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Fast Mapping But Poor Retention By 24-Month-Old Infants

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Four experiments explored the processes that bridge between referent selection and word learning. Twenty-four-month-old infants were presented with several novel names during a referent selection task that included both familiar and novel objects and tested for retention after a five-minute delay. The five-minute delay ensured that word learning was based on retrieval from long-term memory. Moreover, the relative familiarity of objects used during the retention test was explicitly controlled. Across experiments, infants were excellent at referent selection, but very poor at retention. Although the highly controlled retention test was clearly challenging, infants were able to demonstrate retention of the first four novel names presented in the session when referent selection was augmented with ostensive naming. These results suggest that fast mapping is robust for reference selection but may be more transient than previously reported for lexical retention. The relations between reference selection and retention are discussed in terms of competitive processes on two timescales—competition among objects on individual referent selection trials and competition among multiple novel name-object mappings made across an experimental session.

INTRODUCTION

Young children learn words very rapidly. It is estimated that between 1 and 2 years of age, children's productive vocabulary increases by 300 percent (Fenson et al., 1994). Learning even a single new word, however, is an impressive accomplishment that requires that the child perform several non-trivial tasks. To learn the word "kitty" from the sentence "Look at the kitty" the child must 1) segment the target word from the speech stream, 2) find the referent of the novel word in the current scene that typically contains many possible referent objects, 3) encode the novel word form (e.g., the individual phonemes and their sequence), 4) encode something about the referent (e.g., where it was, its color, its shape, what it was doing), and 5) store the encoded information in such a way that the different pieces are linked and can be retrieved at a later point in time when the child needs to find the kitty, recognize the name, or produce the name (see also, Capone & McGregor, 2005; Gupta, in press; Oviatt, 1980, 1982). Further, young language learners hear many new word tokens each day (Brent & Siskind, 2001; Swingley, in press); thus, they must move seamlessly from hearing one word and encoding a word-referent mapping, onto the next word and the next word learning challenge.

In the context of the challenges inherent in real-world word learning, it is clear that we need to understand not just the individual components, but the integrated processes that lead from one part of the word learning task to the next. For instance, we need to understand how the processes that select the

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word and referent and form an initial mapping are related to processes that establish a known word. This emphasis on bridging from referent selection to retention was evident in Carey and Bartlett's (1978) seminal study of fast-mapping. In this original study, 3- and 4-year-old pre-schoolers successfully selected an olive green tray when their preschool teachers, who were setting up for snack time, gestured to two trays and asked them to get "the chromium tray, not the blue one, the chromium one" (Carey, 1978; Carey & Bartlett, 1978). Children demonstrated retention of the novel word one week later when asked to select "the chromium one" from among six color chips. Thus, Carey and Bartlett demonstrated that children could use the sources of information provided in the task—a familiar event sequence and explicit lexical contrast—to determine the referent of a novel word. Further, the novel lexical entry was robust enough to support retention of the novel word-referent mapping over a significant delay.

Numerous studies over the past three decades have replicated the general finding of fast mapping—that children can quickly map a novel name to a novel object. The present paper focuses on the next step—how the newly-formed name-object link becomes a known lexical item. In particular, we ask whether children actually learn the words they fast map. We begin by reviewing the studies that have looked at referent selection and retention, with an emphasis on studies that have examined how these two aspects of word learning are related. The vast majority of these studies can be divided into those that focus on referent selection and those that focus on retention. Critically, only a handful of studies have examined both children's ability to determine the referent of a novel word and retain the novel word-object mapping over a delay.

Studies of Referent Selection or Novel Word Retention

In fast mapping studies of *referent selection,* children are typically shown sets of novel and familiar objects, for example, a duck, a car, and a bird-toy (see Figure 1) and asked to select familiar objects on some trials (e.g., "Get the duck!") and novel objects on other trials (e.g. "Get the blicket!") (Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Wilkinson, Ross, & Diamond, 2003). Note that these tasks differ from that used by Carey and Bartlett in using a contrast between familiar and novel objects, rather than explicit lexical contrast (i.e., saying "the chromium tray, not the blue one") to support children's referent selection. Nevertheless, they follow Carey and Bartlett's lead in examining children's ability to use their prior word knowledge to determine the referent of a novel word. And, as in Carey and Bartlett's work, children have been shown to link new words to novel referents with remarkable accuracy in these kinds of tasks (e.g., Mervis & Bertrand, 1994). In fact, this sense of fast mapping has been demonstrated in infants as young as 17 months of age (Halberda, 2003) and 30-month-old infants have been shown to fast map as many as six novel names within a single experimental session (Golinkoff et al., 1992).

INSERT FIGURE 1 ABOUT HERE

Critically, however, children's ability to retain name-object links beyond the initial exposure has received less attention despite the relevance of this issue for real-world word learning. A few exceptions have tested retention after minimal delay, typically one or two trials after the original naming instance (e.g., Dollaghan, 1985; Golinkoff et al., 1992; Wilkinson & Mazzitelli, 2003; Wilkinson et al., 2003). Although these studies show that children can retain novel word-object mappings after a minimal delay, it is unclear from these studies whether retention is based on a robust representation of the name-object link or the simple repetition of a just-prior selection. This issue is critical because these different possibilities implicate very different mechanisms: retrieval from a long-term memory store in one case versus the short-term maintenance of a prior response in the other.

A handful of fast-mapping studies of referent selection have tested retention after longer delays (e.g., one day or one week). Some of these, however, have included a review of the name-object links (often using ostensive naming) before test (Goodman, McDonough, & Brown, 1998; Mervis & Bertrand, 1994). Consequently, in these studies it is unclear whether the retention infants demonstrate is based on retrieval of name-object links learned during the original referent selection task or on the maintenance of name-object links formed during the review period. Other studies that have included long delays between referent selection and test have used familiar event sequences to introduce the novel name (e.g., setting up for snack time, Carey & Bartlett, 1978; Heibeck & Markman, 1987). These studies are arguably the closest to the naturalistic settings in which children learn words. However, it is difficult to determine the relationship between referent selection and retention in these studies because the basis of children's correct referent selection during the retention task has not been isolated from the many possible supports that could contribute to correct performance. For example, it could be that the rich environment created by the familiar event sequence leads to a more complete encoding of the context in which the name-object link is introduced and thus provides the opportunity for a greater number of retrieval cues when retention is tested later. Likewise, the explicit lexical contrast used in many of these types of tasks could lead to a more robust encoding of the relation between the new word form and other words in the lexicon. This, in turn, could increase the potential cues available for successful retrieval during a retention test. Note that there are important differences in the implicated processes in these examples. In the first case, retention is based on links between the name-object mapping and the richly-structured context in which the new word was learned. In the second case, retention is based on integration of the novel word into the larger lexicon. Although not an exhaustive list of potential processes, these examples highlight that understanding the relationship between referent selection and retention requires understanding which of these is operating in different word learning situations.

Similar issues in fast mapping studies of *retention* make it difficult to form firm conclusions about the processes that underlie the selection-to-retention link. These studies typically present the name-object mapping via ostensive naming: either the target object is held up and named (Waxman & Booth, 2000), the target is the only object that is named (Markson & Bloom, 1997, see also, Childers & Tomasello, 2002), or the target is the only object present when the name is given (e.g., Dollaghan, 1985; Mervis & Bertrand, 1994). These studies have demonstrated that in such circumstances young infants can acquire and retain name-object mappings after limited exposure. For example, Woodward, Markman, and Fitzsimmons (1994) demonstrated that 13-month-old infants can remember a novel name-object mapping after as many as 24 hours if the object is ostensively named. However, because ostensive naming was used in this study, the child was not faced with the problem of picking the correct referent object from a set of competing alternatives[1].

Further, because only one object was ever named (see also Markson & Bloom, 1997), it is not clear whether retention was based on learning of the novel name-object mapping during the referent mapping segment of the task or simply because the target was made to be the most interesting or salient because it was the only object named in the experiment (Baldwin & Markman, 1989; for a similar argument see, Schafer & Plunkett, 1998). Thus, these studies provide critical insights into infants' ability to retain names presented via ostensive naming. However, they are less informative of the relationship between determining the referent of a novel word in the context of competitor items and retaining the novel word-referent link over a delay.

One recent series of studies has specifically attempted to compare children's retention of novel names learned via ostensive definition and names learned in an indirect context involving referent selection. Jaswal and Markman (2001; 2003) presented preschoolers with pairs of novel objects. In their direct learning condition, one of the objects was held up and named ostensively. In the indirect naming condition, syntax was used to differentiate between reference to the animate or inanimate object in the pair. Overall, Jaswal and Markman found little difference in children's ability to retain novel names learned directly versus those learned indirectly, with delays as long as two days (Jaswal and Markman, 2003, Experiment 1). Clearly, these data suggest that in some circumstances children are able to bridge between referent selection and retention quite well. However, it is not clear that children's retention performance was based on a robust memory for the name-object mappings due to the differential familiarity of the items presented during the retention trials. In particular, the test objects presented on the retention trial were the named target, a novel generalization item from the same category, and a completely novel object that the child had not previously seen. Thus, it is not clear whether children's selections of the target during retention were based on the increased familiarity of that object relative to the others or on a long-term representation of the name-object link—a distinction that is critical to a detailed understanding of the processes that relate referent selection and retention.

The Current Studies

Taken together, then, numerous studies on fast mapping have demonstrated that young children can be very good at determining the referent of a novel name given minimal input, and that, under the right circumstances, infants can succeed on a subsequent retention test. Nevertheless, it is unclear from previous studies whether successful retention was based on retrieval of robust name-object mappings from long-term memory and, thus, whether children actually learned the novel words. This highlights the importance of moving beyond existing demonstrations of a selection-to-retention link toward a detailed understanding of the processes that support such links. The present study takes an important step in this direction.

We began by asking the most basic question—can children retain names learned in a fast mapping context when test objects are all equally novel and there is no review of the name-object mappings, extended training period, lexical contrast, or familiar event sequence to facilitate retention? To this end, we presented young children with a simplified version of the referent selection task to obtain a baseline measure of how well children really learn the novel name-referent mappings made during referent selection. Thus, in our first experiment we used a standard laboratory forced-choice fast mapping task (e.g., Behrend, Scofield, &

Kleinknecht, 2001; Mervis & Bertrand, 1994; Wilkinson et al., 2003). We chose this forced-choice procedure rather than a more naturalistic task so that we could isolate the processes that support referent selection and study their contribution to infants' ability to retain name-referent links. Relative to past studies that have used this task, we made two relatively small, yet important changes. First, we modified the task by lengthening the delay between learning and test to ensure that retention was based on long-term memory rather than short-term maintenance. Second, we familiarized infants with the foil items to be used on retention trials. This ensured that correct target selections were based on a long-term representation of the name-object mapping rather than differences in familiarity.

These two modifications set up a very stringent test of infants' memory of name-object links formed in a referent selection task. Although this task certainly tests the limits of infants' abilities, we contend that it provides valuable information about the nature of infants' retention abilities and sets the stage for a deeper understanding of the processes that bridge the gap from referent selection to word learning. We demonstrate this in a second experiment where we modify the details of the referent selection task to promote more robust encoding of name-object mappings, and show that infants can retain words in our challenging task. The results of this experiment also highlight the critical role two types of competition play in the selection-to-retention link—competition among objects on individual referent selection trials and competition among multiple novel name-object mappings made across an experimental session.

EXPERIMENT 1A

To obtain a baseline measure of how well infants learn the novel name-referent mappings made during referent selection, we presented young children with a simplified version of the referent selection task used in previous studies (e.g. Behrend et al., 2001; Mervis & Bertrand, 1994; Wilkinson et al., 2003). We focused on 24-month-old infants because, while they are still in the earlier stages of vocabulary development, they are old enough to robustly fast map novel words and are frequently chosen to participate in fast mapping studies (e.g., Capone & McGregor, 2005). Further, infants this age demonstrate word learning biases such as the principle of mutual exclusivity and the whole object assumption (Markman, 1987; Markman, Wasow, & Hansen, 2003), which may be necessary to solve the referent selection task (see also Halberda, 2006).

Like many previous studies, we used a contrast between familiar and novel objects, rather than explicit lexical contrast, to support referent selection (e.g., Mervis & Bertrand, 1994; Halberda, 2003; Wilkinson, Ross & Diamond, 2003). Thus, we presented 24-month-old infants with referent selection trials in which they saw two familiar objects for which they already knew a name (e.g., a duck and a car) and one novel object for which they did not know a name (e.g., a bird toy, see Figure 1). On some trials, infants were asked to get a familiar object by name (e.g. "Get the duck!"). On other trials, infants were asked to get a novel object via a novel name (e.g. "Get the blicket!"). Each novel name was presented just one time because previous studies with 2-year-old infants suggest that one presentation is sufficient for encoding (see, Jaswal & Markman, 2001). For example, Dollaghan (1985) presented children as young as 25 months with a single naming token and found that 81% of infants showed retention for the name-object mapping and were able to complete production and generalization tasks after the retention task. Note, however, that retention in this study was tested after a minimal delay.

Following the introduction of several novel name-object mappings in this manner and a five-minute delay, infants were tested on retention of the novel name-object mappings. Unlike prior studies that have failed to control the familiarity of foils on test trials (e.g., Jaswal & Markman, 2001; Mervis & Bertrand, 1994), we examined whether the novel name-object mappings were retained by asking infants to retrieve the previously named novel object in the context of two other equally novel objects. One of these objects had been seen but never named (the unnamed foil) and the other had been seen as the referent of a different novel name (the named foil). The inclusion of the unnamed foil prevents the possibility of correct responses on the basis of familiarity only. Inclusion of the named foil prevents the possibility of correct responses on the basis of a memory that a particular object was named without knowing whether it was named with the target name in particular (for a similar argument see Schafer & Plunkett, 1998). Note that like studies with older children (Carey & Bartlett, 1978; Heibeck & Markman, 1987) but unlike prior studies with younger children (Mervis & Bertrand, 1994; Woodward et al., 1994), we did not include ostensive definitions or a review of the name-object links before the retention trials (Goodman, McDonough & Brown, 1998). Finally, we also tested infants' ability to extend the novel names presented in the referent selection task to a second exemplar of the named categories as a means of assessing whether the novel name-object links were between a specific object and a name or a more general category and a name (Golinkoff et al., 1992; Lederberg, Prezbindowski, & Spencer, 2000; Mervis & Bertrand, 1994).

Method

Participants

Sixteen 24-month-old infants (eight girls; *M* = 24 months, 22 days; range = 23m, 28d to 25m, 11d) with a mean productive vocabulary of 310.50 words (range = 23 – 561) participated. Data for two additional infants were not included due to experimenter error and a selection bias. Participants received a small toy for participation.

Stimuli

Figure 2 presents a subset of the stimuli. Sixteen familiar objects and eight novel target objects were used in the referent selection and retention tasks (see Panels C and A of Figure 2, respectively, for examples). A second highly similar version of each of the eight novel targets was used in the extension task. These objects differed from the originals in color or another small feature. Eight additional novel objects served as distractors during the retention tasks (see Panel D of Figure 2 for examples). These objects were chosen to be highly dissimilar to the other novel objects. A set of familiar and novel "substitute" objects was also on hand in case a child did not know the name of one of the familiar objects or already knew a name for one of the novel objects. During the session, stimuli were presented on a white tray divided into three equal sections.

INSERT FIGURE 2 ABOUT HERE

Procedure and Design

Before the experiment began, the experimenter gave the parent a list of the familiar words to be used and asked if the child was familiar with all the words and objects. If the child knew a different label for an object (e.g., "kitty" v. "cat") the experimenter used that label. If the child was not familiar with an object, a substitute object was used. The parent was also shown the novel objects (targets and distractors) and asked if the child could name any of them. If so, a different novel object was substituted. During the study, infants were seated across a white table from the experimenter in a booster seat next to their parents or on their parents' lap. Parents completed the MCDI (Fenson et al., 1994) during the session and were instructed to avoid interacting with their infants but to encourage their infants to respond if necessary. Most infants did not need parental encouragement after the warm-up trials.

INSERT TABLE 1 ABOUT HERE

Warm-up trials. An overview of the session and sequence of trials is depicted in Table 1. The session began with three warm-up trials. For each child, three familiar objects were randomly chosen for use on all warm-up trials. On each trial, the experimenter set the tray containing the objects on the table and silently counted for three seconds. This period gave the child an opportunity to look at the objects. The experimenter then asked the child to get an object (e.g., "Can you get the cup?") and slid the tray forward. Infants were prompted up to four additional times on each trial. Infants were praised heavily for correct responses and corrected if necessary. The positions of the objects on the tray were randomized across trials, and infants were asked for a different object at a different location on each warm-up trial. The warm-up stimuli were used later as familiar objects during the referent selection trials.

Referent selection trials. The referent selection trials immediately followed the warm-up trials and proceeded in the same manner except that infants were not praised or corrected. After each choice, the experimenter either said nothing or simply "ok" or "thank you" as the stimuli were removed. Each child was presented with eight sets of objects that each included two familiar and one novel object (for example, the duck, the car, and the bird toy). Each set was presented twice: once the child was asked for a familiar object (e.g., "Can you get the duck?") and once for the novel object (e.g., "Can you get the cheem?"). The order of familiar and novel trials was pseudo-randomized such that the same set was never presented on two sequential trials and no more than two trials of either type (i.e., familiar name, novel name) were presented sequentially. In addition, the trial order was counterbalanced across infants such that each novel trial occurred equally often as the first, second, third, etc, trial in the session. The location of the target object on the tray (i.e., left, middle, right) was randomly determined for each trial. A different novel name was used for each novel object: cheem, dite, dupe, fode, foo, pabe, roke, and yok (see Wilkinson & Mazzitelli, 2003).

Distractor familiarization. Prior to the retention trials, we familiarized infants with all the objects to be used as unnamed foils on the retention trials. This was done to ensure that infants' responses in the retention test were based on the name-object mapping made during the referent selection trials rather than a preference for novelty or greater familiarity with the named test objects. Thus, immediately following the fast mapping trials, a previously seen novel target (e.g., the bird toy) and randomly selected novel distractor (e.g., the whisk) were set 60cm apart on the table. The child was instructed to "Look!" while the experimenter counted silently to six, at which point the objects were removed and the next pair presented. The order of presentation was random and unrelated to the orders used in the referent selection and retention trials. The left/right positions of the objects were pseudo-randomly determined before the session such that novel distractors were presented equally often on the child's left and right.

Delay period. Following the distractor familiarization task, the child played in the laboratory waiting room during a five-minute delay while the experimenter set up for the retention trials and the parent continued to work on the vocabulary checklist. None of the objects used in the experiment, familiar or novel, were present in the waiting room.

Production task. Upon returning to the testing room, infants were presented with the novel targets that were named during the referent selection task one at a time in a random order. Infants were prompted to name each target up to four times (e.g., "What's this? What is this called?"). None of the infants produced any of the target names. However, all of the infants either said "yes" to the prompt "do you know what this is called?" for at least one object (even though they could not offer a name), or offered a known or made-up name. Thus, the lack of production responses most likely reflects infants' poor memory for the names, rather than a difficulty re-engaging in the experimental task after the delay.

Retention and extension trials. The retention and extension trials followed immediately after the production task and used the same procedure as the referent selection trials. On each retention trial, infants saw two previously named novel targets and a previously seen distractor (e.g., rope bird toy previously named "cheem," pink top previously named "roke," and whisk previously seen but unnamed). On each extension trial, infants saw new instances of two previously named novel objects and a previously seen distractor (e.g., orange version of the rope bird-toy previously named "cheem," green version of rubber pom-pom previously named "yok," and sieve previously seen but unnamed). The pairing of novel objects and distractors was pseudo-randomized across infants for each retention and extension trial. Four of the eight novel names were tested on the retention trials and four were tested on extension trials. The order of trials and the positions of the objects were randomized.

Naïve coders coded infants' selections from DVDs of the sessions. Inter-coder agreement was high, $M = 97.48\%$, $SD = 4.54$ (range = 86.36% – 100.00%).

Results and Discussion

As can be seen in Figure 3, infants chose the target object significantly more than would be expected by chance on both familiar and novel referent selection trials (all p's < .001, two-tailed, Familiars: $d = 1.57$; Novels: $d = 1.86$). This replicates previous findings of very good referent selection in similar fast mapping tasks (Behrend et al., 2001; Mervis & Bertrand, 1994; Wilkinson et al., 2003). As is also clear in the figure, however, infants did not retain or extend names at above chance levels (both p's > .20, two-tailed; note that only retention and extension trials for names correctly mapped in the referent selection trials were analyzed). There was no difference in the proportion of correct choices based on trial type (retention or extension), $t(14) = .14$, *ns*. The overwhelming majority of infants only required one prompt, on average, per trial, $M = 1.38$, mode = 1.00, (range: 1.00 – 2.94), on the retention and extension trials, suggesting that the low retention was not due to infants having trouble re-engaging in the task following the break.

INSERT FIGURE 3 ABOUT HERE

We next examined the types of errors infants made on both the retention and extension trials. Systematic selections of the previously named foil would suggest that infants recognized that the novel name had previously been mapped onto a novel object during the referent selection trials, but they were unable to correctly remember to which object the name referred. In contrast, systematic selections of the previously unnamed foil would suggest that infants were responding based on novelty-in-context (a pattern we tried to limit by including the distractor familiarization). We did not find any systematicity in infants' errors for either the retention or extension trials (see Table 2). Specifically, we found no difference in the proportion of infants' choices of the previously named foil versus the previously unnamed foil on retention trials, $t(14)^2 = 1.74$, $p = .10$, two-tailed or on the extension trials, $t(15) = .45$, *ns.* Thus, infants truly appeared to be responding randomly, indicating that they did not remember that the novel name had previously been mapped to a specific object.

INSERT TABLE 2 ABOUT HERE

It appears, then, that infants did not retain the name-object mappings in our stringent retention test. It is possible, though, that infants encoded the first few names presented in the referent selection task, but the latter names were lost given the memory demands of being presented with multiple novel names in a single session. To check whether infants remembered some but not all of the novel names, retention was examined in two blocks in the order introduced during referent selection. There was no difference between blocks (Block 1: $M = .33$, $SD = .30$; Block 2: $M = .34$, $SD = .40$), $t(15) = -.17$, *ns*, two-tailed, and performance was not greater than chance for either block, $t(15) = -.04$, *ns,* $t(15) = -.15$, *ns*, respectively. To double-check that infants failed to retain even a single name, a binomial was conducted on the retention trial with the best performance. It was non-significant, $p = .11$. Thus, infants did not retain any of the name-object links formed in the referent selection task over the five-minute delay.[3]

Clearly infants exhibited considerable difficulty demonstrating retention of the novel name-object mappings in the context of the long delay and the stringent retention task that prevented the use of differential familiarity as a cue. Although we expected our task would be challenging, the present results were surprising in the context of the extant literature showing that infants can, in some cases, retain fast-mapped words. We expected at least modest retention, but 24-month-olds failed to retain any of the words. The question, then, is why? Previous fast mapping studies that have demonstrated retention have presented between one (e.g., Woodward, Markman, & Fitzsimmons, 1994) and eight (e.g., Wilkinson & Mazzitelli, 2003) novel names. Based on such findings, we included eight novel names in our task to give infants multiple opportunities to show retention. It is possible, however, that competition among the multiple novel name-object mappings formed during the referent selection task made it difficult for infants to retrieve the correct word-referent mapping in the context of equally familiar items at test. We explored this possibility in Experiment 1B by replicating Experiment 1A but only introducing one novel name.

EXPERIMENT 1B

Method

Participants

Thirty-two 24-month-old infants (17 girls; *M* = 24 months, 16 days, range = 23m, 18d to 25m, 14d) with a mean productive vocabulary of 301.90 words (range = 24 – 674) participated. Infants were randomly assigned to either the Trial 2 or Trial 15 condition. There were no differences in vocabulary level, t (30) = .085, *ns*, or age t (30) = .27, *ns*, between conditions. Data for five additional infants were not included due to equipment failure (3), fussiness (1) or failure to respond (1). Infants were recruited as in Experiment 1A.

Stimuli and Procedure

The same stimuli, sets, novel names, procedures, and counterbalancing used in Experiment 1A were used in this experiment, with four exceptions. First, in this experiment seven of the novel name-referent selection trials were replaced with filler trials. This was done to keep the overall number of trials constant. On the filler trials, infants were presented with the same sets of objects as in Experiment 1A but were told to "get the one you like the best!" The single remaining novel name-referent selection trial was trial 2 for half of the infants and trial 15 for the other infants. Second, the distractor familiarization task was omitted. Unnamed novel objects presented in the filler trials were used as distractors on the retention trial. Thus, on the single retention trial, infants saw the target and two previously seen but unnamed novel objects. Third, the production task and the extension trials were omitted from this and the following studies due to infants' poor performance on these tests in Experiment 1A. Fourth, to make sure infants were re-engaged in the task before the retention trial, we added one warm-up trial prior to that task. This trial followed the same format as the initial warm-up but used three different randomly selected familiar objects (e.g., the shoe, the horse, and the book).

Thus, during the referent selection phase of the experiment, infants were presented with three warm-up trials followed by sixteen trials: eight familiar referent selection trials, one novel referent selection trial, and seven filler trials, with the novel trial always occurring as either the second or the fifteenth trial (see Table 1). As in Experiment 1A, but in contrast to previous studies in the literature, we used a five-minute delay to ensure that retention was based on a long-term representation of the name-object mapping, and equated the familiarity of the objects used during the retention test. As in the previous experiment, infants played in the laboratory waiting room during the five-minute delay period between the referent selection task and the retention test.

Results and Discussion

A Chi Square test revealed no difference in referent selection performance between infants who received the novel name on Trial 2 v. 15, so we collapsed these groups, $X^2(1) < 1.00$, *ns*. Infants chose the target object significantly more than expected by chance on the familiar referent selection trials $t(31) = 11.05$, p < .0001, two-tailed, $d = 1.94$. As can be seen in Table 3, infants also chose the target on the novel referent selection trial more than expected by chance (22 out of 32; binomial probability, $p < .0001$). After a short delay, however, infants chose the target object at levels that were only marginally better than chance (10 out of 22; binomial probability, $p = .08$; as in the prior study we only analyzed retention trials for words that were correctly mapped during the referent selection task). As in Experiment 1A, results suggest that infants were very engaged in the task: they overwhelmingly chose the correct object on the warm-up trial, *N* = 27 out of 32; binomial probability, $p < .001$, and required only one prompt per trial, on average, *M* = 1.43, mode = 1.00, (range: 1.00 – 3.94).

INSERT TABLE 3 ABOUT HERE

The results of this experiment are again quite surprising. At least four studies have demonstrated that infants can retain multiple name-object mappings formed in a single session (Golinkoff et al., 1992; Goodman et al., 1998; Mervis & Bertrand, 1994; Wilkinson et al., 2003). By contrast, infants in the present experiment failed to demonstrate significant retention of a *single novel word* in our stringent retention test. This was the case even in the Trial 15 condition where infants only had to remember the mapping through one familiar name trial and the five-minute delay. This strongly suggests that our two key manipulations—a longer delay and constrained retention test—had a substantial impact on infants' ability to retain or correctly retrieve the novel name-object mapping.

Given that our retention test is clearly quite challenging, we conducted a second follow-up experiment with the simplest possible design. In particular, we replicated the trial 2 condition of Experiment 1B but only presented three total trials. Our question was whether infants would be able to retain a single novel name-referent mapping across a five-minute delay when all of the test objects at retention were equally familiar.

EXPERIMENT 1C

Method

Participants

Twenty 24-month-old infants (ten girls; *M* = 24 months, 18 days, range = 23m, 24d to 25m, 30d) with a mean productive vocabulary of 319.60 words (range = 23-556) participated. Infants were recruited as in Experiment 1A.

Stimuli and Procedure

All aspects of the experiment were identical to the Trial 2 condition of Experiment 1B, except infants received only three referent selection trials in total (see Table 1). Thus, infants were presented with three warm-up trials followed by three referent selection trials: two familiar referent selection trials and one novel referent selection trial, with the novel trial always occurring as the second trial. As in the previous experiments we equated the familiarity of the objects used during the retention test—in this case each object had served as the novel object on one familiar-name referent selection trial. Infants again played in the laboratory waiting room during the five-minute delay period between the referent selection task and the retention test, and performed one warm-up trial upon resuming the study.

Results

Infants chose the target object significantly more than would be expected by chance on the familiar referent selection trials, $t(19) = 6.18$, $p < .0001$, two-tailed, $d = 2.84$. As can be seen in Table 3, infants also chose the target on the novel referent selection trial more than would be expected by chance (12 out of 20; exact binomial probability, $p < .01$). After a short delay, however, infants failed to choose the target object at levels significantly different from chance on the retention trial (3 out of 12, *ns*; as in the prior study we only analyzed the retention trial if the word had been correctly mapped during the referent selection task). Again, infants were very engaged in the task; all 20 infants performed correctly on the warm-up trial after the delay and, on average, required only one prompt on the referent selection trial, M = 1.25, mode = 1.00, (range: 1.00 – 5.00).

Discussion

Together, data from Experiments 1A-C suggest that the processes that support 24-month-old infants' ability to select the novel object as the referent of a novel word in the context of a fast-mapping task do not create a strong enough representation to support retention of the mapping five minutes later. Further, the fact that retention did not improve above chance levels when we reduced the number of novel names in the session (Experiment 1B) or the total number of words, novel or familiar, fast-mapped in the session (Experiment 1C), suggests that the weak word-referent encodings result from processes operating at the timescale of individual trials, rather than across trials. This idea is supported by the fact that when we analyzed the data from Experiment 1A by block, we found no difference in infants' retention for words fast-mapped early or later in the session.

Recall that the goal of this experiment was to test the limits of young children's word learning abilities by taking a canonical task used in previous studies of the relationship between referent selection and retention, but controlling two key aspects of the task: (1) we used a longer delay to ensure retention was based on retrieval from long-term memory, and (2) we used a rigorous retention test that could not be solved on the basis of familiarity or salience alone (e.g., all objects had been familiarized in a naming context). In light of the eight previous studies that have shown a selection-to-retention link (Carey & Bartlett, 1978; Golinkoff et al., 1992; Goodman et al., 1998; Markson & Bloom, 1997; Mervis & Bertrand, 1994; Waxman & Booth, 2000; Wilkinson et al., 2003; Woodward et al., 1994), we expected to find at least some retention. Across three experiments with 68 infants, referent selection performance was consistently excellent, but retention never exceeded chance levels. In total, infants in the three experiments only retained 29 of the 75 words they correctly mapped in the referent selection portion of the task, a probability of 38.66%, which is not significantly different from chance levels (binomial p = .38).

Considered in the context of the extant literature, results from Experiments 1A-C demonstrate, therefore, that the demands placed on children during retention are central when considering the crucial real-world issue of how children go from referent selection in contexts with multiple objects to word learning. Clearly infants can show successful retention under some circumstances. But our data suggest that retention in these cases may not have been based solely on a representation of name-object mappings stored in long-term memory. Rather, it was likely also supported by short-term memory processes in some cases (e.g., Dollaghan, 1985; Golinkoff et al., 1992; Wilkinson & Mazzitelli, 2003; Wilkinson et al., 2003) or the details of the foil items during the retention test in others (e.g. Jaswal & Markman, 2003; Markson & Bloom, 1997; Woodward et al., 1994).

The foregoing results suggest that if we want to understand the processes that support retention of name-object mappings made in referent selection tasks, we must hold to a stringent set of criteria for the retention test. Although we agree that this sets a high hurdle for 24-month-old infants to clear, if infants succeed, we know that retention was based on retrieval of the name-object mappings from long-term memory. Thus, in the next experiment, we ask whether infants can ever clear this high hurdle. In particular, are there ways to strengthen the encoding of the word-referent mapping so that retrieval from long-term memory in a rigorous retention test is possible? If this is the case, it would highlight two things: (1) that 24-month-old infants can succeed on our stringent retention test, and (2) we can use our empirical approach to probe the processes that bridge the gap between referent selection and word learning.

EXPERIMENT 2

Why did the infants in Experiment 1 fail to demonstrate retention of the novel name-object mappings formed in the referent selection task? One possibility is that the name-object links formed in the referent selection task were not encoded robustly enough to support retention in our stringent task. This could be due to competition created by the presence of the familiar objects on individual fast mapping trials. This is consistent with prior studies that have demonstrated long-term retention of novel name-object mappings made in the absence of other objects (Dollaghan, 1985; Oviatt, 1980). This possibility is also consistent with the idea that solving the referent selection task requires that infants attend to each of the familiar objects and, by the mutual exclusivity principle or other such word learning bias, rule them out as possible referents (Halberda, 2006; Markman, 1987; Markman et al., 2003).

If competition and weaker word-object encoding on referent selection trials are critical factors in later retention, then it should be possible to facilitate retention of the newly formed novel name-object links by making the relevant name-object mapping more salient and thus strengthening encoding. In particular, support for the distinction between the novel object and the familiar objects after the name-object mapping is made—for example, holding up and naming the novel object—should reduce competition from the activated representations of the familiar objects, facilitate encoding of the novel name-object mapping, and thereby increase retention. In contrast, retention should not increase if the novel name-object mapping is repeated without deliberately strengthening the encoding by making the novel object more salient.

The present experiment used the basic design from Experiment 1A, but attempted to facilitate retention by increasing the salience of the novel names and objects during referent selection, thereby strengthening the encoding of the novel name-object mappings. Specifically, to enhance the salience of the novel name we repeated it multiple times. To enhance the salience of the novel object and the link between the object and the name, infants' referent selection on each trial was immediately followed with ostensive naming. We also checked that enhancing the salience of the novel name alone was not enough to promote retention. A second group of infants heard the novel name repeated multiple times but their selections on each trial were immediately followed by follow-in labeling in which the experimenter did not hold up or single out the requested object. Rather, follow-in labeling consisted of the experimenter naming whatever the infant had chosen, even if it was not the novel object.

Note that we included eight novel referent selection trials as in Experiment 1A to increase infants' opportunities to demonstrate retention by avoiding ceiling effects. Previous studies in the literature (e.g., Golinkoff et al., 1992; Jaswal & Markman, 2003; Wilkinson & Mazzitelli, 2003) as well as our prior experiments suggest that 24-month-old infants are very good at referent selection and can correctly choose the target object even when presented with many trials. The goal here was to increase the salience of the novel names and objects during the referent selection trials in an effort to strengthen the name-object mappings, but at the risk that the task would be rather easy. Further, the inclusion of multiple novel referent selection trials avoids a limitation evident in Experiments 1B and 1C: infants do not always select the correct referent on the novel referent trials; with only a single such trial, therefore, a smaller percentage of infants contribute useable data on the retention test. For instance, 69% of all infants contributed usable data on the retention test in Experiment 1A, while 60% of all infants contributed usable data in Experiment 1C (see Table 3). In this context, it is also worth emphasizing that data from Experiments 1B and 1C failed to show an advantage on retention when a single novel name referent selection trial was presented.

Method

Participants

Thirty-two 24-month-old infants (18 girls; *M* = 24 months, 14 days: range = 23m, 22d to 25m, 28d) with a mean productive vocabulary of 324.09 words (range = 14 - 631) participated. Infants were randomly assigned to either the ostensive naming or follow-in labeling conditions. There were no differences in vocabulary level, $t(30) = .525$, *ns*, or age $t(30) = .38$, *ns*, between conditions. Data for four additional infants were not included due to fussiness (3) and experimenter error (1). Infants were recruited as in Experiment 1A.

Stimuli and Procedure

All aspects of the experiment were the same as Experiment 1A with three exceptions. First, before each referent selection trial, for infants in both conditions, the experimenter named the target object five times, by saying, “Ok, now we’re going to look for a cheem. Can you help me find a cheem? Let’s find a cheem. Are you ready to find a cheem? Ok, let’s find a cheem.” Second, infants received either ostensive naming or follow-in labeling after each referent selection trial. For infants in the ostensive naming condition, selections on each referent selection trial were followed by the experimenter holding up and pointing to the target while saying, for example, “Look, this is the cheem!” For infants in the follow-in labeling condition, selections on each referent selection trial were followed by the experimenter naming the chosen object while the infant was holding and looking at by saying, for example, “yes, that’s the cheem,” when the child chose correctly, or “that’s the duck” when he or she chose incorrectly. The final design change relative to Experiment 1A brought the retention test in line with Experiments 1B and 1C: infants completed one warm-up trial after the 5-minute delay followed by eight retention trials (there were no production or extension trials; see Table 1).

Results

As in previous experiments, we analyzed the referent selection and retention data separately, and only analyzed retention data for names for which infants had previously selected the correct object on the corresponding referent selection trial. Importantly, in this experiment this criterion has the effect of insuring that the number of naming instances for each mapping is consistent across conditions. This is because correct selections in both conditions were followed by the experimenter saying the novel name (i.e. “Look, this is the cheem” in the ostensive definition condition, or “Yes, that is the cheem” in the reinforced condition), whereas infants who chose incorrectly in the reinforced condition heard the name of the familiar object they selected (i.e., “that is the duck”).

Our main question in this experiment was whether the differential highlighting of the name-object link in the two conditions would have differential effects on retention, suggesting a role for competition and encoding strength at the time scale of individual trials. In this context, it is important to note that such effects might also interact with competition at the between-trial time scale. For instance, it is possible that repeated attempts to enhance word-object mappings might boost encoding even further for mappings late in the session. Alternatively, the encoding of more robust word-object mappings early in the session might interfere with the learning of such mappings later in the session.[4] To examine these issues, retention data were collapsed into blocks and submitted to a Condition by Block mixed-design ANOVA. In addition, we compared performance to levels expected by chance and examined infants’ choices of foils as in the previous experiments.

As can be clearly seen in the left panel of Figure 4, infants in both conditions chose the target object significantly more than expected by chance on both familiar and novel referent selection trials (all p’s $< .001$, two-tailed, all d’s > 1.88). As is also clear in the right panel of the figure, retention of the novel name-referent mappings was influenced by both our manipulation of within-trial salience and by our index of between-trial competition, that is, when in the session the mapping was created. The ANOVA yielded a main effect of Block, $F(1,30) = 13.75$, $p < .001$, and a Condition by Block interaction, $F(1,30) = 12.07$, $p < .01$. Infants whose correct referent selections were followed by ostensive naming retained novel names on block 1 at greater than chance levels, $t(15) = 3.77$, $p < .01$, two-tailed, $d = .94$ and better than on block 2, $t(15) = 4.24$, $p < .001$, two-tailed, $d = 1.62$. In contrast, infants whose correct referent selections were simply labeled a second time (follow-in labeling condition) failed to retain novel names at greater than chance levels in either block, both p’s $> .41$. Further, infants whose referent selections were followed by ostensive naming showed significantly better retention on block 1 than infants who received follow-in labeling, $t(30) = 2.10$, $p < .05$, two-tailed, $d = 73$.

INSERT FIGURE 4 ABOUT HERE

Importantly, the lack of retention seen in the follow-in naming condition and in the second block of the ostensive definition condition did not appear to result from a difficulty re-engaging in the task following the delay. Most infants required only one prompt per trial, $M = 1.23$, mode = 1.00 (range: 1.00 – 3.44). There were no differences between conditions regarding infants’ average number of prompts, $t(30) = 1.26$, *ns*. Moreover, infants were very engaged in the task and overwhelmingly chose the correct object on the warm-up trial after the delay, 31 out of 32; binomial probability, $p < .001$.

One possible interpretation of the graph in Figure 4 is that the difference in performance across blocks is a fatigue effect—infants just failed to perform on retention trials that came at the end of a reasonably long experiment. Recall, however, that blocks were defined on the basis of trial order in the *referent selection*, not retention portion of the experiment. Further, different random orders of trials were used in the referent selection and retention portions of the task. Consequently, some of the correct retention choices infants made came at the very end of the experimental session. Is it possible, then, that the block effect in retention is actually due to fatigue during referent selection? At one level, this seems unlikely because we only analyzed retention trials for words that were correctly mapped during referent selection. Importantly, however, there was no difference in referent selection performance across the two blocks for infants in the ostensive definition condition, M = .66 and .67, for blocks one and two, respectively, $t(15)$ = -.324, *ns*. Likewise, infants' likelihood of correct selections in referent selection was independent of trial number $X^2(7)$ = .95, *ns*. Thus, it does not appear that the poor retention for words presented later in the referent selection task was due to fatigue in that task.

An examination of infants' errors on the retention trials did not reveal a bias to systematically select one foil over the other (see Table 2). Specifically, there was no preference for the previously named foil over the previously unnamed foil for infants in the ostensive naming condition, $t(15)$ = .82, *ns,* or for infants in the follow-in labeling condition, $t(15)$ = 1.51, *ns.* There was a marginal difference between conditions in the proportion of choices to the unnamed foil. Specifically, infants in the follow-in labeling condition selected the previously unnamed foil more than infants in the ostensive naming condition, $t(30)$ = 1.93, p = .06. The higher proportion of choices to the unnamed foil, however, is likely attributable to the fact that infants in the follow-in labeling condition made marginally more errors overall (M = 3.81, SD = 1.38, range 2.00-6.00) than infants in the ostensive naming condition (M = 3.00, SD = 1.03, range 1.00-5.00), $t(30)$ = 1.89, p = .07.

Discussion

Data from this experiment suggest an intriguing role for competition and the salience of word-object mappings in the processes that bridge the gap between referent selection and retention in early word learning. Specifically, data from the follow-in labeling condition suggest that repeating the novel name multiple times without increasing the salience of the novel object by separating it from the familiar ones is not enough to support retention. At face value, this result is striking—we named the novel object five times, infants correctly picked the novel target, and we reinforced this correct selection by repeating the name, yet infants failed to recall this mapping during the retention test. This supports the proposal that the presence of the familiar objects in the referent selection task creates competition, hinders encoding of the name-object mapping, and thereby works against retention. This proposal is also consistent with data from the ostensive naming condition in which 24-month-old infants showed increased retention when the referent they selected was made more salient by singling it out and effectively reducing competition from other recently activated object representations.

Note, however, how subtle this difference between conditions was. In both conditions, the child made a correct selection and the novel word was repeated. What differed was who was holding the object when the novel name was repeated—the child (in the follow-in condition) or the experimenter (in the ostensive naming condition). Although subtle, this difference had a large impact on performance. This result fits with recent work by Booth, McGregor, and Rohlfing (under review) demonstrating improved word learning when the experimenter physically contacted the named object (i.e., picking the object up) versus when the experimenter pointed to the named object. From a more social-constructionist position (Tomasello, 2003), one might argue that the basis of this effect is that the ostensive naming event makes it more obvious to the child that the experimenter intended to name the novel object. We do not disagree with this position. However, we contend that at a mechanistic level such understanding on the part of the child may in fact be implemented via reduced competition from the distractors (Samuelson & Smith, 1998).

Competition between the familiar foils and the novel target on individual referent selection trials is not the only process at work, however. Even when infants' selections were singled out in the ostensive naming condition, infants were only able to retain up to four words. This result suggests that processes at the level of the trial-to-trial timescale also influence infants' retention (an effect that was likely overshadowed in Experiment 1A by the competition occurring at the timescale of individual trials). Further work examining competition at this time scale—by varying the delay between trials or the similarity of activated representations across trials—is clearly necessary. Nevertheless, we contend that the current study lays the foundation for such work by showing that it is possible for infants to demonstrate significant retention of novel name-referent mappings after a reasonable delay, even in our stringent retention task.

General Discussion

The literature on early word learning contains numerous studies suggesting that infants and young children can quickly link a novel name to a novel referent object even in the context of multiple possible referents, and, in some contexts, demonstrate retention over a delay. These important abilities are certainly central to the process of vocabulary development given the cluttered, real-world environment in which referent selection must occur outside of the laboratory, and the likelihood of a considerable delay between the initial and subsequent naming instances. The goal of the present study was to take an in-depth look at the relationship between referent selection and retention. In particular, we asked whether 24-month-old infants could demonstrate retention of newly-formed name-referent mappings in a retention test that used a long enough delay to ensure retrieval from long-term memory and that controlled the relative familiarity of the test objects.

Based on the extant literature, we expected infants would demonstrate some retention, even in our stringent retention task. We found, however, that while 24-month-old infants were very good at quickly picking the referent of novel names, they were not able to retain these novel name-object mappings over a five-minute delay. In subsequent experiments, we replicated infants' excellent referent selection and also their poor retention—even when only one novel object was named during the entire experimental session. In fact, infants only demonstrated significant retention when ostensive naming was added to the referent selection task, and then only for names introduced early in the session. This finding is in stark contrast to infants' seemingly unlimited capacity for referent selection—across our experiments, performance on referent selection trials never dropped below 67%, regardless of the number of novel and familiar trials.

The current results, thus, urge caution regarding claims about the relation between referent selection and word learning (for a similar argument see, Markman & Abelev, 2004). Prior studies that have shown retention of fast-mapped words have sometimes led to a conflation of fast mapping and word learning in the literature. Understanding the processes that support word learning requires being specific about the individual tasks children confront and the relations among them. In particular, understanding what particular aspects of the naming and retention contexts have facilitated prior demonstrations of fast-mapping and retention is a critical first step to a detailed understanding of the processes that facilitate both referent selection and retention.

The primary contribution of the current work, then, is to point towards the importance of understanding the processes that bridge between successful referent selection and retention at the level of the specific context cues, stimulus relations, and time course. In this way, our work is similar in spirit to several other recent studies that have taken a detailed look at the processes that support the formation and retrieval of infants' initial word-referent mappings. For example, Akhtar, Jipson and Callanan (2001) have shown that infants can form and retain novel name-object mappings in an overhearing context where they are not primary participants, but rather observe novel objects being named for another person. Similarly, Jaswal and Markman (2003) have compared retention of novel name-object mappings made in direct versus indirect naming contexts in which the syntactic context (proper versus common nouns) was also manipulated. Childers and Tomasello (2002) have demonstrated that the frequency and distribution of naming events influence infants' retention of name-object mappings provided via definition. And finally, Swingley and Aslin (2007; see also, Swingley, in press) have used 18-month-old infants' ability to detect mispronunciations to investigate the roles of competition in the specifics of the phonological representations infants form when making novel name-object mappings.

In our final study we examined the role that competition during referent selection plays on later retention by increasing the salience of the novel object in the referent selection task via ostensive naming after infants made their selections. By holding up, pointing to, and explicitly naming the target object we effectively reduced the competition created by the familiar objects also activated during the trial, thereby facilitating retention. While the presence of the familiar objects may help infants determine the referent of the novel name in the referent selection task, it may also hinder long-term retention of the name-object mapping. This experiment not only revealed this within-trial competition but also competition acting at the trial-to-trial timescale: despite the addition of ostensive naming to the referent selection task, infants only retained the first four name-object mappings they made. Taken together, these results suggest an important role for competition at these different time scales in determining whether infants retain novel name-object mappings.

Importantly, the view that competition plays an important role in referent selection and retention also reduces the apparent discrepancy between our initial results and those of previous studies. That is, previous studies showing retention of novel name-object links over a delay may be viewed as having reduced competition via contextual supports such as lexical contrast and ostensive naming. For example, the successful retention after a one-week delay in Carey and Bartlett (1978) may have been because their use of lexical contrast effectively inhibited the competitor color term (blue) when children were asked to "get the chromium tray, not the blue one." Similarly, the ostensive naming Mervis and Bertrand (1994) used to highlight the target object would have reduced within-trial competition and boosted retention (see also, Dollaghan, 1985; Woodward et al., 1994). Likewise, trial-to-trial competition would have been reduced in studies that only named one object over the course of the experiment (e.g., Markson & Bloom, 1997) or that tested retention one or two trials after the initial naming instance (Golinkoff et al., 1992; Wilkinson & Mazzitelli, 2003; Wilkinson et al., 2003). In this way then, prior results also support the idea that competition at these two timescales has a critical influence on retention of novel name-object mappings.

A final issue is how such effects play out at the even longer timescale of developmental change in fast mapping and retention abilities. The literature on fast mapping spans a broad age-range that includes 13-month-old infants just beginning to develop a lexicon (Woodward et al., 1994) to 4-year-old preschoolers who have extensive productive vocabularies (Markson & Bloom, 1997). No systematic studies of changes in children's referent selection and retention abilities across this age-range have been conducted. Differences in the kinds of tasks used in prior fast mapping studies—from two-item preferential looking procedures (e.g., Schafer & Plunkett, 1998; Werker, Cohen, Lloyd, Casasola, & Stager, 1998) to mutual exclusivity based tasks with up to five stimuli at a time (e.g., Behrend et al., 2001; Golinkoff et al., 1992; Mervis & Bertrand, 1994), to incidental learning procedures (e.g., Carey & Bartlett, 1978; Markson & Bloom, 1997)—make comparisons across studies difficult (but see Jaswal and Markman, 2001, 2003; for initial steps in this direction). Nevertheless, the idea that competition during referent selection plays an important role in determining later retention, would suggest that differences in performance across tasks should correspond to differences in the number and kind of potential competitor objects present during referent selection. Likewise, we may see differences in performance across ages that correspond to developmental differences in children's ability to inhibit competitor objects.

Clearly, additional studies of the role of competition in infants' ability to solve referent selection tasks and learn new words are needed. For example, it will be important to systematically manipulate the number of familiar competitors present during referent selection and the subsequent effects on encoding and retention. Likewise, additional studies investigating whether infants retain some part of the name-object mapping made in referent selection tasks are needed. For example, a preferential looking or contingent head-turn procedure could be used to explore whether infants retain a memory for the individual objects or the individual words presented in the referent selection trials (see Swingley and Aslin, 2007; and Swingley, in press, for studies examining similar issues in infants' retention of specific phonological forms). We contend, however, that a more complete understanding of the contribution of salience and competition to the formation of long-term representations of names, objects, and mappings will require more stringent consideration of what we are testing both empirically and theoretically in the form of formal models of the underlying processes (Gupta & Cohen, 2002; Horst, McMurray, & Samuelson, 2006; McMurray, Horst, Toscano, & Samuelson, in press). This points toward future work that builds upon the growing literature investigating how general cognitive processes are involved in word learning (Deák, 2000; Markson & Bloom, 1997; Samuelson, 2002). Further, it suggests that a complete understanding of fast mapping and word learning will require us to more fully understand the dual challenges faced by young word learners—determining the referent of naming in often complex settings and turning that novel name into a known one.

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REFERENCES

Akhtar, N., Jipson, J., & Callanan, M. A. (2001). Learning words through overhearing. *Child Development, 72*(2), 416-430.

Baldwin, D. A., & Markman, E. M. (1989). Establishing word-object relations: A first step. *Child Development, 60(2), 381-398.*

Behrend, D. A., Scofield, J., & Kleinknecht, E. E. (2001). Beyond fast mapping: Young children's extensions of novel words and novel facts. *Developmental Psychology, 37*(5), 698-705.

Booth, A. E., McGregor, K. K., & Rohlfing, K. J. (under review). From eye-gaze to manipulation: A hierarchy of gestural supports for early word learning.

Capone, N. C., & McGregor, K. K. (2005). The effect of semantic representation on toddlers' word retrieval. *Journal of Speech, Language, and Hearing Research, 48*(1468-1480).

Carey, S. (1978). The child as word learner. In M. Halle, J. Bresnan & A. Miller (Eds.), *Linguistic Theory and Psychological Reality* (pp. 264-293). Cambridge, MA: MIT Press.

Carey, S., & Bartlett, E. (1978). Acquiring a single new word. *Proceedings of the Stanford Child Language Conference, 15*(17-29).

Childers, J. B., & Tomasello, M. (2002). Two-year-olds learn novel nouns, verbs, and conventional actions from massed or distributed exposures. *Developmental Psychology, 38*(6), 967-978.

Deák, G. O. (2000). Hunting the fox of word learning: Why "constraints" fail to capture it. *Developmental Review, 20*(1), 29-80.

Dollaghan, C. (1985). Child meets word - Fast mapping in preschool children. *Journal of Speech and Hearing Research, 28*(3), 449-454.

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D., & Pethick, S. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development Vol 59(5) 1994, v-173.*

Golinkoff, R. M., Hirsh-Pasek, K., Bailey, L. M., & Wenger, N. R. (1992). Young-children and adults use lexical principles to learn new nouns. *Developmental Psychology, 28*(1), 99-108.

Goodman, J. C., McDonough, L., & Brown, N. B. (1998). The role of semantic context and memory in the acquisition of novel nouns. *Child Development, 69*(5), 1330-1344.

Gupta, P. (in press). What's in a word? A functional analysis of word learning. In K. McGregor (Ed.), *Perspectives on Language Learning and Education*.

Gupta, P., & Cohen, N. J. (2002). Theoretical and computational analysis of skill learning, repetition priming, and procedural memory. *Psychological Review, 109*(2), 401-448.

Halberda, J. (2003). The development of a word-learning strategy. *Cognition, 87*(1), B23-B34.

Halberda, J. (2006). Is this a dax which I see before me? Use of the logical argument disjunctive syllogism supports word-learning in children and adults. *Cognitive Psychology, 53(4), 310-344*.

Heibeck, T. H., & Markman, E. M. (1987). Word Learning in children- an examination of fast mapping. *Child Development, 58*(4), 1021-1034.

Horst, J. S., McMurray, B., & Samuelson, L. K. (2006). Online processing is essential for leaning: Understanding fast mapping and word learning in a dynamic connectionist architecture. *Proceedings from the 28th Meeting of the Cognitive Science Society*, 339-344.

Jaswal, V. K., & Markman, E. M. (2001). Learning proper and common names in inferential versus ostensive contexts. *Child Development,72(3) May-Jun 2001, 768-786*.

Jaswal, V. K., & Markman, E. M. (2003). The relative strengths of indirect and direct word learning. *Developmental Psychology, 39(4), 745-760*.

Lederberg, A. R., Prezbindowski, A. K., & Spencer, P. E. (2000). Word-learning skills of deaf preschoolers: The development of novel mapping and rapid word-learning strategies. *Child Development, 71(6). 1571-1585*.

Markman, E. M. (1987). How children constrain the possible meanings of words. *Neisser, Ulric (Ed), Concepts and conceptual development: Ecological and intellectual factors in categorization. (pp. 255-287)*, NY, US: Cambridge University Press.

Markman, E. M., & Abelev, M. (2004). Word learning in dogs? *Trends in Cognitive Sciences, 8*(11), 479-481.

Markman, E. M., Wasow, J. L., & Hansen, M. B. (2003). Use of the mutual exclusivity assumption by young word learners. *Cognitive Psychology, 47(3), 241-275*.

Markson, L., & Bloom, P. (1997). Evidence against a dedicated system for word learning in children. *Nature, 385*(6619), 813-815.

McMurray, B., Horst, J. S., Toscano, J., & Samuelson, L. K. (in press). Connectionist learning and dynamic processing: Symbiotic developmental mechanisms. In J. P. Spencer, M. Thomas & J. McClelland (Eds.), *Towards a New Grand Theory of Development? Connectionism and Dynamic Systems Theory Reconsidered*. New York, NY: Oxford University Press.

Mervis, C. B., & Bertrand, J. (1994). Acquisition of the novel name nameless category (N3c) principle. *Child Development, 65*(6), 1646-1662.

Oviatt, S. L. (1980). The emerging ability to comprehend language: An experimental approach. *Child Development, 51*(1), 97-106.

Oviatt, S. L. (1982). Inferring what words mean: Early development in infants' comprehension of common object names. *Child Development, 53*(1), 274-277.

Samuelson, L. K. (2002). Statistical regularities in vocabulary guide language acquisition in connectionist models and 15-20-month-olds. *Developmental Psychology, 38*(6), 1016-1037.

Samuelson, L. K., & Smith, L. B. (1998). Memory and attention make smart word learning: An alternative account of Akhtar, Carpenter and Tomasello. *Child Development, 1*, 94-104.

Schafer, G., & Plunkett, K. (1998). Rapid word learning by fifteen-month-olds under tightly controlled conditions. *Child Development, 69*(2), 309-320.

Swingley, D. (in press). Lexical exposure and word-form encoding in 1.5-year-olds. *Developmental Psychology*.

Swingley, D., & Aslin, R. N. (2007). Lexical competition in young children's word learning. *Cognitive Psychology, 54, 99-132*.

Tomasello, M. (2003). Constructing a language: A usage-based theory of language acquisition, Cambridge, MA, US: Harvard University Press.

Waxman, S. R., & Booth, A. E. (2000). Principles that are invoked in the acquisition of words, but not facts. *Cognition, 77*(2), B33-B43.

Werker, J. F., Cohen, L. B., Lloyd, V. L., Casasola, M., & Stager, C. L. (1998). Acquisition of word-object associations by 14-month-old infants. *Developmental Psychology, 34*(6), 1289-1309.

Wilkinson, K. M., & Mazzitelli, K. (2003). The effect of 'missing' information on children's retention of fast-mapped labels. *Journal of Child Language, 30*(1), 47-73.

Wilkinson, K. M., Ross, E., & Diamond, A. (2003). Fast mapping of multiple words: Insights into when "the information provided" does and does not equal "the information perceived". *Applied Developmental Psychology, 24*, 739-762.

Woodward, A. L., Markman, E. M., & Fitzsimmons, C. M. (1994). Rapid word learning in 13- and 18-month-olds. *Developmental Psychology, 30*(4), 553-566.

Footnotes

1. We acknowledge that there is some sense in which referent selection is still required in these ostensive naming tasks. In particular, even when a single object is held up and named, the child has to determine whether the novel name refers to the whole object, the color of the object, what is being done with the object, etc. However, we note that in most studies that have used such a task, when retention is tested the child is typically presented with a choice between the original target object and an alternative object that does not embody (nor rule out) any of the possible alternative meanings. Thus, a child who picked the color of the object, for example, as the referent of the novel word can not be distinguished from a child who picked the whole object as the referent. Therefore, these studies do not inform our understanding of the link between referent selection and retention.

2. Because retention was only tested for four names, and because we only analyzed retention trials for which children responded correctly on the referent selection trials, one child did not contribute retention data. This reduced the degrees of freedom for this analysis.

3. In addition to these analyses, we also examined the possible influence of vocabulary size by dividing participants into two groups based on a median split on productive vocabulary (for the High Vocabulary Group, M = 467.13, SD = 55.30, range = 419 – 561; for the Low Vocabulary Group, M = 153.88, SD = 105.72, range = 23 – 339). Analyses revealed that there were no differences in responding between groups across trial types (familiar referent selection, novel referent selection, retention, or extension) and that the proportion of correct responses on the retention and extension trials did not exceed chance for either group, all p's > .14.

4. Although we did not find any difference in retention for words fast mapped early versus later in the session in Experiment 1A, it is possible that this simply reflected weak encoding of any of the novel name-object links.

Table 1. Order of events in each of the experiments. Certain events, for instance, the distractor familiarization, occurred in some experiments but not others, indicted by Y and N, respectively. Numbers indicate the number of trials of a given type. Note that the three referent selection trial types were presented in a pseudo-random order for each infant, not in blocks.

	Experiment			
	1A	**1B**	**1C**	**2**
Order of Events During the Session				
Total Warm-Up Trials	3	3	3	3
Total Referent Selection Trials	16	16	3	16
by Type:				
Novel Names	8	1	1	8
Familiar Names	8	8	2	8
"the one you like the best"	0	7	0	0
Distractor Familiarization	Y	N	N	Y
Five-Minute Delay	Y	Y	Y	Y
Production Task	Y	N	N	N
Warm-Up before Retention	N	Y	Y	Y
Total Retention Trials	4	1	1	8
Total Extension Trials	4	0	0	0

Table 2. Proportion of children's choices on the retention trials for each object (target, named foil, unnamed foil) collapsed across blocks. None of the proportions was greater than chance (.33), all *p*'s >.06.

			Foils	
		Target	Named	Unnamed
Experiment 1A				
	Retention	.36	.22	.42
	Extension	.40	.33	.27
Experiment 2				
	Ostensive Naming	.39	.37	.24
	Follow-In Labeling	.30	.31	.39

Table 3. The number of children who correctly chose the target on the novel referent selection and retention trials of Experiment 1B (in each condition and combined) and Experiment 1C. Only data from children who correctly chose the target on the referent selection trial were included in the counts of retention.

		Referent Selection	Retention
Experiment 1B		22	10
	N	32	22
Overall	*P*	<.0001	.08
		12	6
	N	16	12
Trial #2	*P*	<.001	.11
		10	4
	N	16	10
Trial #15	*P*	<.001	.23
		12	3
	N	20	12
Experiment 1C	*P*	<.01	.22

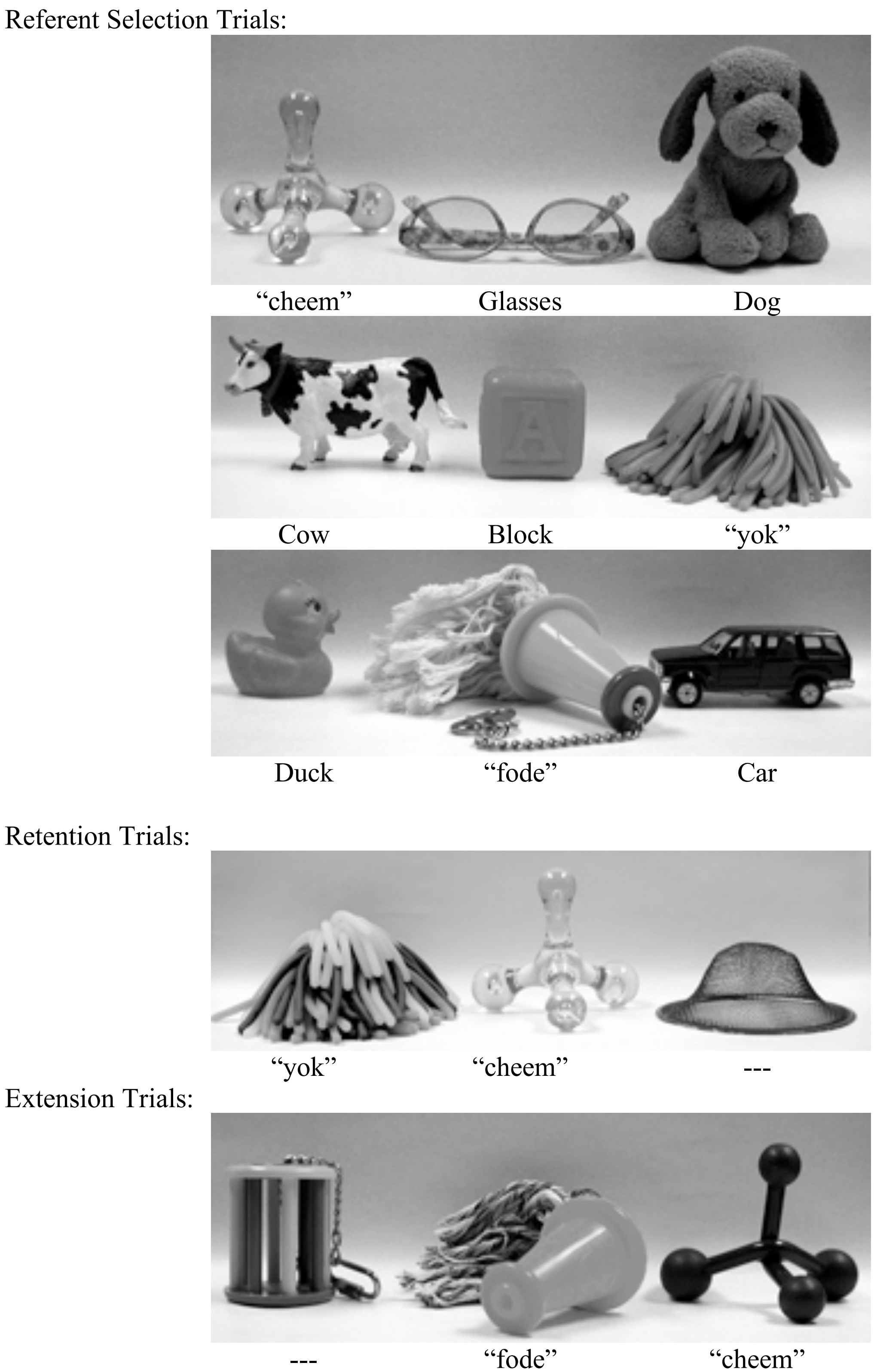

Figure 1. Example stimuli used on the referent selection and retention trials.

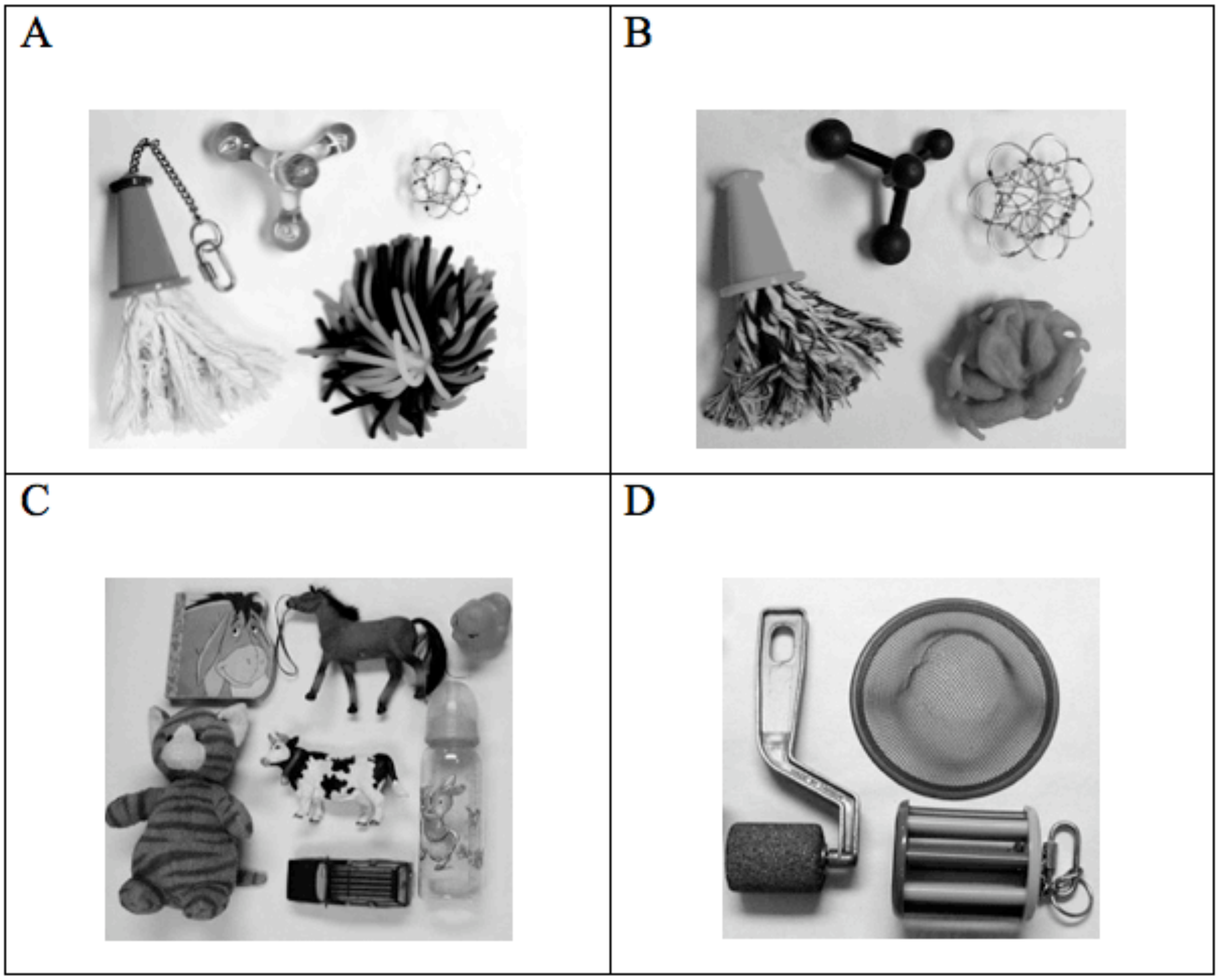

Figure 2. A subset of the stimuli used in the experiments. Examples of novel target objects are depicted in Panel A: a rope bird-toy, metal puzzle, rubber pom-pom, plastic massager. Examples of novel extension objects are depicted in Panel B: a rope bird-toy, metal puzzle, rubber pom-pom, wooden massager. Examples of familiar objects are depicted in Panel C: a book, car, bottle, cat, cow, horse and duck. Finally, examples of novel distractor objects are depicted in Panel D: a metal curtain tie-back, gold seem-roller, red metal sieve, blue and white nail brush, pink and purple bird-toy. Novel and extension objects that are not pictured included a wooden ball-toss toy, plastic cat-toy, top, plastic bubble toy without appendage (novel set) and with appendage (extension set). Familiar objects that are not pictured included a ball, Winnie the Pooh stuffed animal, cup, fork, banana, glasses, block, shoe and dog. Finally, distractor objects that are not pictured included a yellow plastic plumbing fixture, white whisk and silver, wooden bird-toy.

Figure 3.

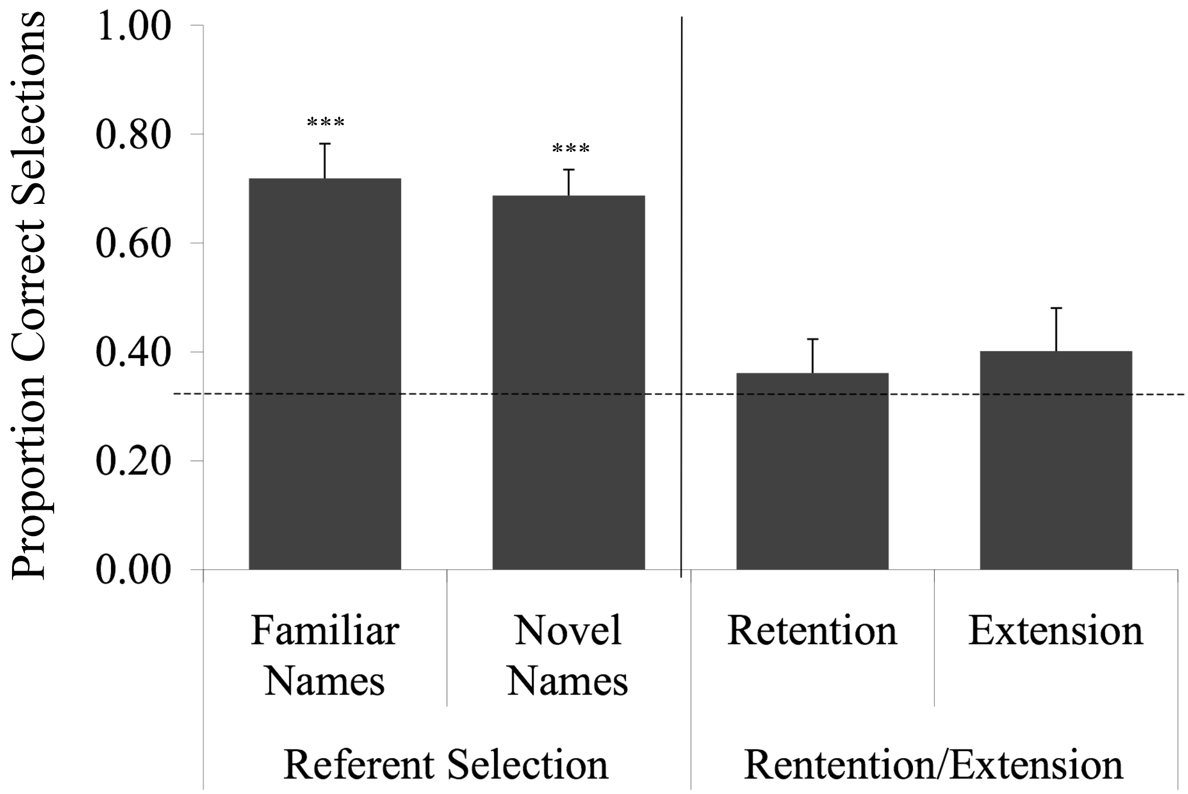

Figure 3. Proportion of trials on which children chose target objects in Experiment 1A during referent selection (left panel), and retention (right panel). Dotted line represents chance (.33). Errors bars indicate standard error. *** $p < .0001$.

Figure 4.

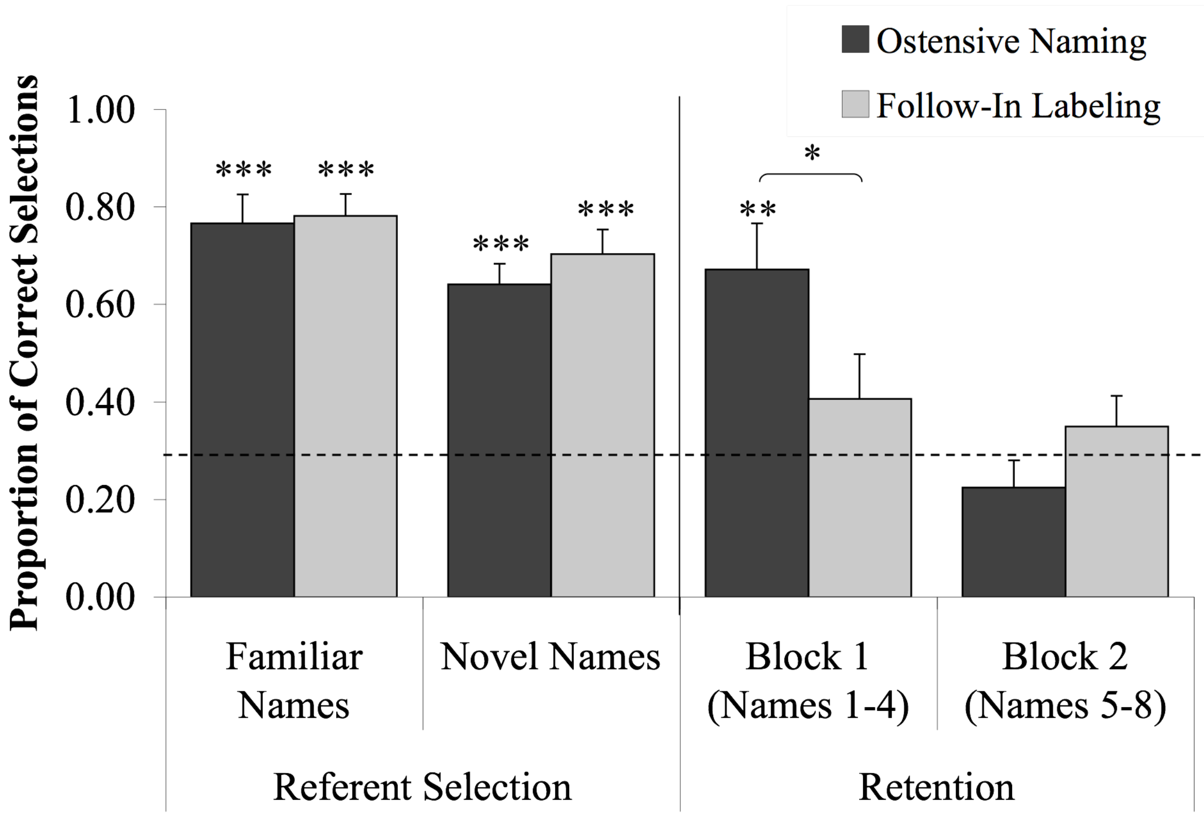

Figure 4. Data from Experiment 2. The left panel depicts the proportion of trials on which children chose target objects during referent selection. Right panel depicts target choices in retention by blocks of four names in the order presented during referent selection. Dotted line represents chance (.33). Errors bars indicate standard error. *** $p < .0001$, ** $p < .01$, * $p < .05$.