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Object and Word Familiarization Differentially Boost Retention in Fast-Mapping

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Abstract

Recent research demonstrated that although twenty-four month-old infants do well on the initial pairing of a novel word and novel object in fast-mapping tasks, they are unable to retain the mapping after a five-minute break. The current study examines the role of familiarity with the objects and words on children's retention in fast-mapping tasks. Twenty-four month-old infants were familiarized with either a series of novel objects or a series of novel names prior to the referent selection portion of a fast-mapping task. Infants retained the novel mapping after a delay when familiarized with the novel objects, but did not demonstrate retention when familiarized with the novel words. The results suggest familiarity with the object or word-form lead to differential encoding of the name-object link and altered subsequent word learning.

Keywords: language acquisition; fast-mapping; word learning

Introduction

Fast-mapping, or the ability to quickly link a novel word to a novel referent is perhaps the canonical example of young children's word learning prowess. In Carey's (1978) original demonstration of this phenomenon, preschoolers correctly determined that the novel word "chromium" referred to a novel olive-green colored tray rather than a familiar blue-colored tray. This result has been replicated and extended many times (see, for instance, Golinkoff, Hirsch-Pasek, Bailey, & Wenger, 1992; Mervis & Bertrand, 1994; Wilkinson, Ross, & Diamond, 2003). Fast-mapping has been demonstrated in infants as young as 17 months (Halberda, 2003), and 30-month-olds have been shown to fast-map as many as six novel items in a single session (Golinkoff et al, 1992). On the basis of such results, there has been a general tendency in the literature to equate fast-mapping and word learning and to see fast-mapping as the basis for children's rapid word learning (see Horst & Samuelson, 2008 for discussion). However, retention has only rarely been examined in fast-mapping paradigms, and recent work suggests that children do not retain the links between a novel name and object formed in these tasks.

Horst and Samuelson (2008) examined retention of name-object links presented in a fast-mapping context with 24-month-old infants. Their fast-mapping paradigm included both referent selection and retention trials. On referent selection trials, infants were presented with two known objects ("get the block"); on other trials, infants were asked

for the novel object ("get the roke"). On retention trials, which followed five minutes after referent selection, infants were presented with two objects that had been fast-mapped in the referent selection trials, and a third, previously seen but not named object. During these trials, infants were asked to get one of the previously fast-mapped objects by name. Because all three objects presented on retention trials were equally novel, Horst and Samuelson's task is very stringent. In this carefully controlled environment, infants performed well in the referent selection trials – choosing the known object 73% of the time when requested, and the novel object 69% of the time it was requested. However, retention of the fast-mapped name-object link was no higher than chance after the 5-minute delay (Horst & Samuelson, 2008; Experiment 1A).

The fact that the children in Horst and Samuelson's (2008) study did not retain the newly fast-mapped words contradicts some prior findings of retention following fast mapping. For example, Carey & Bartlett (1978) examined children's memory for "chromium" a week after the original presentation and found that the majority of children retained the link between the word "chromium" and some form of the color green. Likewise, Markson and Bloom (1997) demonstrated retention of novel fast-mapped words in 3-4 year-old children. However, as Horst and Samuelson (2008) point out, many of these prior studies did not use as stringent a measure of retention. For example, Carey and Bartlett (1978) presented the novel name and referent during a very familiar sequence of events (setting up for snack time), thus allowing for many possible contextual supports for retention. Other work demonstrating retention has isolated the target so that it is the only object named during test (Markson & Bloom, 1997) or used ostensive naming in conjunction with fast-mapping (Mervis & Bertrand, 1994), thus failing to provide a stringent test of retention.

Furthermore, Horst and Samuelson's data does fit with Carey's (1978) original proposal of a slow-mapping process that follows the initial fast-mapping of a word to an object. In particular, Carey proposed that after children initially map the novel object and name (fast-mapping), further experience and exposure is required to fully learn the new word and referent (slow-mapping). Subsequent studies have examined this slow-mapping process, demonstrating that depth of semantic representation (Capone & McGregor, 2005), lexical practice (Gershkoff-Stowe, 2002; Gershkoff-Stowe & Hahn, 2007), and word segmentation (Graf Estes,

Evans, Alibali, & Saffran, 2007) all play a role in successful word retention and retrieval. The current study follows this line of work, examining the role of prior familiarity with the components of the mapping on retention of newly fast-mapped words.

It seems like familiarity with the components to be mapped may aid children's formation of a lasting association between a novel word and object by aiding in the creation a fairly robust, stable representation of each component. Horst, Samuelson, and McMurray (under review), have recently demonstrated that visual familiarity influences the process of referent selection. Likewise, Capone and McGregor (2005) demonstrated that ostensibly highlighting the visual properties of objects (i.e. cueing shape) boosts infants' fast-mapping of object labels and their referents, whereas Graf Estes et al. (2007) demonstrated that statistical segmentation of auditory word forms can play a role in subsequent referent selection.

In the present experiments we used a stringent version of the standard forced-choice referent selection and retention task, modeled after Horst and Samuelson (2008), but added a minimal familiarization period prior to the referent selection task. We used the 3-trial version of Horst and Samuelson's task (2008, Experiment 1C) to reduce the chance of fatigue that might be caused by the time added by the familiarization period. Using this procedure, Horst and Samuelson (2008) found that only 60% of infants in their 3-trial experiment succeeded in the initial mapping of the name and object during referent selection. While this was a statistically significant level of mapping, it means that retention could only be tested in 12 infants. We found similar levels of mapping in pilot testing. Thus, in an effort to boost the number of infants who initially map the novel word to the novel object, we used the same three known items throughout the warm-up and referent selection trials (rather than using different known objects on each of the referent selection trials).

In Experiment 1 we examined the role of minimal familiarity with the objects or word-forms in infants' retention of fast-mapped words. Half the infants were given the novel objects to explore freely for two minutes prior to the referent selection task. The other half of the infants heard the novel word multiple times prior to the referent selection trials. As in Horst and Samuelson (2008), there was a five minute delay between the referent selection and retention trials. Only infants familiarized with the objects demonstrated significant retention. Experiments 2 and 3 serve as controls to ensure our findings were not due to our use of the same known objects on all referent

selection trials (Experiment 2), or the use of a highly salient favorite novel item as the target (Experiment 3). Taken together, then, these experiments probe the degree to which prior encoding of either the word or object boosts the retention of fast-mapped words.

Experiment 1: Object and Word Familiarization

Methods

Participants Forty 24-month-old-infants (20 girls, $M = 24$ months, 26 days; range = 24 months, 10 days – 25 months, 13 days) with a mean vocabulary of 303 words (range = 21-672) participated. All infants were recruited through county birth records and were native English speakers. Participant's parents provided informed consent prior to the start of the study. Participants received a small toy for participation.

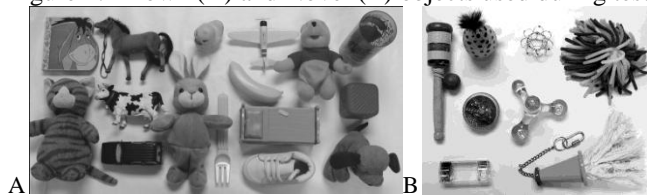
Stimuli Each infant saw a random selection of three out of sixteen possible known items and three or six of eight possible novel items over the course of the experiment (see Figure 1). Parents confirmed the status of each object as known or novel prior to the experiment. Substitute items were used if the infant was unfamiliar with any of the known items or familiar with any of the novel items. During the session, stimuli were presented on a 24x45cm white tray divided into three equal sections. Up to six possible novel non-words (Horst & Samuelson, 2008) were randomly selection for use with each child.

Procedure During the study, infants were seated across a white table from the experimenter in a booster seat next to their parents or in their parent's lab. Parents completed the MacArthur-Bates Communicative Development Inventory: Words and Sentences (MCDI; Fenson et al, 1994) during the session and were instructed to avoid interacting with their child, only offering encouragement if necessary.

Pre-familiarization. Half the children began the session with a one minute familiarization period with six novel objects. The experimenter drew the infant's attention to each object by picking it up or by pointing to it and saying "Look." Once the infant had explored each object, the experimenter lined all six items along the middle of the table and asked the infant to pick their favorite item. The favorite item was then given back to the infant to explore briefly. This was repeated twice more and the remaining three non-favorites were then removed from the table. The three favorite items were then used as the novel objects in the experiment with the favorite item selected first being the target during the novel referent selection trial.

The other half of the children began the session with a familiarization period in which they were exposed to six possible novel non-words. A 19-inch, 1280x1024 pixel touch screen computer was presented on the table approximately 24 cm in front of the child. The computer screen showed six 241x241 pixel basic shapes (i.e. circle, triangle, diamond, cross, square, octagon) in six different

Figure 1: Known (A) and Novel (B) objects used during test



basic colors (i.e. red, purple, orange, green, yellow, blue) in a 2x3 matrix with each item roughly 130 pixels away from each other. The trial began when the buttons appeared on the screen. The experimenter directed the infant's attention to the screen saying "Look! You can push the buttons!" and then randomly touched a button, producing one of six possible novel words. This was repeated until all buttons had been pushed and thus all six of the novel words were produced one time each. The experimenter then directed the infant to push the buttons by asking "Can you push the buttons?" If the infant did not respond, the experimenter again demonstrated by randomly pushing each button once. If the infant again did not respond, the experimenter demonstrated the buttons a third time and encouraged the infant to try themselves. At this point, if the infant refused to push the buttons themselves, the experimenter then randomly chose a button and pushed it multiple times to familiarize the infant with one of the six novel names. There were eight possible examples of each novel word varying in intonation, pitch, and frequency, which were randomly selected from at each button press. All words were spoken by the same female experimenter who was running the experimental session. After two minutes of familiarization with the sounds, the computer was removed and the experiment continued with the warm-up trials. The novel name that was produced the most during the familiarization period was used as the target name during the novel referent selection trial.

Warm-up trials. For each infant, three known objects were randomly chosen for use throughout the warm-up trials. The experiment placed each of the items in a slot on the tray, keeping the tray out of sight of the infant. The trial began with the experimenter placing the tray on the table and allowing the infant to examine the objects for three seconds. The experimenter then asked the infant to get an object ("Can you get the block") and slid the tray forward. Infants were prompted up to three times until a response was given. Responses on these warm-up trials were corrected or praised heavily as necessary. Infants were asked for a different object in a different location across the three warm-up trials.

Referent Mapping Trials. The referent selection trials immediately followed the warm-up trials, proceeding in the same manner except that no corrections or praise was given. Each infant was presented with three sets of objects, each of which included two known objects and one novel object. The same three known objects used during warm-up were used. On the first and third trials, infants were asked to get a known object. On the second trial, infants were asked to get a novel object (i.e. "Can you get the roke?"). Location of the target item was counterbalanced across trials and randomized across infants.

Delay Period. A five-minute delay followed the referent selection trials. During the delay, the infant was allowed to play in the waiting room. None of the items used during the experiment were present during the delay.

Retention Trial. The delay period was immediately followed

by a single warm-up trial that proceeded in the same manner as the previous warm-up trials and used the same three known objects. Praise was given and infants were corrected as needed. The warm-up trial was immediately followed by the retention trial in which the infant was presented with the three novel objects present during the referent mapping trials, one of which had been named in the second trial and two of which were distracters present when the experimenter had asked for a known objects on trials one and three. The position of items was randomized across infants with the target item never being in the same location it had been during the referent selection trial.

Results

Infants chose the target significantly more than would be expected by chance on novel referent selection trials in both conditions, as seen in Table 1. In particular, 13 out of 19 infants familiarized with the novel object selected it when asked during referent selection as did 18 out of 20 familiarized with the word form; exact binomial, $p < .01$ and $p < .001$ respectively, see Table 1. These results are similar to those of Horst and Samuelson (2008; see also Mervis & Bertrand, 1994; Wilkinson et al, 2003). In contrast to Horst and Samuelson (2008), however, infants familiarized with the object prior to referent selection chose the target object at levels significantly greater than chance on the retention trials (10 out of 13, exact binomial, $p < .01$, note that only data from the infants who correctly mapped in the novel referent selection trials were included in this analysis). Infants familiarized with the word prior to referent selection, in contrast, performed at chance levels on retention trials (6 out of 18, exact binomial, p ns).

Table 1: Referent selection (RS) and retention (Ret) performance in Horst & Samuelson (2008) and current work

		KnownRS	NovelRS	Ret.
Horst & Sam (2008)	# Correct		12	3
	N		20	12
	% map		0.60	0.25
	p		<.01	ns
Exp 1 Favorite Object Familiariz.	# Correct	27	13	10
	N		19	13
	% map	0.71	0.68	0.77
	p	<.001	<.01	<.01
Exp 1 Word-Form Familiariz.	# Correct	24	18	6
	N		20	18
	% map	0.63	0.90	0.33
	p	<.001	<.001	ns
Exp 2 No Familiariz.	# Correct	29	18	8
	N		20	18
	% map	0.73	0.90	0.44
	p	<.001	<.001	ns
Exp 3 Non-Fav Object Familiariz.	# Correct	28	14	10
	N		20	14
	% map	0.70	0.70	0.71
	p	<.001	<.001	<.01

To directly examine the difference between conditions, we performed X^2 tests of homogeneity of proportions. These revealed no differences in referent selection performance across conditions, X^2 (1, $N=39$), *ns*, however, performance in retention did differ significantly between conditions, X^2 (1, $N=31$) $<.05$. Thus, it appears that familiarization with the novel object, but not the novel word, prior to the formation of a novel word-object mapping boosts retention of that mapping.

However, before accepting this conclusion we examine the possible role differences between our task and that of prior studies, as well as differences between our conditions, may have had on our findings.

Experiment 2: No Familiarization

One difference between our current procedure and that of Horst and Samuelson (2008) was our use of the same three known objects during warm-up and test. Pilot testing demonstrated that with both a familiarization period and different known objects on every trial, infants could not succeed in referent selection and thus, retention could not be analyzed. Thus, in Experiment 1 we had used the same known objects on each trial in an effort to direct children's attention to the novel object even more, thereby boosting infants' initial mapping during referent selection. However, it is possible that our repeated use of the same known objects on every trial also served to boost retention. We examine this possibility by testing retention in our procedure without the familiarization period, thus demonstrating that using the same three known items serves to boost referent selection but not retention.

Method

Participants Twenty 24-month-old infants (9 girls, $M = 24$ months, 19 days; range = 23 months, 20 days – 25 months, 4 days) with a mean vocabulary of 342 words (range = 134–536) participated. All infants were recruited through county birth records and were native English speakers. Participant's parents provided informed consent prior to the start of the study. Participants received a small toy for participation. Data for one additional infant was not included due to a recording error.

Stimuli The same novel objects and novel names from Experiment 1 were used (see Figure 1).

Procedure The procedure was identical to that of Experiment 1, with the exception that there was no pre-familiarization period.

Results

Infants chose the target significantly more than would be expected by chance on novel referent selection trials (18 out of 20, exact binomial, $p < .001$, see Table 1). In contrast to infants in Experiment 1 who were familiarized with the object prior to referent selection, infants in this experiment did not retain the novel object-word mapping over the delay; they selected the target object at chance levels during the

retention test (8 out of 18, *ns*, note that again, only data from infants who correctly mapped in the novel referent selection trials were included in this analysis). Chi-square tests of homogeneity of proportions revealed that while there was a difference in referent selection performance between infants in Horst and Samuelson (2008) and infants here, X^2 (1, $N=40$), $<.05$, there was no significant difference in retention between the two groups, X^2 (1, $N=28$), *ns*. With respect to Experiment 1, then, these results indicate that easing the task by using the same known stimuli throughout did boost children's mapping ability during initial referent selection, but it was likely not responsible for the boost in retention seen when infants were familiarized with the novel objects.

Experiment 3: Non-Favorite Novel Target

One possible explanation for the difference in retention performance seen for children familiarized with the objects versus the words in Experiment 1 has to do with our use of the child's favorite object as the novel target. Recall that during familiarization we asked children for their three favorite items from the set of six novel objects, using these as the novel items present during referent selection. When then asked to find the target item during the retention trial when all three were present, children would be scored as correct if they chose their overall favorite item, even if they did not recall its link to the novel name. To test this possibility, we re-ran the object familiarization condition of Experiment 1, but instead used the non-favorite items as the novel items during referent selection.

Method

Participants Twenty 24-month-old infants (11 girls; $M = 24$ months, 22 days; range = 23 months, 21 days–25 months, 3 days) with a mean vocabulary of 272 words (18–567) participated. All infants were recruited through county birth records and were native English speakers. Participant's parents provided informed consent prior to the start of the study. Participants received a small toy for participation.

Stimuli The same novel objects and novel names from Experiment 1 were used (see Figure 1).

Procedure The procedure was identical to the visual condition in Experiment 1, with the exception that when asked to pick their favorite novel item during familiarization, that item was then removed from the table. This was repeated until three non-favorite items were remaining. These three remaining items were then used as the novel referents during the experiment.

Results

Infants chose the target significantly more than would be expected by chance on novel referent selection trials (14 out of 20, exact binomial, $p < .001$, see Table 1). Like infants in Experiment 1 who were familiarized with the object prior to referent selection, infants in this experiment also retained the novel word-object mapping over the delay, selecting the target object the majority of the time (10 out of 14, exact

binomial, $p < .01$, note that again, only data from infants who correctly mapped in the novel referent selection trials were included in this analysis). Chi-square tests of homogeneity of proportions revealed that there was no significant difference in referent selection, $X^2(1, N=39)$, *ns*, or retention $X^2(1, N=27)$, *ns*, between infants familiarized with the object in Experiment 1 and infants here. These results then indicate that the use of the infant's favorite novel object as the target during referent selection did not alter the infant's ability to retain the word-object link after a delay.

General Discussion

Despite the complexity of word learning, young children are remarkable at quickly mapping a novel word to a novel object. However, recent work has suggested that this mapping may not be as robust as previously thought, and thus, not the basis of children's rapid acquisition of new words. The goal of the present set of experiments was to probe how prior familiarity with the parts of a novel name-object mapping may help children retain novel name-object links. The results indicate that children given prior familiarity with the novel object to be mapped retained the mapping between the object and a novel word following a delay. In contrast, children given prior familiarity with the word-form mapped the novel word to a novel object during referent selection, but did not retain this mapping over a delay. Even when repetition of known objects and novel item preference were controlled for, children still demonstrated retention of a word-object mapping when familiarized with the object prior to test. Thus, our results indicate an important difference in the word-learning boost given by familiarity with the objects versus familiarity with the words in a fast-mapping task.

Importantly, the results of Experiments 1 and 3 support previous suggestions that a slow-mapping process (Carey, 1978; Carey & Bartlett, 1978) is needed for a robust mapping between a word and object. Notably, however, the results also demonstrate that prior familiarity with the object, but not the word, to be mapped helps this process. A similar idea has been presented in a recent model of word learning proposed by Mayor and Plunkett (2010). In this model, fast-mapping is facilitated by a well-developed representation of the object category prior to the actual name-object mapping. Likewise, our findings are also consistent with previous work by Smith and Yu (2008) suggesting that multiple exposures to a novel name and object are necessary for learning (see also McMurray, Horst & Samuelson, in prep; and Horst, McMurray, & Samuelson, 2006). It is clear from the literature that with more experience or information, children's ability to make specific word-object mappings is heightened (see also, Horst, 2007; and McMurray, Horst & Samuelson, in prep; Horst, Samuelson, & McMurray, 2010). One implication of the current study is the suggestion that across multiple exposures, visual and auditory components may not have been encoded equivalently. The literature presents several interesting suggestions as to why this might be the case.

One possible interpretation of the differential effects of word and object familiarization in our results comes from Sloutsky and colleagues' proposal of auditory dominance (Robinson & Sloutsky, 2004; Robinson & Sloutsky, 2007; Robinson & Sloutsky, 2008; Sloutsky & Napolitano, 2003; Sloutsky & Robinson, 2008). This is the suggestion that when both auditory and visual information are given to infants simultaneously, the auditory information receives preferentially processing. Support for this idea comes from studies in which infants were trained that a particular combination of auditory and visual stimuli indicated the location of a prize. When presented with either the trained auditory or visual cue paired with a competing auditory or visual cue, infants relied more on the auditory modality to anticipate the location of the prize (Robinson & Sloutsky, 2004; Robinson & Sloutsky, 2007). This theory would suggest that in Horst & Samuelson's (2008) referent selection task when infants were only given a single exposure to the novel object and name, they preferentially processed the auditory information and thus, only encoded half of the mapping – the novel name, not the physical referent. In the current study, the theory of auditory dominance would suggest that the familiarization period had a differential effect on infant's processing of novel names and objects at the point of referent selection. If infants come to the task with an auditory processing bias and are given additional familiarity with the visual component prior to test, when the word and object were presented during referent selection, both components could be processed at equivalent levels, allowing both the word and object to be encoded robustly. On the other hand, when infants were pre-familiarized with the word-form, the auditory processing was boosted even further, thus overshadowing the encoding of the visual object during referent selection.

It is also possible, however, that the apparent difference in visual and auditory familiarization stems more from task demands than differential processing of each component. That is, perhaps the use of a comprehension task to test retention creates the appearance of processing differences. In the traditional fast-mapping task, the experimenter provides the word during testing. When the infants are pre-familiarized with the objects and the experimenter provides the word during the retention task, children would then have both components necessary to demonstrate robust retention of the word-object link. On the other hand, when infants are pre-familiarized with the words and again given the word at test, the infants only have a rich encoding of the auditory component and do not demonstrate retention of the link. By this view then, the object familiarization condition did provide a boost to word learning, not because infants are biased to process the word form, but rather, because the task privileged the modality in which the children would subsequently use to find the referent.

It may be possible to discriminate between these explanations by examining the strength of the representations of the word and object following the initial referent selection trials without a pre-familiarization period.

Sloutsky's auditory dominance proposal would suggest that in a recognition test following referent selection, infants should show recognition of the words, but not the objects. In contrast, if the differences in results in our experiment are due to task effects, infants should show no encoding of the auditory information following referent selection. These results would also give insight to the extent to which familiarization might boost the representation of the category, as Mayor and Plunkett (2010) predict in their model. We are currently examining this possibility.

While further research is required to elucidate the exact depth to which object and word forms are processed by infants in a fast-mapping task, the current study makes it clear that the novel words and objects presented for mapping play different roles in the establishment of that mapping and in its retention. Thus, our finding that infants retain novel word-object mappings when familiarized with the objects but not the words reinforces Horst & Samuelson's (2008) and Carey's (1978) point that fast mapping is not equivalent to word learning. Our results also point to the importance of further work into the incremental process by which representations of words, objects and their mappings are created on the way to word learning.

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