That's More Like It: Multiple Exemplars Facilitate Word Learning

Katherine E. Twomey[1], Samantha L. Ranson[2] & Jessica S. Horst[2*]

[1]University of Liverpool, [2]University of Sussex

*Address correspondence to Jessica S. Horst, School of Psychology, Pevensey 1 Building, Falmer, Brighton, East Sussex, BN1 9QH, United Kingdom, email: jessica@sussex.ac.uk.

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Abstract

Previous research indicates learning words facilitates categorization. The current study explores how categorization affects word learning. In the current study, we investigated whether learning about a category facilitates word learning (retention) by presenting 2-year-old children with multiple referent selection trials to the same object category. In Experiment 1, children either encountered the same exemplar repeatedly or encountered multiple exemplars across trials. All children did very well on the initial task, however, only children who encountered multiple exemplars retained these mappings after a short delay. Experiment 2 replicated and extended this finding by exploring the effect of within-category variability on children's word retention. Children either encountered narrow or broad exemplars across trials. Again, all children did very well on the initial task, however, only children who encountered narrow exemplars retained mappings after a short delay. Overall, these data offer strong evidence that providing children with the opportunity to compare across exemplars during fast mapping facilitates retention.

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Learning the names for object categories is fundamental to children's ability to make sense of their world and to communicate about it effectively. Perhaps it is not surprising, then, that children's early vocabularies are dominated by names for object categories (Samuelson & Smith, 1999; Waxman, 2003). Previous research has demonstrated a close relationship between vocabulary acquisition and categorization (e.g., Gopnik & Meltzoff, 1992; Nazzi & Gopnik, 2001; Smith, Jones, Landau, Gershkoff-Stowe & Samuelson, 2002; Thom & Sandhofer, 2009). For example, toddlers with larger productive vocabularies are better able to categorize objects at the basic level (Singer-Freeman & Bauer, 1997) and are better able to appreciate commonalities among category members at the superordinate level (Waxman & Markow, 1995). Although several studies have demonstrated that knowing more words facilitates categorization, it remains unclear whether experience with object categories in turn facilitates word learning.

Learning Names for Object Categories

Learning names for object categories is a complicated process. Specifically, learning a new word for a new category involves both initial *fast mapping* and gradual *slow mapping* (McMurray, Horst, & Samuelson, 2012). Fast mapping occurs when a child quickly forms an initial, rough hypothesis of the word's meaning (Carey, 1978). For example, when presented with a boat, a cup and a novel black-and-white stuffed animal and asked for the *penguin*, a 2-year-old child can reliably determine that *penguin* refers to the animal (PENGUIN). However, simply forming this initial mapping does not mean that the child has really learned the word. Demonstrating word learning requires that the child recall the name-object association after a delay or in a new context such as among other novel toys (Bloom, 2000; Horst & Samuelson, 2008; Riches, Tomasello, & Conti-Ramsden, 2005, Waxman & Booth, 2000). Thus, by word learning we mean word *retention:* having a memory representation of a name-object association that is strong enough to be robust against reasonable delays and changes in context. Indeed, processing demands might prevent young children from learning the correct name-object association after only a single exposure (Mather & Plunkett, 2009).

Retention depends on *slow mapping*, which occurs gradually over an extended period of time (Capone & McGregor, 2005; Horst & Samuelson, 2008; Munro, Baker, McGregor, Docking & Arculi, 2012). During this phase, repeated encounters with a name and an object allow the child to strengthen the name-object association such that it can be recalled after a delay. For example, the *penguin*-PENGUIN association will be strengthened each time the child hears the word *penguin* and plays with her toy PENGUIN in a new situation. Across such situations children learn about the statistical regularity with which names and their referents co-occur (cross-situational word learning; Smith & Yu, 2008). Clearly, then, repeated exposures are critical for word learning.

As well as learning names for individual items during cross-situational word learning, children also learn names for object categories. Categories are collections of items which share common features, but are still discriminable from each other (Mandler, Fivush, & Reznick, 1987; Quinn, 1986; Rosch, 1975; Younger & Cohen 1985). In the PENGUIN category, for instance, the majority of members share the common features of black-and-white coloring, two legs and the ability to swim, but the individual members are discriminable based on their individual features such as height, wing-span and other species-specific features such as breast coloring. Importantly, during early word learning, children encounter both the same category exemplar repeatedly and also multiple, different exemplars over time. For example, a child may play with a stuffed penguin in the morning, watch a movie about a penguin in the afternoon and play with a plastic penguin bath toy in the evening. Whether repeated, cross-situational exposures to the same exemplars or to multiple, different exemplars better facilitates word learning remains unknown.

Encountering Multiple Exemplars

Providing children with the opportunity to compare across multiple exemplars facilitates categorization (e.g., Kovack-Lesh & Oakes, 2007; Oakes & Ribar, 2005). For example, 6-month-old infants are able to form categories when allowed to compare pairs of different cats, but fail to form categories when presented with pairs of identical cats (Oakes & Ribar, 2005). Further research demonstrates that young children are able to compare between exemplars across trials, that is, across situations (Kovack-Lesh & Oakes, 2007). This is especially important because it demonstrates that cross-situational learning may also occur when forming categories. For example, Kovack-Lesh and Oakes (2007) demonstrated that 10-month-old infants are able to form categories when they are given the opportunity to compare exemplars during the transition between trials. In contrast, infants are unable to form categories with the same items presented in the same sequence if they are not given that opportunity to compare exemplars between trials. That is, simply providing a brief opportunity to compare exemplars allows infants to infants form a category they otherwise do not form. Presenting multiple exemplars also facilitates phonological acquisition (e.g., Rost & McMurray, 2009). Across several domains, we see that comparison between exemplars helps children to detect both the commonalities and differences between category members, thus inducing categorization.

Namy and Gentner (2002), as well as others (e.g., Casasola, Bhagwat, & Burke, 2009; Plunkett, Hu & Cohen, 2008; Waxman, 2003), have demonstrated that exposing children to multiple, variable exemplars labeled with a common, novel name also facilitates categorization.

Importantly, exposure to multiple exemplars facilitates word *generalization:* extending the name for one exemplar to another object from the same category. For example, when two exemplars are given the same name, children extend this common name to new objects that share perceptual features with the named exemplars (e.g., texture; Graham, Namy, Gentner & Meagher, 2010) or to new objects from the same taxonomic category (Liu, Golinkoff & Sak, 2001; Gentner & Namy 1999). When toddlers are taught color-word vocabularies that include more exemplars (six) they are also better able to generalize novel color names to new instances than toddlers trained on vocabularies that include fewer exemplars (four or two, Thom & Sandhofer, 2009). In addition, when toddlers are trained on multiple, perceptually variable exemplars they experience a significant acceleration in vocabulary growth and are better able to generalize novel names to novel exemplars, in contrast to children who encountered perceptually similar exemplars (Perry, Samuelson, Malloy, & Schiffer, 2010).

However, such studies have focused on how categorization influences word *generalization*—which is only one part of the word learning puzzle. Full word learning ultimately requires *retention* (Horst, McMurray & Samuelson, 2006). To build a vocabulary, children must learn the meanings of words well enough to recall them after a delay or after a change in context (Horst & Samuelson, 2008). Just as it is important to be able to generalize *penguin* to a never-before-seen PENGUIN, it is also important to be able to remember which previously-seen object someone is talking about when she asks for the *penguin*. Therefore, the current study focuses on how categorization influences word retention.

The Current Study

The current study tests the effect of encountering multiple exemplars on children's gradual, longer-term word learning. Whereas previous studies have focused on how encountering multiple exemplars affects children's generalization of novel names, the current study focuses on how encountering multiple exemplars facilitates word retention. Across two experiments, we explored how experience with multiple exemplars during fast mapping facilitates children's ability to learn and retain names for novel object categories. Experiment 1 explores whether encountering multiple, variable exemplars facilitates word retention and Experiment 2 explores the extent to which variability among exemplars impacts word retention.

We gave children multiple fast mapping trials for each word to better understand how providing children with multiple exemplars across trials facilitates cross-situational word learning. In Experiment 1, children either encountered the same exemplar across trials or encountered multiple, variable exemplars across trials. If providing children with the opportunity to compare between category exemplars across trials facilitates word learning, then children who fast-mapped multiple exemplars should demonstrate better retention. In Experiment 2, children either encountered multiple, low variability exemplars across trials or encountered multiple, high variability exemplars across trials. If variability among category exemplars influences word learning, then children's ability to retain novel names should be different between groups.

Experiment 1

Method

Participants. Twenty-four typically developing, monolingual, English-speaking children aged 2;6 (13 girls, *M* = 2;6 *SD* = 43.19 days; range = 2;4 – 2;8) with a mean productive vocabulary of 563.75 words (*SD* = 81.91 words, range = 391 - 668 words) and no family history of colorblindness participated. We tested children in this age range because they tend to enjoy selecting objects in this paradigm and can complete several 3-alternative forced-choice trials without becoming overly tired. Half of the children were randomly assigned to the single exemplars condition, and the other half were randomly assigned to the multiple exemplars condition. Children's ages and productive vocabularies did not differ between conditions (both *p*s >.13). Data from two additional children were excluded from analyses due to fussiness and experimenter error. Parents were reimbursed for travel expenses and children received a small gift for participating.

Stimuli. Eighteen known objects, chosen because they are highly familiar to 2-year-old children, served as familiar objects: six animals (bird, chicken, elephant, fish, giraffe, lion), six vehicles (boat, bus, car, motorcycle, plane, train), and six household objects (block, chair, comb, cup, toy mobile phone, spoon).

Nine novel objects from three categories, chosen because they are not easily named by 2-year-old children, served as the target objects. Consistent with other studies (e.g., Vlach et al., 2008), the objects in these categories varied in color, but shared the same shape (see Figure 1). The *doff* category consisted of slightly transparent, plus-sign shaped tops in green, red and yellow. The *cheem* category consisted of plastic rods with small balls on one end in blue/orange, orange/blue and yellow/green. The *hux* category consisted of rubber balloons with elastic strings hanging down in blue/orange, green/white and yellow/blue. The balloons kept their shape because they had foam balls inside. All objects were similar in size (5cm x 8cm x 10cm). Stimuli were presented on a white tray divided into three even sections. A digital kitchen timer was used to time some parts of the experiment (see below).

Procedure and design. Before the experiment began, the experimenter showed the parent color photographs of the known and novel objects to ensure they were known and novel to the child, respectively (which they were for all children). If the child knew a different name for an object (e.g., “kitty” v. “cat”) the experimenter used that name.

During the experiment, children were seated in a booster seat at a white table across from the experimenter. Parents sat next to their children and completed a vocabulary checklist (Klee & Harrison, 2001) and were instructed to only encourage children during the warm-up trials, if necessary (for similar instructions see Zosh, Brinster & Halberda, 2013).

Warm-up trials. Each session began with three warm-up trials to introduce children to the task. On each trial, children were presented with three randomly selected known objects. First, the experimenter set the tray of objects on the table and silently counted for three seconds to give the child an opportunity to look at the objects (see Horst, Scott, & Pollard, 2010). Then, the experimenter asked the child to select an object by naming it twice (e.g., “Can you find the block? Can you get the block?”) before sliding the tray forward. Children were praised heavily for correct responses and corrected if necessary. Between trials the experimenter replaced the tray on her lap and arranged the objects for the next trial out of the child’s view. The same objects were presented on each warm-up trial, but object positions (left, middle, right) were pseudo-randomized across trials, to ensure children practised choosing an item at each possible location. Thus, children were asked for a different object in a different position on each trial and the order of locations varied across children. Warm-up stimuli were later used as known objects during the referent selection trials (see Horst & Samuelson, 2008).

Referent Selection Task. Referent selection trials immediately followed the warm-up trials and proceeded in the same manner except that children were neither praised nor corrected. After each choice, the experimenter either said nothing or simply “ok” or “thank you.” Figure 2, Panel A depicts an example procedure for one of the categories encountered by children during the referent selection task. Each child was presented with nine sets and saw each set once on a known name trial and once on a novel name trial for a total of 18 referent selection trials. Known name referent selection trials were included as a control to ensure that children were mapping the names to the targets and not simply mapping novelty to novelty (see also Horst, Samuelson, Kucker & McMurray, 2011; Mather & Plunkett, 2012). Each set included two familiar objects (e.g., boat and cup) and one novel object (e.g., top). Different familiar objects were used in each set to provide cross-situational learning opportunities across trials. Children in the multiple exemplars condition saw a different novel exemplar in each set. For example, a child might see the green top with the block and lion, the red top with the chair and train and the yellow top with the bus and fish (see Figure 2, Panel A). Children in the single exemplars condition saw the same exemplar in each set. For example, a child might see the green top with the block and lion, and again the chair and train and once more with the bus and fish. Thus, the only difference between conditions was whether children saw one or three exemplars from each category.

Referent selection trials were presented in three blocks. For example, one child completed all trials with the top category, then all trials with the rod category and finally all trials with the balloon category. Block order was counterbalanced across participants using a Latin Square design. The order of known and novel trials was pseudo-randomized in each block such that the same set (e.g., green top, lion, block) was never presented on two consecutive trials and no more than two trials of either type (i.e., known or novel) were presented sequentially. Object position (left, middle, right) was randomly determined on each trial.

Between the referent selection task and the retention task the child remained at the table and colored pictures from a coloring book during a five-minute delay period. This delay period was included to ensure that children's retention was based on long-term memory representations for the novel name-object associations formed during the referent selection phase rather than short-term maintenance (for a similar argument see, Horst & Samuelson, 2008). Previous research suggests delays are necessary to ensure full word learning has occurred (Bloom, 2000) and are more akin to how children learn to use new words in the real world than test trials that immediately follow the initial referent selection trial.

Retention task. The retention task was the same in both conditions and provided our critical test of cross-situational word learning. On these trials all of the objects were equally novel; therefore, these trials could not be solved by employing process of elimination to exclude known objects. Instead, correctly choosing the target object required having learned the name-object associations across referent selection trials. Importantly, because additional supportive cues (e.g., ostensive naming, Horst & Samuelson, 2008) were not provided, children could only solve these trials if they had engaged in cross-situational learning across referent selection trials.

To re-engage children in the task, a new warm-up trial with three different known objects was presented. This was immediately followed by three retention trials, during which children saw three novel exemplars: one from each novel category (top, rod, balloon). Importantly, each of the novel objects presented on the retention trials had been previously seen during the referent selection trials and served as both a target and a distractor. This ensured that the test alternatives were equally novel, as object novelty can bias children's behavior in word learning experiments (Axelsson & Horst, in press; Horst et al., 2011). The same exemplars were presented on each trial for a given child. In the multiple exemplars condition, which previously-seen exemplars (i.e., which top, which rod, which balloon) were presented was counterbalanced across participants. In the single exemplars condition, children were presented with the same exemplars encountered earlier. Object positions were randomized across trials and children were asked for a different novel object in a different position on each trial.

Coding. As in previous studies only the words that a child correctly fast-mapped at least once during the referent selection trials were included in the analyses of the child's retention (e.g., Gray & Brinkley, 2011; Kucker & Samuelson, 2012). Children's responses were coded offline from DVD. A second coder blind to the experimental hypotheses coded 20% of the sessions of both experiments for reliability. Inter-coder agreement was high, $M = 97.94\%$, $SD = 3.31\%$ (range = 92.31% – 100.00%).

Results and Discussion

We first compare children's performance to chance levels and then compare children's performance between conditions. As can be clearly seen in the left panel of Figure 3, children in both conditions were very accurate at choosing the target object during the referent selection task. On known name referent selection trials, 11 children in each condition chose the target on every trial (9 out of 9), and one child in each condition chose the target on 8 out of 9 trials. Thus, children's proportion of target choices was the same for both conditions (single: $M = 0.99$, $SD = 0.03$; multiple, $M = 0.99$, $SD = 0.00$) and greater than would be expected by chance (.33), $t(11) = 71.73$, $p < .0001$, $d = 20.60$ (all *p*s are two-tailed). On novel name referent selection trials, children's proportion of target choices was also greater than expected by chance (.33) both for children in the multiple exemplars condition ($M = 0.74$, $SD = 0.12$), $t(11) = 6.57$, $p < .0001$, $d = 2.38$ and for children in the single exemplars condition, ($M = 0.70$, $SD = 0.28$), $t(11) = 4.59$, $p < .001$, $d = .84$. Again, there was no difference between conditions, $t(22) = .345$, *ns*. Thus, whether children encountered multiple exemplars or the same exemplars repeatedly during referent selection did not influence children's performance on either known or novel name referent selection trials.

Our main question in this experiment was whether encountering multiple exemplars or the same exemplars repeatedly during referent selection influenced retention. As can be seen in the right panel of Figure 3, only children in the multiple exemplars condition ($M = 0.72$, $SD = 0.27$) retained more names than expected by chance (.33), $t(11) = 5.00$, $p < .001$, $d = 1.46$. Children in the single exemplars condition ($M = 0.47$, $SD = 0.32$) failed to retain more words than expected by chance, $t(11) = 1.47$, *ns*, $d = .44$[1]. An unpaired *t*-test confirmed that children who encountered multiple exemplars retained more words than children who encountered the same exemplars repeatedly, $t(22) = 2.06$, $p \leq .05$, $\eta^2 = .16$. Taken together, then, these data clearly demonstrate that encountering multiple exemplars during referent selection facilitates word retention.

In this experiment, children in the multiple exemplars condition encountered *categories* of novel objects, while those in the single exemplars condition encountered the same objects repeatedly. Children who were taught names for categories learned more words than those who were taught names for single objects. Put another way, children who encountered variable exemplars learned more words than children who encountered identical exemplars. However, within each category, exemplars varied only in color, meaning that children encountered only restricted variability. Thus, while Experiment 1 demonstrates that encountering multiple, variable exemplars influences word retention, it does not inform our understanding of the extent to which within-category variability influences retention.

Previous research suggests that within-category variability strongly influences early categorization (e.g., French, Mareschal, Mermillod & Quinn 2004; Kovack-Lesh & Oakes, 2007; Quinn, Eimas, & Rosenkrantz, 1993; Ribar, Oakes & Spalding, 2004) and word generalization (e.g., Perry et al., 2010). For example, in a seminal study, Quinn and colleagues (1993) demonstrated that infants familiarized with a category with low within-category varibaility (cats) formed a narrow category which excluded out-of-category items (i.e., cats but not dogs), while infants familiarized with a category with high within-category variability (dogs) formed a broad category that included members of both categories (i.e., dogs and cats). Later, when within-category variabilty of the variable category was reduced, infants formed a narrow category (i.e., dogs but not cats), demonstrating that it was the the extent of the within-category variability that led to the original effect. Within-category variability also influences word generalization. When toddlers are taught names for categories with high within-category variability they develop more sophisticated word generalization biases than those taught names for categories with low within-category variability (Perry et al., 2010). However, precisely how within-category variability influences word retention remains unknown.

Therefore, to better understand how encountering multiple, variable exemplars affects word retention, we manipulated within-category variability in Experiment 2. Specifically, we presented all children with multiple exemplars during the initial referent selection task. However, half of the children were presented with narrow categories (i.e., low within-category variability) and the other half of the children were presented with broad categories (i.e., high within-category variability).

Experiment 2

Method

Participants. Twenty-four typically developing, monolingual, English speaking children aged 2;6 (12 girls, *M* = 2;6, *SD* = 54.54 days; range = 2;3 – 2;9) with a mean productive vocabulary of 568.71 words (*SD* = 106.71 words, range = 294 - 665 words) and no family history of colorblindness participated. Half of the children were randomly assigned to the narrow exemplars condition and the other half were randomly assigned to the broad exemplars condition. Children's ages and productive vocabularies did not differ between conditions (both $ps > .48$). Data from four additional children were excluded from analyses due to fussiness (2) and parental interference (2). Parents were reimbursed for travel expenses and children received a small gift for participating.

Stimuli. Eighteen known objects, chosen because they are highly familiar to 2-year-old children, served as familiar objects: seven animals (cow, chicken, elephant, fish, giraffe, lion, turtle), six vehicles (boat, bus, car, motorcycle, plane, train), and five household objects (block, cup, fork, phone, spoon).

Fifteen novel objects from three categories, chosen because they are not easily named by 2-year-old children, served as the target objects (see Figure 4). Between conditions these novel objects either varied along one dimension (color in the narrow condition) or multiple dimensions (e.g., color, size and texture in the broad condition). That is, the novel objects used in the narrow condition had low within-category variability and those used in the broad condition had higher within-category variability[2].

Children in the narrow exemplars condition encountered nine of these novel objects. Like the objects shown to the children in the multiple exemplars condition in Experiment 1, the objects in these categories varied in color only (see Figure 4). For these children, the *doff* category consisted of wooden castanets in green, red and yellow. The base of each castanet matched the top half and each top half had a polka-dot pattern with flowers, hearts and hoops, respectively. The *cheem* category consisted of small plastic kazoos in yellow, red, and blue. The *hux* category consisted of rubber pom-poms in purple, pink and blue with multicolored, plastic caps on the ends (the caps were purple, blue, yellow, pink and green).

Children in the broad exemplars condition also encountered nine of the novel objects (see Figure 4). For these children, the *doff* category consisted of wooden castanets including one with a green base with a green top and flowers, one with a red pointy base with a yellow top with black stripes and one with a pink scalloped base with a yellow top with pink dots. The *cheem* category consisted of plastic kazoos that were small and yellow, large and red and large and blue with orange dots. The *hux* category consisted of rubber pom-poms in purple, blue and yellow with multicolored, plastic caps on the ends. The blue pom-pom had the same number of ends as the purple pom-pom but only half of the ends had caps (all purple). The yellow pom-pom had fewer ends than the others but all the ends had caps (green and pink).

Importantly, one exemplar from each category was seen by children in both conditions: the green castanet (*doff*), the yellow kazoo (*cheem*) and the purple pom-pom (*hux*). The only difference between conditions was the within-category variability of the novel categories. For children in the narrow exemplars condition, the categories only varied in color, however, for children in the broad exemplars condition the categories varied in color, texture, size and slightly in overall shape (due to the castanet base, kazoo length and number of caps, respectively). All objects were similar in size (3cm x 7cm x 10cm).

Procedure and design. All aspects of the experiment were identical to Experiment 1 except different stimuli were used so that within-category variability could be controlled.

Results and Discussion

We first compare children's performance to chance levels and then compare children's performance between conditions. As can be clearly seen in the left panel of Figure 5, children in both conditions were very accurate at choosing the target object during the referent selection task. On known name referent selection trials, children's proportion of target choices were greater than would be expected by chance (.33) for both children in the narrow exemplars condition ($M = 0.91$, $SD = 0.19$), $t(11) = 10.56$, $p < .0001$, $d = 3.05$, and children in the broad exemplars condition ($M = 0.93$, $SD = 0.12$), $t(11) = 17.51$, p < .0001, $d = 5.05$. There was no difference between conditions, $t(22) = 0.28$, *ns*. On novel name referent selection trials, children's proportion of target choices was also greater than expected by chance (.33) for both children in the narrow exemplars condition ($M = 0.78$, $SD = 0.26$), $t(11) = 5.99$, $p < .0001$, $d = 1.73$ and children in the broad exemplars condition ($M = 0.83$, $SD = 0.11$), $t(11) = 15.67$, $p < .0001$, $d = 4.52$. Again, there was no difference between conditions, $t(22) = 0.63$, *ns*. Thus, whether children encountered narrow or broad categories during referent selection did not influence children's performance on either known or novel name referent selection trials.

Our main question in this experiment was whether encountering narrow or broad categories during referent selection influenced children's ability to retain and extend novel name-object mappings. As can be seen in the right panel of Figure 5, only children in the narrow exemplars condition ($M = 0.69$, $SD = 0.27$) retained more names than expected by chance (.33), $t(11) = 4.73$, $p < .001$, $d = 1.38$. In contrast, children in the broad exemplars condition ($M = 0.39$, $SD = 0.24$) failed to retain more names than expected by chance, $t(11) = 0.97$, *ns*, $d = 0.45$[3]. An unpaired *t*-test confirmed that children who encountered narrow categories retained significantly more names than children who encountered broad categories, $t(22) = 2.98$, $p < .01$, $\eta^2 = 0.29$. Thus, within-category variability does influence children's ability to retain names for object categories.

General Discussion

Across two experiments, we explored how encountering multiple exemplars during fast mapping facilitates children's retention of new words. In Experiment 1, we presented 2-year-old children with multiple referent selection trials with the same object category. Children either encountered the same exemplar repeatedly or multiple exemplars across trials. Overall, all children did very well on the initial referent selection task. However, only children who encountered multiple exemplars demonstrated that cross-situational learning had occurred across referent selection trials by retaining the previously fast-mapped novel names after a delay. Further, these children demonstrated significantly better retention than children who only encountered the same exemplar repeatedly. In Experiment 2, all children were presented with multiple exemplars, however, children either encountered narrow (low within-category variability) or broad (high within-category variability) categories. Again, all children did very well on the referent selection task, but only children who encountered narrow exemplars retained the previously fast-mapped novel names after a delay.

Overall, these data demonstrate that experience with multiple exemplars facilitates cross-situational word learning by improving retention of fast-mapped names for object categories. Other studies that have explored the relationship between vocabulary and categorization have typically tested children over a long time scale, such as several weeks (Ellis & Oakes, 2006; Perry et al., 2010). However, the current study reveals that exposing children to an object category, rather than a single category member, facilitates children's ability to learn the name for that category within minutes (see also Kemler Nelson, O'Neil, & Asher, 2008). In addition, previous research demonstrates infants can compare between exemplars presented on different trials in an object examining categorization task (Kovack-Lesh & Oakes, 2007). We extend this finding to demonstrate that toddlers can compare between exemplars presented on different trials in a fast mapping task.

The Current Study in Context

Previous research that has investigated how multiple exemplars influence children's word learning has done so by presenting multiple exemplars *at test*. Typical test trials include another exemplar from the same category, a completely novel foil and two known objects (e.g., Mervis & Bertrand, 1994; Golinkoff et al., 1992). However, any delay is minimal (e.g., 1-2 trials later), thus we cannot be sure that we are testing children's long-term memory (i.e., retention) for the name-object associations rather than their working memory. Other studies have included a delay and these test trials include the same previously-encountered exemplar, another exemplar from the same category and a novel foil (e.g., Jaswal & Markman, 2003; Waxman & Booth, 2000). However, as in the method noted above, the relative novelty of the test alternatives is not controlled (e.g., Vlach, Sandhofer & Kornell, 2008), which can lead to children responding simply based on an endogenous bias to novelty (Horst et al., 2011).

The current study is the first to present multiple exemplars *during referent selection* to provide an opportunity to compare across exemplars during fast mapping in order to test the effect of comparison on word retention. Note: other studies that have tested children's retention for name-object associations learned via fast mapping have only included one exemplar for each category (e.g., Horst & Samuelson, 2008; Kucker & Samuelson, 2011). In addition, in the current study, the relative novelty of the test alternatives was controlled as each had previously served as a target and each had been encountered the same number of times. Although previous research has tested the strength of children's newly formed name-object category associations by presenting different exemplars at test, the current study is the first fast mapping study to explore the role of comparison in cross-situational word learning by manipulating the strength of children's name-object category associations formed across encounters with multiple exemplars (but see Ankowski, Vlach & Sandhofer, 2012 on word generalization).

How Comparison Facilitates Retention

The current study also adds to a growing body of literature demonstrating that applying a common name to multiple objects invites children to compare across items, drawing their attention to shared commonalities (Casasola et al., 2009; Gentner & Namy, 1999; Namy & Gentner, 2002; Plunkett, et al., 2008). While repeated encounters with a novel name likely strengthened stored name-object associations for all children, only encountering multiple object exemplars led to name-object associations strong enough to withstand a short delay.

We believe that children who encountered multiple exemplars retained words at greater rates because each encounter with a new exemplar invited them to compare the new exemplar to their stored memory representation for that object category. Specifically, comparing exemplars across trials enabled children to identify category-relevant features while downplaying category-irrelevant features (see also, Murphy, 2002). This explanation is also consistent with findings from the infant categorization literature. In particular, Quinn and Bhatt (2010) demonstrated that encountering variability across trials, but not within trials, helped infants form a category for abstract bar-shapes. These authors explain that cross-trial variability highlights the common global features shared by category members and dampens attention to features specific to individual exemplars. Applied to the current study, this explains why children in the multiple exemplars and narrow exemplars conditions learned more words: children's attention was directed to the novel objects' shared global features (shape) and directed away from the features specific to individual exemplars. This finding is in line with other fast mapping studies which have demonstrated better novel name retention when children's attention is directed toward critical information and away from irrelevant information (e.g., Horst & Samuelson, 2008; Axelsson et al., 2012).

Children in the single exemplars condition did not learn the novel names at rates greater than expected by chance. Again, this is consistent with findings from the infant categorization literature that when children are not provided with the opportunity to compare between multiple exemplars they fail to form a category (Oakes & Ribar, 2006; Kovack-Lesh & Oakes, 2007). Because single exemplars do not help direct children's attention to one particular feature, children may be attempting to encode too much information (shape, color, size, weight, material, texture), leaving fewer attentional resources for committing the name-object associations into long-term memory. Consequently, each feature may be encoded too weakly to facilitate retention after so few fast mapping trials. In contrast, multiple exemplars help children extract what is common among category members (e.g., balls are round, cups are cup-shaped, *huxes* are round with strings; see Smith et al., 2002), which may free up attentional resources to aid encoding.

The Effect of Variability

As demonstrated in Experiment 2, encountering multiple exemplars only helps retention up to a point. When within-category variability was very high children were unable to retain category names. It is possible that encountering broad exemplars may have added greater attentional demands to the task because the objects were more variable, again leaving fewer resources for committing the name-object associations into long-term memory. Other research demonstrates that children have difficulty retaining new words when attentional demands are too great during the initial referent selection tasks (Horst et al., 2010; Horst, 2013). Nevertheless, children do learn names for broad categories such as insects, construction vehicles and other superordinate categories, in both the real world and experimental environments (Pauen, 2002; Younger & Fearing, 2000). It is possible that children simply need more exposures to learn names for such highly variable categories because of the greater attentional demands of processing such stimuli.

Previous research, however, has demonstrated an advantage for encountering highly variable exemplars (e.g., Perry et al., 2010). Importantly, this advantage for high within-category variability promoted word *generalization.* Here we find that low within-category variability promotes word *retention* (for a demonstration of these effects in neural network models see Twomey & Horst, 2011; Twomey, Morse & Horst, 2013).

Future research is needed to better understand how children learn to retain names for broad categories (e.g., insects, construction vehicles) and how they learn to generalize names for narrow categories (e.g., pencils, scissors). In the context of evidence suggesting that categorization is at least initially perceptually-based (Quinn et al., 1993), future research should examine children's fine-grained encoding of both narrow and broad categories and factors that might facilitate both generalization and retention such as the number of encounters, the number of exemplars and time spent exploring the individual objects.

Conclusions

Overall, the current studies are among the first to systematically investigate the interplay between category variability and cross-situational word learning across fast mapping trials. The current findings that experience with multiple exemplars facilitates word retention demonstrate that categorization can have a profound effect on young children's cross-situational word learn-ing. Thus, this research provides important groundwork for further research in the area, as well as inform our understanding of category learning and cognitive development more generally.

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Footnotes:

[1] The same pattern was observed when non-parametric Wilcoxon-Signed Rank tests were used: Multiple exemplars, $V = 55$, $p < .01$; single exemplars, $V = 63$, *ns*.

[2] To confirm that the broad stimuli were more perceptually variable than the narrow stimuli, 18 adults from the university community provided similarity ratings using an 11-point Likert scale (1 = very similar, 11 = not similar at all), thus larger scores indicated exemplars were more perceptually variable. Adults were tested individually and compared the exemplar that was the same between conditions (e.g., the green castanet) to each of the other exemplars from that set (e.g., the red, yellow, flower-base and striped castanets). Ratings confirmed that the broad stimuli ($M = 7.30$, $SD = 1.61$) were more perceptually variable than the narrow stimuli ($M = 2.54$, $SD = 0.81$), $t(17) = 14.02$, $p < .001$, two-tailed.

[3] The same pattern was observed when non-parametric Wilcoxon-Signed Rank tests were used: Narrow exemplars, $V = 45$, $p < .01$; broad exemplars, $V = 5$, *ns*.

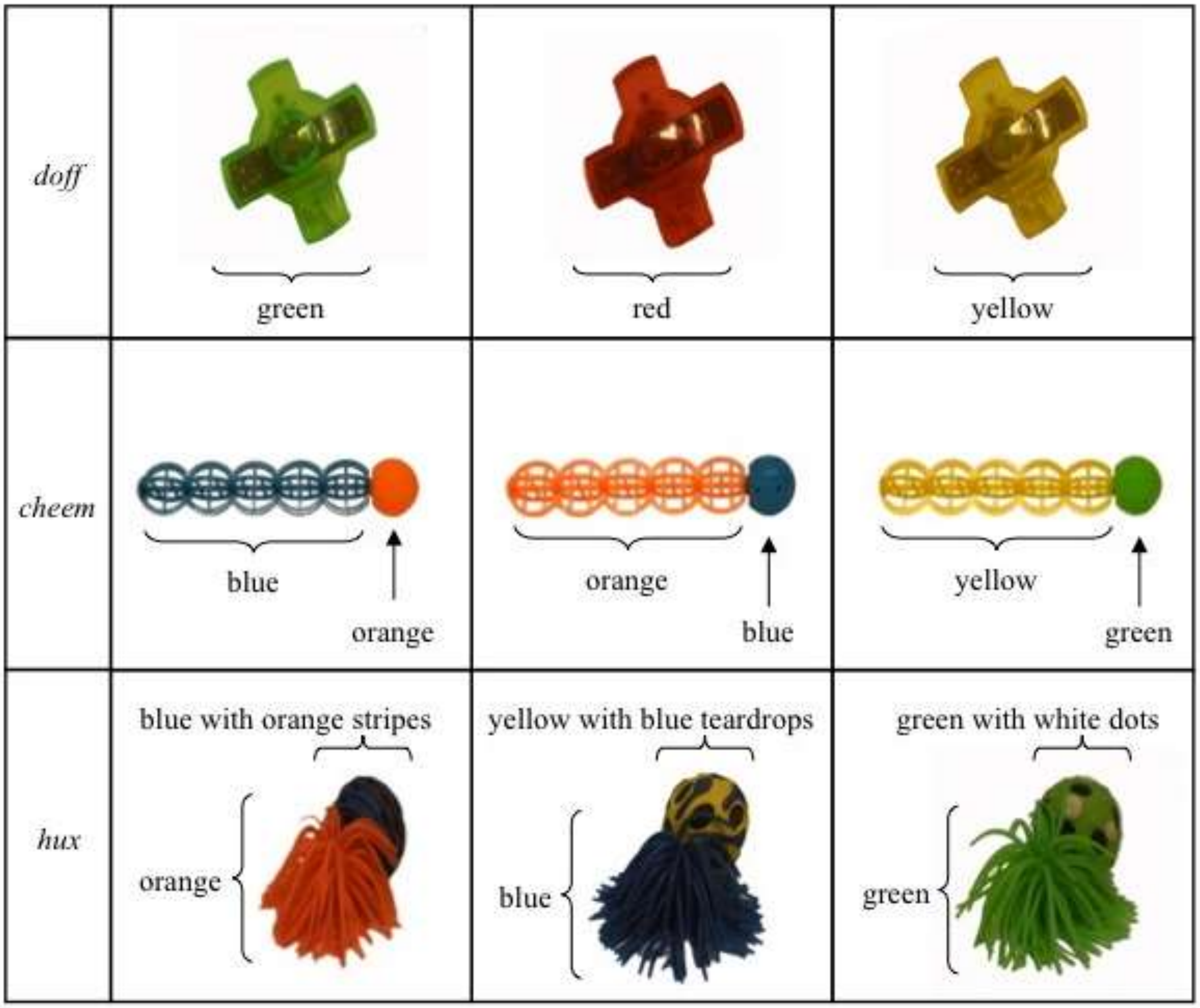

Figure 1. Novel objects used as target stimuli in Experiment 1.

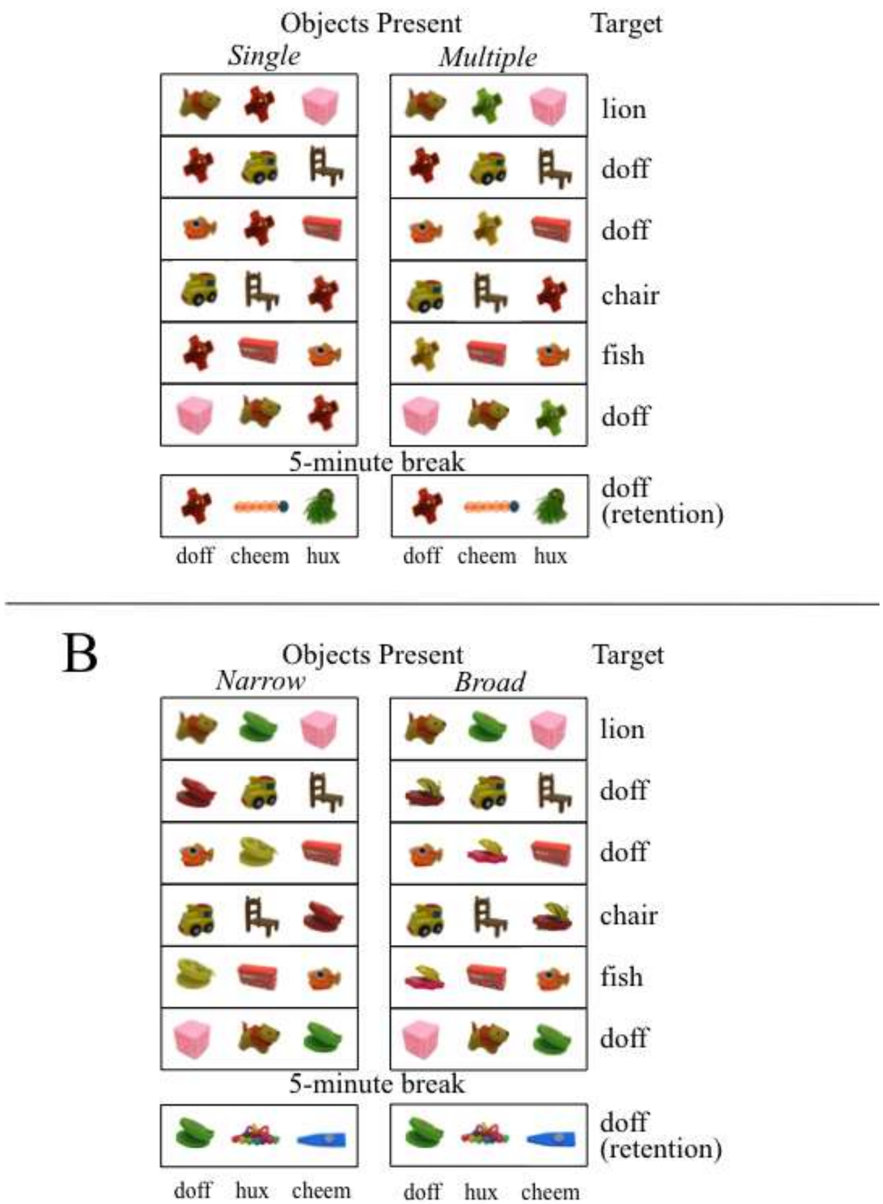

Figure 2. Examples of what children saw across trials in a single referent selection block in Experiment 1 (Panel A) and Experiment 2 (Panel B). Each object presented on retention trials had served as a target during the referent selection phase.

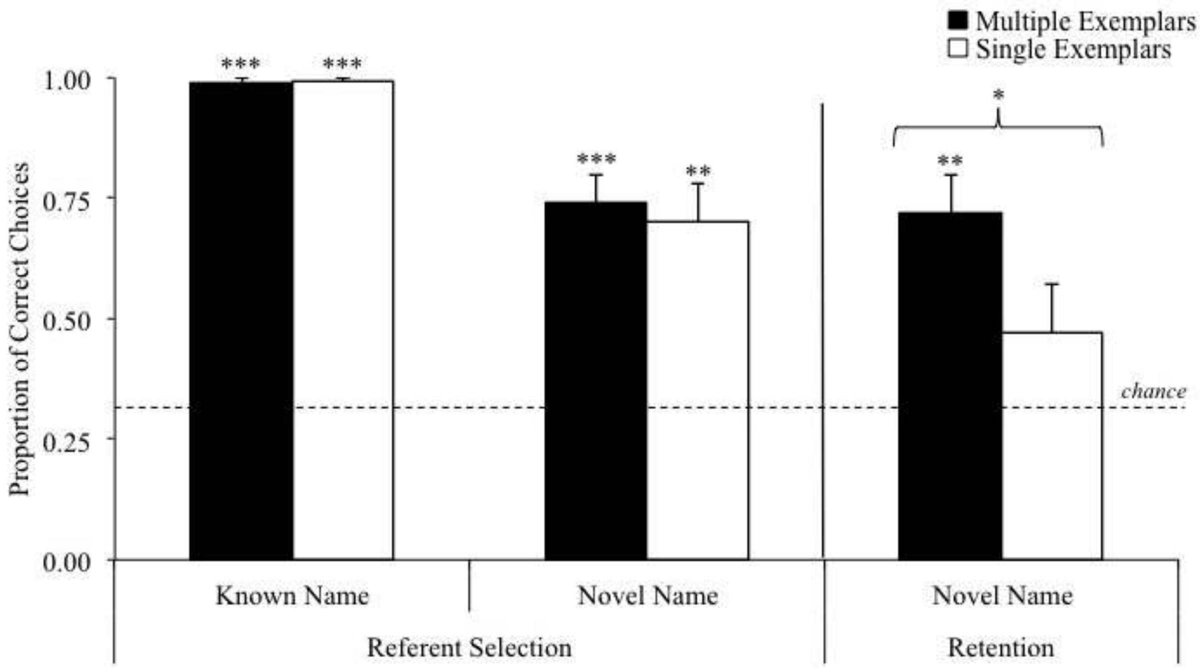

Figure 3. Children's proportion of correct choices in Experiment 1. Dotted line represents chance (.33). Error bars represent one standard error. *** $p < .0001$, ** $p < .001$, * $p \leq .05$. All *p*s are two-tailed.

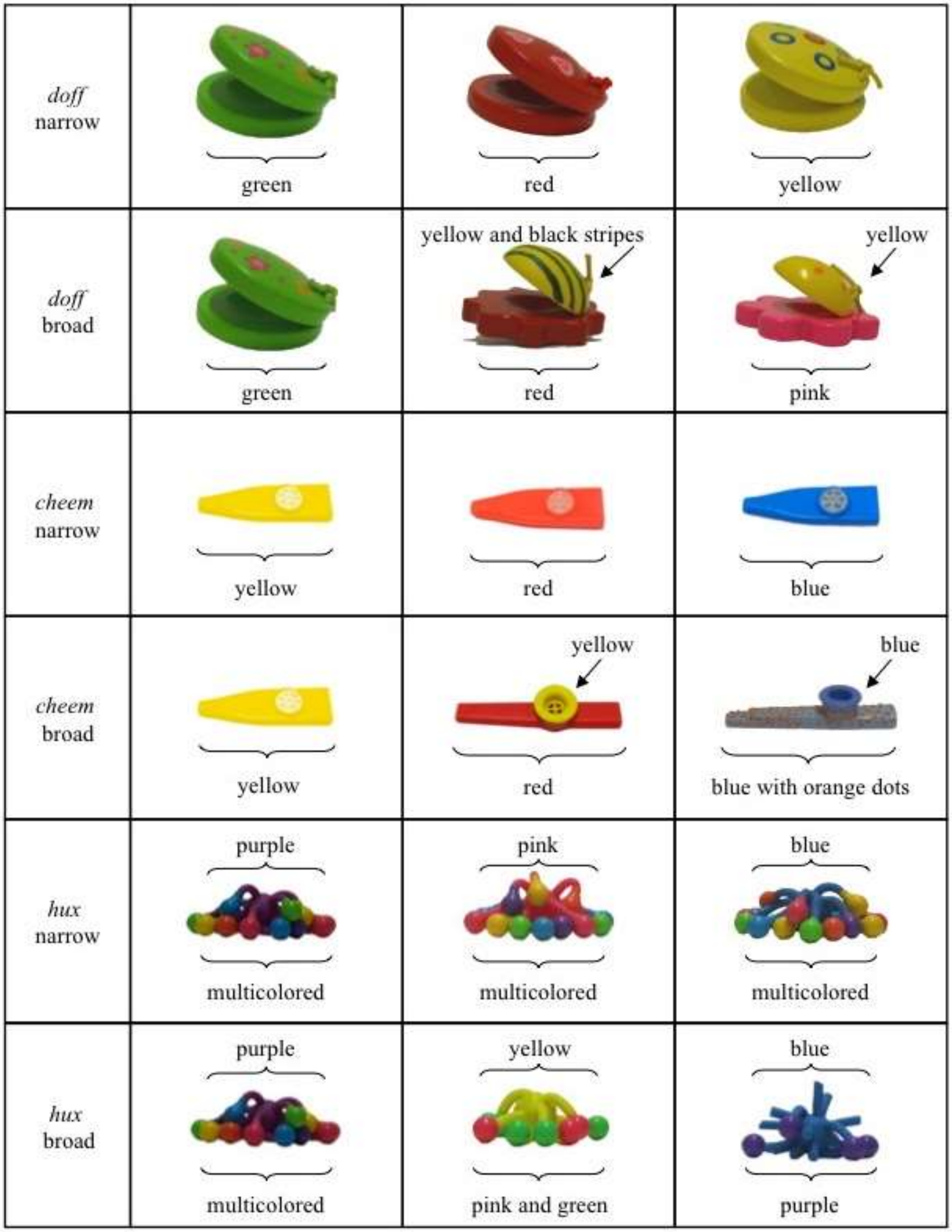

Figure 4. Novel objects that served as stimuli in Experiment 2.

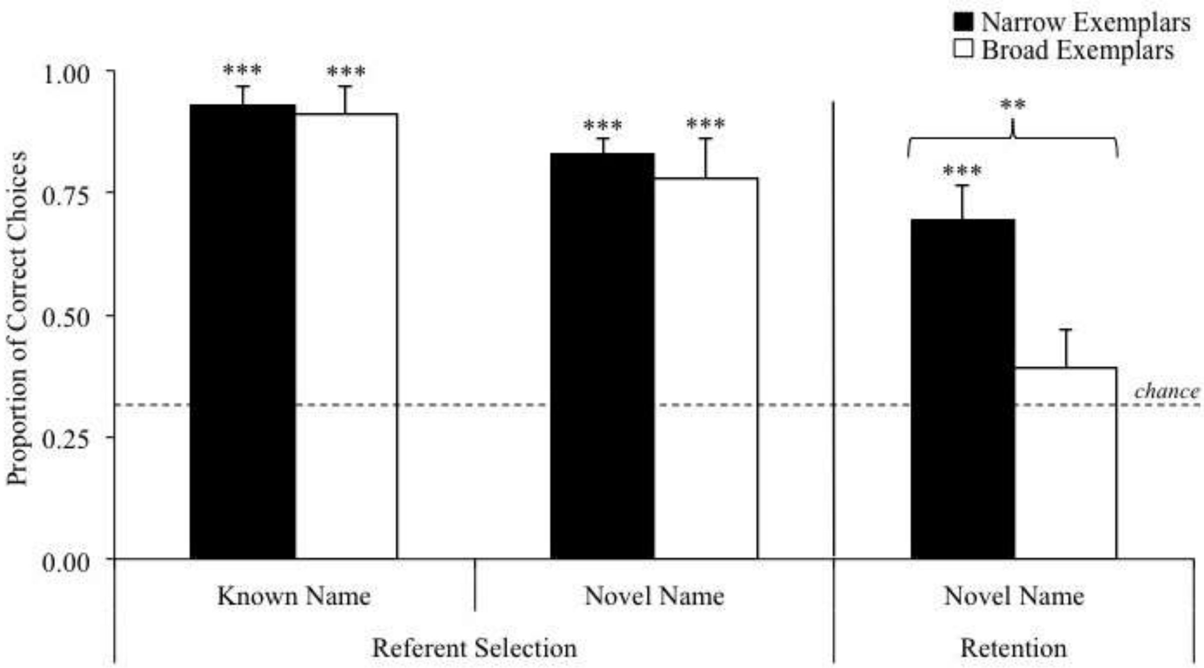

Figure 5. Children's proportion of correct choices in Experiment 2. Dotted line represents chance (.33). Error bars represent one standard error. *** $p < .0001$, ** $p < .001$, * $p < .05$. All *p*s are two-tailed.