same test questions.

Coding—As in the previous study, each of the child's choices at test was coded as a shape choice or action choice. Each experimental session was coded live by an observer and would have been used if the session could not be coded from videotape (n = 0 in this study). Responses were coded from videotape by a second observer who had not seen the original experimental session and did not have access to the original coding sheets. A third observer then coded a random sample of 31% of the participants from tape (n= 13). Interrater agreement between the second and third coders was found to be 100% with a Cohen's kappa = 1.0.

Results

A univariate ANOVA with Word Type (3: Noun, Verb, No Word) as a between subjects factor and the mean number of shape choices as the dependent variable revealed a main effect of Word Type, $F(2, 41) = 3.67$, $p < .05$ (see Table 3). Tukey HSD post-hoc tests showed that the Verb condition differed significantly from the Noun condition, $p < .03$. A one sample t-test comparing the number of shape choices in the Verb condition to chance also was significant, $t(13) = 2.92$, $p < .02$.

Discussion

In this study, children in the verb condition were able to choose new objects that could perform the relevant action at test, or extend the new verbs. The overall analysis showed a significant difference between the word conditions, the results in the Verb condition were significantly different from the Noun condition, and the mean number of shape choices in the Verb condition was significantly below chance. An interpretation of these results is that children hearing new verbs can attend to consistent actions and extend new verbs if the utterances they hear throughout the study have structures that support each other from teaching to test, and if they can compare examples to each other. At the same time, children hearing new nouns did not make consistent extensions to objects with similar shapes, even though those two cues were available.

There are several possible reasons for this noun result, and further studies would be needed to fully explore them. The noun sentences in the comparison phase were very different from those used in Study 1, embedding the new words within longer sentences that were more

complex. In addition, the initial sentences provided a strong pragmatic cue to attend to action, and this pragmatic information may have been the key reason for the weakened shape bias. Studies manipulating pragmatic cues and sentence complexity separately would be needed to tease these interpretations apart. In any case, the set of cues available in Study 2 weakened the shape bias without resulting in an overall tendency to extend on the basis of action.

These results are important because no prior word extension study has manipulated the stimulus sentences heard, and the findings from Studies 1 and 2 suggest that the structure of these sentences plays an important role. At the same time, the separate role of comparison is not revealed because both studies had a comparison phase. Thus, in Study 3, we removed this phase to test whether noun learning, verb learning, or both would be impacted.

Study 3

Method

Participants—42 2 1/2- year-old children (M = 2 years, 9 months; range = 2;4–2;10) participated, with 21 girls and 21 boys. Most participants lived in middle-class or upper-middle-class families in a major city in the south central US. Twenty-one of the participants were Caucasian, 19 were Hispanic or Latino, one was Black/African-American, and one was American Indian.

Participants were recruited for the study using the same procedures that had been used in the previous studies (see Table 1). All of parents reported minimal exposure to languages other than English, children produced 77 verbs on average (range: 12–103; n = 37), and the mean length of longest sentence was 7.1 words (range: 3–16 words; n = 36). The participants who participated in day care centers were reported by teachers to be monolingual English speakers with no marked speech delay. Additional children participated but were excluded from the final data set for failing to complete all four trials or being extremely distracted during the experiment (ten), failing to pass the practice trials (one), experimenter error (eight), or excessive parental involvement (one).

Materials—The materials were the same as used in the previous studies.

Design—Participants were randomly assigned to one of three conditions (Noun, Verb, No Word), with 14 participants per group. As in the previous studies, the object sets were presented in a random order and the order in which the objects were presented within each object set (e.g., shape objects first) was counterbalanced.

Procedure

Practice Trials: The practice trials were the same as previous studies.

Introduction to the Target: The experimenter presented the target in the same way s/he had presented it in the previous studies. The stimulus sentences used in Study 2 were also used in this study.

Introduction and Exploration of the Test Objects: Because the comparison phase was removed, we decided to have the experimenter expose the participants to the test stimuli in this study (see Table 2). During the presentation of each of the test stimuli, the experimenter produced a set of sentences that corresponded to a specific sentence condition (e.g., nouns: “See? Look at this one! Wow”; verbs: “See? Look at what this one can do! Wow.”; no word: “See? Look! Wow.”). The child was not able to play with the test objects until after both had

been demonstrated, then, as in previous studies, the experimenter invited the child to play with the test objects (e.g., “Now, look. Do you want to try?”).

Test: The test phase was exactly the same as in the previous studies, with the same test questions.

Coding—As in the previous study, each of the child’s choices at test was coded as a shape choice or action choice. Each experimental session was coded live by an observer and this record was used in the final analysis if the session could not be coded from videotape (n = 1 in this study). All other responses were coded from videotape by a second observer who had not seen the original experimental session and did not have access to the original coding sheets. A third observer then coded a random sample of 26% of the participants (n = 11) from tape. Interrater agreement between the second and third coders was found to be 95% with a Cohen’s kappa = .91.

Results

A univariate ANOVA with Word Type (3: Noun, Verb, No Word) as a between subjects factor and the mean number of shape choices as the dependent variable revealed no effect of Word Type, $F(2, 41) = 2.02$, ns (see Table 3). However, given the pattern of responses, we computed a one sample t-test comparing the mean number of shape choices in the Verb condition; this was significantly below chance, $t(13) = 2.28$, $p < .05$.

Results Across Studies—Because we did not vary the test phase across the studies, we could perform an analysis that examined whether differences in the learning conditions affected children’s responses. A univariate ANOVA with Word Type (3: Noun, Verb, No Word) and Study (3: 1, 2, 3) as between subjects factors, and mean number of shape choices as the dependent variable, revealed a main effect for Word Type, $F(2, 119) = 10.03$, $p < .001$, and a main effect for Study, $F(2, 119) = 4.26$, $p < .02$. There was no significant interaction between Word Type and Study. Post-hoc Tukey HSD tests showed that, across studies, Noun differed from Verb, $p < .001$, and Noun differed from No Word, $p < .05$; Verb and No Word did not differ. In addition, Tukey HSD post-hoc tests showed that Study 1 differed significantly from Studies 2 and 3, $ps < .05$, while Study 2 did not differ from Study 3 (see Table 3).

An additional set of analyses across studies examined possible influences of gender or number of verbs reported on the MCDI on children’s responses across the three studies. Pearson correlations and Kendall’s tau correlations, considering gender and perceptual choices were computed within each word type; none were significant. To test the possible relationship of MCDI scores and shape choices, Pearson’s r scores within each word type condition, and Kendall’s tau correlations within word type, were computed across the three studies and were not significant (see Table 1).

Discussion

The main finding from Study 3 was that children in the Verb condition produced results that differed from chance; however, the differences between the word conditions did not reach significance.[2] Even though these results seem weaker than those from Study 2 (because differences between conditions were found in that study), an analysis across studies shows that these apparent differences between the two studies were not significant. For this reason,

[2]The main effect of condition did not emerge in this study likely because the standard deviation, particularly in the Noun condition, appeared to be slightly higher than in Study 2 and the means of the Noun and Verb condition were somewhat closer; the comparison to chance in the Verb condition was less affected by these differences than was the overall analysis.

we interpret the results from Study 3 as providing additional support to those from Study 2. Both studies show children in the verb condition can choose new objects at test that can perform the relevant action under certain sentence conditions. In addition, Study 3 shows that children's noun extensions are disrupted when the new nouns are embedded within the sentence, even when no comparisons are shown. Because Studies 2 and 3 revealed similar results, one inference that can be drawn is that seeing multiple events and having to discover actions for new objects on one's own was as useful as was direct demonstrations from an adult of how objects can move. We offer this interpretation tentatively as other studies would be needed to a make a strong argument for it. However, if true, this is potentially important because this is the first study to suggest that comparison events may help children draw the same kinds of conclusions on their own as are available through direct instruction. This result is important for cultural groups that experience less direct instruction, because it suggests one way children may learn on their own.

General Discussion

These studies explored how two different cues influence children's ability to extend different types of words. We first consider what the pattern of results demonstrates about noun learning, comparing our results with the noun results from similar studies, and then turn to verb learning.

In terms of noun learning, the results from Study 1 show that children hearing nouns have a strong shape bias. Thus, if sentences are simple, even though objects are shown in motion and a salient result emerges, children learning nouns still make shape choices at test. This pattern was not found in Study 2, which differed from Study 1 only in terms of the sentences produced, and Study 3, which had the same sentences as did Study 2. In both of those studies, children's responses in the Noun condition fell to chance. Thus, the results from Studies 2 and 3 suggest that the shape bias fails under certain sentence conditions, particularly longer sentences in which the new noun is embedded. It is still unclear whether the sentence complexity per se was important, or whether a more pragmatic account with the adult seemingly focused on action in the second set of sentences is the key to this disruption; future studies exploring these possibilities are needed. However, other studies that have focused on noun learning and produced results showing an ability to overcome shape also have had nouns embedded in complex sentences (Kemler-Nelson, 1995; 1999; Kemler-Nelson et al., 2000).

Comparing the sentences used in the present studies to the three previous studies of noun and verb learning, Kersten and Smith (2002) presented children with fairly simple labeling sentences (similar to our Set 1 sentences), and the sentences in Japanese also were fairly short in the noun condition (Imai et al., 2005); the sentences presented in the noun condition in Waxman et al. (2009) were longer sentences, but those children also had access to both comparison and contrast information. In addition, previous studies of noun and verb learning have included scenes with novel objects in motion, but the motions typically consisted of large body movements. Thus, in none of the previous three studies of noun and verb learning were children asked to learn new nouns embedded in longer sentences and for novel objects used in complex actions with a result. These were the conditions in which we asked children to learn new nouns in Studies 2 and 3, and we found that, under these conditions, their responses fell to chance. Many researchers have argued that noun learning is "easier" than is verb learning, however nouns are typically presented in the lab with simple sentences and verbs are not. Thus an additional benefit to noun learning may be the kinds of sentences in which they are typically heard, both in the lab and in everyday life (at least in some languages or cultures).

Furthermore, it is clear that the availability of multiple exemplars to compare was not what disrupted performance in the noun condition in Study 2, as when that was removed in Study 3, results in the noun condition were unaffected. Thus, although seeing more than one example of an object in a dynamic event could have led children away from attention to shape, results across our studies suggest it did not. In addition, while access to multiple examples has been shown to facilitate the categorization of objects (Gentner & Namy, 2000; Namy & Gentner, 2002), these multiple examples did not appear to play a major role in noun learning in the present studies, possibly because objects were shown in motion, or the pragmatic cues and/or sentence structures weakened their usefulness.

A separate set of cues seemed to be important for verb learning, or combine in different ways than in the noun condition. Children in Study 1 in the verb condition demonstrated chance responding, while children in this condition in Study 2 differed significantly from the Noun condition and from chance. The only difference between these studies was in the sentences produced by the experimenter. In addition, children in Study 3 who heard the same sentences as those in Study 2 produced a set of results that was similar to results in Study 2 under different learning conditions (direct instruction).

Because the key difference between Study 1 and Studies 2 and 3 was the sentences, further discussion of these sentences is needed. It seems to us that it was not simply the syntax of the sentences that was important because the sentences used in Study 1 include two sentence frames, one a canonical transitive frame and one an unaccusative intransitive frame, which show that the novel verb allows an alternation between these frames as is common for change of state verbs. Because these frames provide more information about potential verb meaning than do the frames used in Studies 2 and 3, syntactically they should have led to promising results. However, it is possible that children were confused by this argument alternation (between transitive and unaccusative frames)[3] or were confused by the switch in speaker perspective: from a self-focused perspective in the learning phase (I'm meeking it") to an object-focused perspective at test ("Give me the one that meeks. Which one can meek?"). Importantly, the test question in all three studies was kept constant. Thus, children in Study 2, with the same test question as in Study 1, were able to extend verbs and the only difference between these studies was that they heard different initial sentences in the learning phase. Verbs incorporate speakers' perspective on events to a much greater degree than do nouns, but very few studies have explored how children attend to speaker perspective when learning new verbs. Additional studies exploring how attention to speaker perspective develops and is used in verb acquisition could be very fruitful.

A cue that appeared to be important for verb learning was access to multiple examples that could be compared. In the verb condition, children were as successful following a comparison phase as they were after direct instruction from an adult. That is, children in Study 2 (with comparisons) could make correct inferences about objects the experimenter had not manipulated, and their test behavior was similar to children in Study 3 who saw an experimenter manipulate the test objects. We cannot make a strong case for comparison based solely on these results, but it is remarkable that children performed as well as they did in Study 2 given that, during our comparison trials, children heard sentences without the novel words. In addition, we could have used both comparisons *and* had the experimenter demonstrate actions using the test objects, and this may have revealed an even more powerful influence of comparison than was found.

It is important that the 2 ½ year old children in Studies 2 and 3 performed well in the verb condition as only a few studies have shown that children this young and younger can extend

[3]We thank an anonymous reviewer for comments concerning these stimulus sentences.

newly learned verbs (Forbes & Poulin-Dubois, 1997; Maguire et al., 2008; Waxman et al., 2009). Most previous studies demonstrate verb extension in children older than three (e.g., Behrend, 1990, 1995; Forbes & Farrar, 1993, 1995). The studies reported here also rely on an interactive task whereas the majority of studies showing children extending new verbs have included video events in some way (Behrend, 1990; 1995; Forbes & Farrar, 1993, 1995; Forbes & Poulin-Dubois, 1997; Maguire et al., 2008; Waxman et al., 2009). An advantage of asking children to interact directly with objects is that they can handle the objects directly and perform their own movements on them (here in the test exploration phase), and this may be especially important for this young age group.

Perhaps the most important contribution these studies make is that they examine how different combinations of cues influence children's noun and verb extensions differently. Word extension studies often only include one type of stimuli, one set of syntactic frames and only one object or event (i.e., they typically do not include comparisons), and thus the influence of these cues is unclear. The present studies show that sentence structures are important for both noun and verb learning, but in different ways. In noun learning, children benefit from hearing simple sentences, either because they are easier to process than are sentences with embedded novel nouns, they are common in everyday life sentences with nouns and thus are better practiced structures for noun learning, or they signal that the situation is "about" objects and not actions. Children learning verbs need different types of sentences, and are influenced by whether initial learning contexts are similar to later extension contexts in ways not clearly relevant for nouns. Thus children learning verbs exhibit some rigidity in their thinking such that once an initial learning context is established, it is difficult for them to "switch gears" at test and take a new perspective. This conclusion is supported by many studies that have suggested often have difficulty extending newly learned verbs. In addition, the present studies provide suggestive evidence that access to multiple instances when learning verbs is beneficial, while similar access may not be as useful or necessary in noun learning (at least for nouns referring to basic level concrete objects).

Cues may not function independently and the set of cues, and settings, a researcher chooses likely has an important impact on their results. In the area of speech perception, Peter Jusczyk and others (e.g., Johnson & Jusczyk, 2001) suggested an approach to speech segmentation that considered the influence of multiple cues on infants' growing language abilities. Although the present studies were not designed to test a particular model of multiple cue use, they were designed to examine word learning in a complex environment in which multiple cues are available. Examining multiple cues may be an important approach for future word learning research, leading to better explanations of language learning in typically developing children and more effective interventions for children experiencing language delay.

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Appendix

Novel Word	Target	Shape matches	Action matches
Gep	The experimenter presses a soft, green sponge ball in a Styrofoam bowl, with magnet insert to pick up disc	**Comparisons:** The experimenter turns a hard, yellow ball in a Styrofoam bowl	**Comparisons:** The experimenter presses a net-covered, cylindrical sponge with magnets to pick up disc
	shape: Saucer action: Picks up small metal disc when squished	The experimenter turns a hard, white *ball in a Styrofoam bowl*	The experimenter presses a clover-shaped sponge with magnets to pick up disc
		Test Stimuli: Hard, silver ball inserted through the base of a Styrofoam bowl	Bow-tie shaped pillow with magnet insert
Dax	The experimenter sweeps a silver, double-handled round brush across fibers	**Comparison objects:** The experimenter taps a dowel within a yellow spongy tube on floor	**Comparison objects:** The experimenter brushes fibers using single-handled grout brush
	shape: Spindle action: Smoothes fibers attached to a small clipboard by brushing	The experimenter taps a dowel within a black film container on floor	The experimenter brushes fibers using round vegetable scrubber
		Test Stimuli: Blue dowel within a white cylinder	Silver brush, no handles
Koob	The experimenter shakes a wavy, orange translucent cup with protruding straw, containing marbles	**Comparisons:** The experimenter balances on hand a wavy, blue translucent cup with protruding straw, empty	**Comparisons:** The experimenter shakes an opaque plastic cylinder containing marbles
	shape: Wavy action: Makes noise when shaken	The experimenter balances on hand a wavy, green translucent cup with protruding straw, empty	The experimenter shakes an oblong, opaque object containing marbles
		Test Stimuli: Wavy, clear transparent cup with protruding straw, empty	"Figure-8" shaped infant's rattle
Blick	The experimenter twists a dumb-bell shaped object consisting of two connected pieces to connect split	**Comparisons:** The experimenter rolls a single-unit dumb-bell shaped	**Comparisons:** The experimenter twists a two-piece plastic Easter

Novel Word	Target	Shape matches	Action matches
	image of Elmo	object with image of Big Bird on floor	egg to connect split-image of cartoon frog
	shape: Dumb-bell action: Creates full image of Elmo when two pieces are twisted	The experimenter rolls a single-unit dumb-bell shaped object with image of cartoon dog on floor	The experimenter twists a two-piece, turning box to connect split image of cartoon baby
		Test Stimuli: Single-unit cylinder with bug image	Two-piece, turning pyramid with split image of colorful bug image

* Comparison stimuli was used only in Studies 1 and 2.

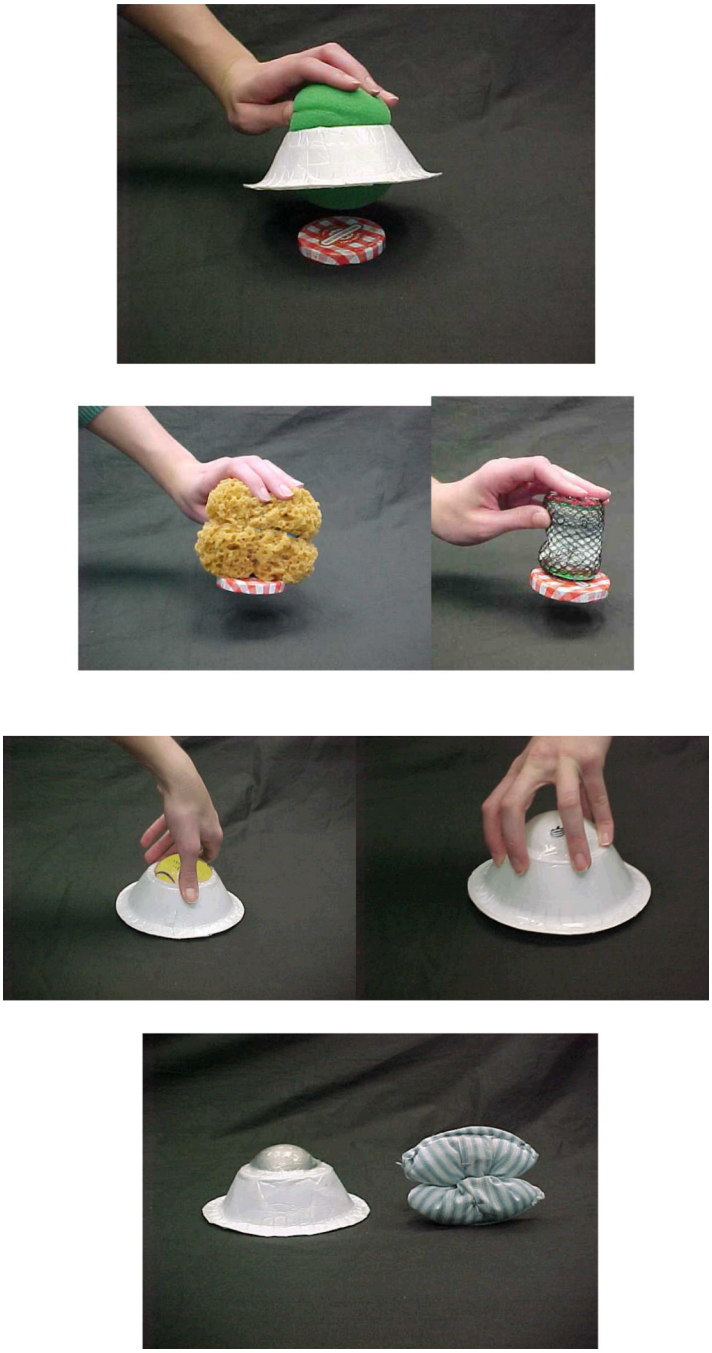

Figure 1.
Example of stimuli. Top object is the Target, two middle objects used in action comparisons (Study 1 and 2 only), two middle objects used in shape comparisons (Study 1 and 2 only), bottom left object is the shape extension choice, bottom right object is the action extension choice.

Table 1

Demographic Information

Study	Ages mean (range)	Gender m, f	MCDI results mean (range)
Study 1	2;8 (2;4–2;10)	25, 11	76 verbs (21–103)
Study 2	2;8 (2;4–2;11)	18, 24	73 verbs (17–103)
Study 3	2;9 (2;4–2;10)	21, 21	77 verbs (12–103)

Note. Correlational analyses computed across studies within each word condition revealed no significant relationships between gender or MCDI scores and children's responses at test.

Table 2

Summary of Stimulus Sentences

Study 1: Set 1 Sentences, With Comparison	**Studies 2 and 3: Set 2 Sentences, With Comparison (S2) and Without (S3)**	
Introduction to the Target	*Introduction to the Target*	
N: Look. It's a <*novel wd* >.	N: Look what the <*novel wd* > does.	
See? It's a <*novel wd* >.	See what the <*novel wd* > can do?	
V: Look. I'm going to <*novel wd* > it.	V: Look, the toy <*novel wd* >-s.	
See? I'm <*novel wd* >-ing it.	S2: See? The toy can <*novel wd* >. S3: See how it can < *n wd* >?	
NoW: Look! See? Wow.	NoW: See? Look! Wow.	
Comparisons	*S2 only: Comparisons*	*S3 only: Introduction to the Test stimuli*
N: See? Look at this one. Wow.	N: See? Look at this one. Wow.	N: See? Look at this one. Wow.
V: See? Look what I can do with this. Wow.	V: See? Look what this toy can do. Wow.	V: See? Look at what this one can do. Wow.
NoW: See? Look! Wow.	NoW: See? Look! Wow.	NoW: See? Look! Wow.
Exploration of test stimuli	*S2: Exploration of test stimuli*	*S3: Exploration of test stimuli*
All: See? Look at these.	All: Look at these.	All: Now look.
What can you do with these?	What can these do?	Do you want to try?
Test	*Test*	
N: Give me the <*novel wd* >. Where's the <*novel wd* >?	N: Give me the <*novel wd* >. Where's the <*novel wd* >?	
V: Give me the one that <*novel wd* >-s.	V: Give me the one that <*novel wd* >-s.	
Which one can <*novel wd* >?	Which one can <*novel wd* >?	
NoW: Give me one. Which one?	NoW: Give me one. Which one?	

Table 3

Mean (Standard Deviation) of Shape Choices in All Studies

Study	Word Type	Mean (SD)
Study 1: Set 1 Sentences, +Comparisons		
	Noun	3.1 (.9)[a, b, *]
	Verb	2.0 (.9)[a]
	No Word	2.1 (.7)[b]
Study 2: Set 2 Sentences, +Comparisons		
	Noun	2.3 (1.2)[c]
	Verb	1.3 (.9)[c, *]
	No Word	1.9 (.8)
Study 3: Set 2 Sentences, -Comparisons		
	Noun	2.2 (1.3)
	Verb	1.4 (.9)[*]
	No Word	1.9 (.9)

Note. Study 1: $F(2, 35) = 6.59$, $p < .01$. Tukey HSD post-hoc tests:

[a] $p < .01$;

[b] $p < .02$;

[*] one sample t test, $p < .01$.

Study 2: $F(2, 41) = 3.67$, $p < .05$. Tukey HSD post-hoc tests:

[c] $p < .03$;

[*] one sample t test, $p < .02$.

Study 3: $F(2, 41) = 2.02$, ns.;

[*] one sample t test, $p < .05$.

Across studies there was a significant difference between Study 1 and Studies 2 and 3, which did not differ from each other.