Young children retain fast mapped object labels better than shape, color and texture words

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Abstract

We compared short- and long-term retention of fast mapped color, shape and texture words as well as object labels. In an exposure session, 354 3- and 4-year-old children were shown a set of two familiar and three novel stimuli. One of the novel stimuli was labeled with a new object label, color, shape or texture word. Retention of the mapping between the new word and the novel object or property was measured either five minutes or one week later. After five minutes, retention was significantly above chance in all conditions. However, after one week only the mappings for object labels were retained above chance levels. Our findings suggest that fast mapped object labels are retained long-term better than color, shape and texture words. The results also highlight the importance of comparing short- and long-term retention when studying children's word learning**.**

Key words: word learning, fast mapping, long-term retention

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Children are prodigious word learners. By the age of seventeen, the average English-speaker knows more than 60,000 words (Bloom, 2000). And yet, learning a word is far from easy and involves several steps. On hearing a novel word for the first time the child needs to separate it out from the stream of speech and determine its referent or meaning. The sound of the word also needs to be mapped to the referent, and this representation stored in long-term memory.

Carey and Bartlett (1978) claimed that quick incidental learning enabled words to be acquired from only one or two exposures, and coined the term “fast mapping” to describe such learning. They tested young children’s ability to learn a novel color word from a single exposure. Children aged 3 to 4 years were shown two colored trays, blue and “chromium” (actually an unusual olive color) and asked to “bring me the chromium tray, not the blue one, the chromium one”. In this lexical contrast task children correctly inferred “chromium” as referring to the olive tray. Heibeck and Markman (1987) extended Carey and Bartlett’s (1978) study and tested children’s ability to fast map unfamiliar shape and texture words as well as color words. Using a similar procedure, they found that fast mapped color and shape words were retained after ten minutes, although texture words were not retained above chance levels.

It is worth noting that in the two studies above, children used the novel word to select the appropriate referent (the novel object). However, as a growing number of researchers have emphasized word learning involves more than referent selection - it also involves retention (Bloom, 2000; Horst & Samuelson, 2008; Swingley, 2010;

Vlach & Sandhofer, 2012). In the research reported here, we investigate both the short- and long-term retention of different fast mapped words.

Interestingly, Carey and Bartlett (1978) did test retention after a long-term delay but it is difficult to interpret their data because a control group, who did not have prior exposure to the novel word, performed no worse than the experimental group. Recently however a number of studies have investigated the relationship between reference selection and retention more convincingly. Horst and Samuelson (2008) tested 2-year-old children and found that while they could readily select the target novel object upon hearing a new word, retention after just five minutes was poor. After reviewing the literature, Horst and Samuelson (2008) argued that there is very little evidence for either retention of fast mapped words in either younger (2-yr-old) or older (3- and 4-yr-old) children. They went on to claim that, although a number of studies report good retention of fast mapped words, their methodological limitations make it unclear whether good performance reflected fast mapping. For example, Mervis and Bertrand (1994) recapitulated the object-label link with children prior to testing. Participants may have performed well by accessing an object-label representation formed during this recapitulation, rather than from rapid incidental learning. In another study Waxman and Booth (2000) used a procedure where the new word and its referent were accentuated (e.g., "Look at this one. This one is SO special to me. It is called a koba"), while Childers and Tomasello (2002) introduced children to the mapping repeatedly over an extended period of many weeks.

One study with 3- and 4-year-old children that does report good long-term retention of fast mapped words is Markson & Bloom (1997). Young children and adults were presented with a set of four familiar and six novel objects and given novel information about one of the novel objects. There were three different conditions: object labeling ("let's use the *koba*"), a linguistically-presented fact ("let's use the thing my uncle gave me") and a visually-presented fact (a sticker placed on a particular object). At test, participants were shown the same objects and asked to "Find the koba", "Find the one my uncle gave me", or "Put the sticker where it should go". When tested after a few minutes (it is unclear exactly how long from the procedure) children and adults performed extremely well in all three conditions, suggesting that they had fast mapped the novel information to the novel object. One month later, both children and adults recognized the object associated with the label and the linguistically-presented fact. Interestingly however, performance significantly deteriorated in the 'sticker' condition with children selecting the correct object no better than chance after the month delay.

More recently, Vlach and Sandhofer (2012) found that short-term retention does not guarantee good long-term retention. They failed to find any long-term retention of fast mapped object labels in 3-year-olds or adults, even though short-term retention was good. The pattern of performance across time appeared to be similar to that of a standard forgetting curve: the rate of forgetting was rapid initially but slowed over time.

To recap: a clear picture emerges with young 2 year olds. They can select the appropriate novel referent on hearing a novel object-label, but retention is poor even in the short-term. With older children, around 3 to 4 years of age, the story is more mixed. Evidence for long-term retention of fast mapped object-labels was reported by Markson and Bloom (1997), but not by Vlach and Sandhofer (2012). It appears that fast mapped color words and shape words are retained after ten minutes, but texture words are not (Heibeck & Markman, 1987). Surprisingly, no evidence exists for the long-term retention of fast mapped shape, color or texture words. Thus, across a number of studies we find a variation in both short- and long-term retention across different word types. That we find such variation is perhaps not surprising given that different studies use quite different procedures. Indeed, some fast mapping studies have specifically explored this issue (Horst & Samuelson, 2008; Vlach & Sandhofer, 2012) and found significant differences in rates of retention of fast mapped object-labels following subtle changes in experimental procedure.

Given (i) the variation in both short- and long-term retention rates, likely due, at least in part, to different experimental procedures, and (ii) the paucity of long-term data so important for theories of word learning, the aim of the present study was straightforward: to investigate, within a single experiment, 3- and 4-year-olds' retention of fast mapped words in both the short- and long-term. Words from four different semantic domains were examined: object labels, color, shape and texture words.

We tested children's retention after two time delays. Five minutes was considered suitable for a short delay. It allowed enough time between exposure and test so that children were not able to identify the target immediately after the exposure session using working or episodic memory. A week (6-9 days) was chosen as the long-term delay as this is consistent with long-term retention studies in the literature (Markson & Bloom, 1997; Waxman and Booth, 2000; Vlach and Sandhofer, 2012).

Color, shape and texture terms were tested along with object-labels for the following reason. Color, shape and texture words are similar to object-labels in that they label a referent that is visible. There is a direct mapping between the label and the referent in the external world. Contrast this with other relational adjectives such as size (e.g. large, small) or speed terms (fast, slow), which are more abstract. Given this similarity, one might therefore expect that property labels should be as easy to retain long-term as object-labels. Indeed this is a commonly held assumption in the fast mapping literature (e.g. Carey & Bartlett, 1978; Bloom, 2000; Horst & Samuelson, 2008). However, it is perhaps surprising that this assumption is held as no convincing evidence exists for retention beyond 10 minutes (Heibeck & Markman, 1987). Moreover, we know from other research outside of the fast mapping literature that children find it difficult to learn color and shape words in training studies (O'Hanlon & Roberson, 2006, 2007). On balance therefore, we predicted that shape, color and texture terms would not be retained as well in the long-term as object-labels. In the short-term, we expected performance to be significantly greater than chance for most, if not all, of the word types in line with the literature. Evidence suggests that retention of a newly mapped object-label is around 65-67% (Markson & Bloom, 1997; Vlach & Sandhofer, 2012) – comparable to the rates of retention Heibeck and Markman (1987) reported for color and shape terms (72% and 82%, respectively).

We chose to test 3- and 4-year-olds as this is the age group commonly tested in fast mapping studies that incorporate at least some delay between exposure and test (Carey & Bartlett, 1978; Heibeck & Markman, 1987; Markson & Bloom, 1997; Vlach & Sandhofer, 2012).

Method

Participants

Three hundred and fifty-nine 3- and 4-year-olds took part in the study (see Table 1). We decided against using younger children because there is no evidence for retention after ten minutes with younger 2-year olds (Heibeck & Markman, 1987). Testing older age groups was deemed less important than comparing word types and delay intervals. Both Markson and Bloom (1997) and Vlach and Sandhofer (2012) found few significant differences in retention between 3-year-olds and adults.

Five children in the Long Delay conditions took part in the training session but were not available for the testing session. The remaining 354 children (approximately equal numbers of both genders) had a mean age of 49 months. All the participants were typically developing English language speakers and attended nursery schools in North London, UK.

Table 1. Participants – sample size (n), mean age, age range and gender by condition

Time Delay	Participants	**Word Type**			
		Object condition	Color condition	Shape condition	Texture condition
Short Delay (5 mins)	n	44	44	44	44
	mean age (yrs)	4	4.1	4	4.1
	age range (yrs)	3.0-5.0	3.4-4.9	3.2-5.0	3.5-5.0
	gender (M/F)	22/22	22/22	22/22	22/22
Long Delay	n	44	44	44	46
	mean age (yrs)	4.1	4.1	4.1	4.1
	age range (yrs)	3.0-4.9	3.1-4.9	3.1-4.9	3.1-4.9
	gender (M/F)	22/22	22/22	22/22	22/22

Design

The study used a between participants experimental design. There were two independent variables – Word Type (Object label, Color, Shape, Texture) and Testing

Delay (Short and Long). The dependent variable was retention accuracy – picking the previously labeled item from an array of five objects. Each child was introduced to one new word. Half the children were tested in the Short Delay and half were tested in the Long Delay. Thus there were four Short Delay conditions, and four Long Delay conditions.

Stimuli

Twenty items were used in the study: a set of five objects in each of the four 'Word Type' conditions. Each object set comprised two familiar stimuli and three novel stimuli (identified and assessed in pilot testing) - see Figure 1 and Table 2. In the object label condition there were 2 familiar objects (duck, pen) and 3 novel objects. In the shape condition the stimuli were not pictorial representations - they could be handled. However, they were similar to 2D shapes: they were flat (a maximum of 1cm in depth) and did not afford an obvious function. Two of the shapes were familiar (circle, star), and three were unfamiliar, designed to look like regular (and therefore, nameable) shapes. In the color and texture conditions, all the objects were familiar but only two of the properties were familiar - three were unfamiliar. For example, in the color condition, children were presented with two objects in familiar colors, a blue ball and a pink shoe, and a further three objects whose colors were unfamiliar: a 'teal' sock, a 'mushroom' car and an 'olive' pen.

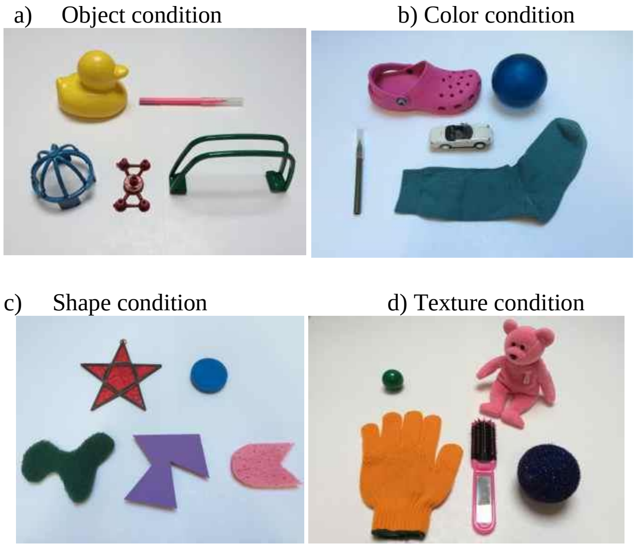

Fig. 1. Stimuli sets for each Word Type condition

Table 2. Stimuli set for each Word Type condition

	Object Condition		**Colour Condition**		**Shape Condition**		**Texture Condition**	
	Object	*Color*	*Color*	*Object*	*Shape*	*Color*	*Texture*	*Object*
familiar 1	Duck	Yellow	Pink	Shoe	Star	Red	Hard	Marble
familiar 2	Pen	Pink	Blue	Ball	Circle	Blue	Soft	Teddy
unfamiliar 1	Leafguard	Blue	Olive	Pen	Curved Edges	Green	Bobbly	Glove
unfamiliar 2	“Nodes”	Red	Mushroom	Car	Straight Edges	Purple	Spiky	Hairbrush
unfamiliar 3	“Bridge”	Green	Teal	Sock	Curved & Straight Edges	Pink	Prickly	Ball

For each word type, the same array of objects was used in both the Short Delay and the Long Delay conditions, although these object sets differed across word types. Ideally the same array of objects would have been used across all the conditions, but given that the object label condition tested for the mapping of novel names to novel objects this would have meant using three novel objects in all the conditions. This was untenable for two reasons. First, it proved impossible to find three unfamiliar objects, with unfamiliar colors, and unfamiliar textures, and with unfamiliar (yet clear and distinct) shapes. Second, and *more importantly*, unfamiliar objects had to be used in the object label condition, so that the novel word could be mapped to a novel object. If unfamiliar objects had also been used in the color, shape and texture conditions, children would likely have attached the novel word to the unfamiliar object rather than the novel color, shape or texture due to the 'whole object' bias. There is considerable evidence that children and adults tend to interpret new words as referring to whole objects, rather than parts of objects (e.g., Hollich, Golinkoff & Hirsh-Pasek, 2007), properties of objects (e.g. Markman & Hutchinson, 1984) or the stuff that objects are made of (e.g. Waxman & Markow, 1995).

The novel word introduced to all participants in all conditions was 'koba'. This ensured that factors that can affect fast mapping were held constant across conditions, like the complexity of the word (number of phonemes), phonotactic probability and neighbourhood density. The use of a nonword ensured that children did not hear the word between exposure and test.

Procedure

Participants were tested individually. The child was invited to play a fun 'game' with the experimenter and sat next to her at a table.

Exposure session. Each participant was presented with the appropriate stimuli set and introduced to a new word 'koba', applied to either an unfamiliar object/item or an unfamiliar feature of an object. All participants were introduced to the new word 'koba' in the context of a conversation between the experimenter and the participant.

The five objects were placed in front of the child in a clear plastic box. The child was asked to take the objects out of the box one-by-one and then to count them. This ensured that the child attended individually to each object. The child was then asked to identify the two familiar referents in turn. In the object label condition, the experimenter asked the child “Which one is a duck? Can you point to it for me? Which one is a pen? Can you point to it for me?” These questions provided a context (that we were talking about objects) and served to confirm that the child knew the familiar objects. The new word was then introduced about one of the three target objects (used in rotation). To all children in the object label condition the experimenter said, “Yes that’s right. This is a yellow duck and this is a pink pen. Can you give me the X koba?” where X represented the color of one of the 3 target objects. For a third of participants the experimenter said, “Can you give me the blue koba” (referring to the blue “leaf guard” – see Fig.1). A third of participants were asked, “Can you give me the red koba?” (referring to the red “nodes”) and a third of participants were asked, “Can you give me the green koba?” (referring to the green “bridge”).

The structure of the other conditions was the same. In the shape condition, participants were asked to identify the two familiar shapes: “Which one is a star? … Which one is a circle? …” Then they were asked, “Can you give me the green [or purple or pink] koba” where ‘koba’ referred to one of the 3 unfamiliar target shapes. In the color and texture conditions the grammatical modeling was slightly different – appropriate for describing the property of an object rather than the whole object. The experimenter asked the child “Which one is pink? …… Which one is blue? ….” To all children in the color condition the experimenter said, “Yes that’s right. This is a pink shoe and this is a blue ball. Can you give me the koba pen [or car or sock]?” where koba referred to one of the 3 novel colors. In the texture condition the participants were asked to point to the two familiar textures: “Which one is hard?........Which one is soft?...". Then they were asked, "Can you give me the koba glove [or hairbrush or ball]" where koba referred to one of the three novel textures ('bobbly', 'spiky'or 'prickly').

It is important to note here that the modeling of the new word in the object label and shape conditions ("Can you give me the X koba?") was identical and differed from the modeling used in both the color and texture conditions ("Can you give me the koba X?"). In the shape label condition, the label referred to the whole item (albeit a flat object) just like it did in the object label condition. In contrast, the label in the color and texture conditions referred to the features of familiar objects. Using identical grammatical structure in a minimum of two Word Type conditions helped ensure that any differences in retention resulting from grammatical differences could be identified. We return to this point in the Discussion.

Distracter task. The objects were then put to one side and the child underwent a completely unrelated task of thinking up a name for a toy puppy. This task allowed for a five-minute delay between exposure and testing in the Short Delay conditions.

Test session. For children in the Short Delay conditions the testing session followed immediately after the distracter task. For children in the Long Delay conditions the distracter task marked the end of the first session. The child then participated in the testing session one week (6-9 days) later.

Whatever the time delay, the testing session followed exactly the same format. Children were presented with the original object array and the experimenter pointed out the familiar items. For example, in the color condition, the experimenter said: "Look at all these things. This one's pink and this one's blue." Participants were then asked to identify to which object the new word (koba) referred. Children in the color and texture conditions were asked, "Can you show me which one is *koba*?" Children in the shape and object conditions were asked, "Can you show me which one is *a koba*?" Thus, like the exposure session, the grammatical structure of the test questions was not identical across all conditions – a point we return to in the Discussion.

Results

Referent Selection

In the Exposure session, the percentage of children selecting the appropriate referent for all word types was high and significantly greater than chance (1 in 3). The target object was selected in each of the conditions as follows: object label 89%, color 89%, shape 76% and texture 90%. The data were analyzed using a hierarchical three-way log-linear analysis that produced a final model that retained a two-way interaction: Word Type x Referent Selection Response. The likelihood ratio of this model was $\chi^{2(}8)=4.52$, $p=81$, a non-significant result demonstrating that the model was a good fit of the data. The Word Type x Referent Selection Response interaction was significant $\chi^2 (3)=8.45$, $p=0.04$. This indicated that the ratio of correct to incorrect referent selection responses differed across the four Word Types. A Spearman correlation revealed a modest negative correlation ($\rho(354)= -.12$, $p=0.02$) between referent selection and subsequent retention. Making the wrong referent selection slightly increased the likelihood of selecting the right object in the Test session. This finding is less surprising then it may at first seem. If children made the wrong referent selection the experimenter corrected them, and this may have increased their attention to the target object.

Retention

In order to ensure uniformity across Word Type conditions, participants with incorrect referent selection responses were removed from the data (in common with other fast mapping studies, e.g., Horst & Samuelson, 2008). This reduced the total number of participants by 50, from 354 to 304, and resulted in more variability in the sample sizes across Word Type and Delay conditions (see Table 3). In the Test session, children were assessed after five minutes (Short Delay) or after approximately one week (Long Delay) to see if they retained the novel word-object link. Retention accuracy is summarized in Table 3. A hierarchical three-way log-linear analysis produced a final model that retained the two-way interactions: Time Delay x Retention Response and the Word Type x Retention Response. The likelihood ratio of this model was χ^2 (6)=4.31, p=.635, indicating that the model was a good fit of the data.

The Time Delay x Retention Response interaction was significant, $\chi^2(1)=14.64$, $p<0.001$, suggesting that the ratio of correct to incorrect responses was different across the two time delays. The odds ratio is a useful measure of effect size (Finney, 1978) and indicated that the likelihood of children retaining the newly learned word was 2.44 times more likely after a 5-minute delay than after a week's delay. The Word Type x Retention Response interaction was also significant χ^2 (3)=8.81, p=0.032. This indicated that the ratio of correct to incorrect retention responses differed across the four Word Types.

Table 3. Number of participants and rate of retention accuracy (% of children choosing the target object at test) by Word Type and Time Delay. Binomial comparison of performance to chance [n.s. (*p*>.05); *(*p*<.05); ***(*p*<.001)]

Time Delay		**Word Type**			
		Object condition	**Color condition**	**Shape condition**	**Texture condition**
Short Delay (5 mins)	n	38	40	34	37
	Rate of retention accuracy (%)	71%	60%	76%	49%
	comparison to chance (1 in 3)	***	***	***	*
Long Delay (1 week)	n	40	38	33	44
	Rate of retention accuracy (%)	58%	37%	36%	36%
	comparison to chance (1 in 3)	***	n.s.	n.s.	n.s.

Further analysis compared object labels to the sum of the remaining Word Type data to avoid a large adjustment to the critical value from multiple post hoc comparisons. This was deemed appropriate as comparisons to chance supported treating the ‘Other’ Word Types as a single sample. A binomial comparison to chance (1 in 3) was calculated for each of the eight groups of data – the four Word Type conditions in each of the two Time Delay conditions. These results are summarized in Table 3 and showed that retention was significantly above chance for all Word Types when children were tested after a 5-minute delay. However, after a week, only the children who had been introduced to an object label could demonstrate comprehension at levels significantly greater than chance (*p*<.001). Retention of all the other Word Types after one week was no different from chance.

The data were collapsed across all the Word Types other than object labels. Retention accuracy for the “other word types” was 64% in the Short Delay and 37% in the Long Delay (compared to 71% and 58% for Object Labels). The retention of object-labels was compared to ‘other word types’ using Chi-square tests. In the Short Delay, χ^2 (1)=1.175, *p*=0.28, indicating that there was no significant difference in performance between object-labels and other word types. In the Long Delay χ^2 (1)=5.364, *p*=0.02, demonstrating that children’s retention of object-labels was significantly better than other word types, when there was a substantial delay between exposure and test. The odds ratio indicated that the children were 2.33 times more likely to retain an object-label than another word type after a week’s delay.

Discussion

Within a single experiment, we assessed 3- and 4-year-olds’ retention of a fast mapped novel object-label, shape, color and texture word. Participants were tested after either five minutes or approximately one week following the initial exposure. Children were able to infer the referent of all the novel word types easily. As expected, when children were tested after five minutes, retention was significantly above chance in all word type conditions and there were no significant differences between word types in the short term. However, after one week, only retention of the object-label was sustained at a level significantly above chance. Color, shape and texture words were fast mapped, and retained for five minutes on the basis of a single, incidental exposure, but not retained in the long-term.

Before discussing what the implications of our findings might be for accounts of word learning, we consider possible objections to our methodology. One might want to suggest that the differences in wording at exposure (“...can you give me the koba X?" versus "...can you give me the X koba?") and differences in wording at testing ("...can you show me which one is koba?" versus "...can you show me which one is a koba?") were responsible for the differences we found in long-term retention across different word types. This is unlikely. First, there were no differences in the mapping and retention across all word types after five minutes. Second, the wording (both at exposure and testing) was identical in the object label and shape conditions, but long-term retention was only good for object labels.

Another possibility is that the differences in long-term retention across different word types reflect the fact that different objects were used in different conditions. This too is unlikely for a number of reasons. Recall that for each different word the materials used in the short- and long-term conditions were the same. If the materials used in the object-label condition were simply more salient in some way, then we would expect performance on the object-label condition to be better than the color, shape and texture conditions when all were tested after five minutes. There was no such difference. In addition, the target objects within each condition were counterbalanced, so to argue that there was an object effect between conditions one would have to argue that the three target objects in the object label condition were on average more salient than the three target objects in any of the other conditions. This is highly unlikely.

What then do our data tell us about the relationship between fast mapping and retention of different word types? All the types of words tested here (object, color, shape and texture labels) were accurately mapped to their referents initially, and subsequently retained after five minutes, at well above chance levels. This suggests that unlike young 2-year-olds (Horst & Samuelson, 2008), older children can retain labels for objects and labels for object properties after five minutes. The high levels of retention of the color, shape and texture labels after five minutes are broadly consistent with the Heibeck and Markman (1987) data. The poor long-term retention data for these word types is consistent with the word training literature of new color and shape terms (O'Hanlon & Roberson, 2006; 2007).

It would appear that the difficulty in learning labels for color, shape and texture is not a result of poor referent selection or poor encoding. The rates of referent selection for these words, and their retention after 5 minutes, was high. This suggests that children established an accurate link between the novel word and its referent and remembered it, for a few minutes at least. The word-referent link appears to fail in long-term memory. Why would this be? One possibility is that the initial encoding, or strength of the word-referent link, may be weaker for property words than for object-labels. Perhaps the retention test after 5 minutes is too blunt an instrument to detect subtle differences in encoding, or referent selection.

Another possibility is that children may have answered the retention test correctly after a short delay by simply remembering a connection between, for example, a particular colored object and the word *koba*, rather than because they encoded the *new word* as *signifying* a particular color. Further testing may elucidate this. For example, if, after 5 minutes, children were better at extending a novel object-label than a novel color word, it would suggest better encoding of the object-label *as a word* (rather than a more superficial association). A similar manipulation was carried out by Booth and Waxman (2008) who demonstrated that 14- to 18-month-old infants extended novel count nouns appropriately based on shape, but color terms were extended to both shape-based and color-based exemplars.

Next the ‘special status’ of object-labels is considered. Object-labels were associated with high rates of referent selection and both short- and long-term retention. There was no deterioration in object-label retention from the short delay to the long delay. In contrast, retention of the other word types was no different from chance after one week. What could account for this? These data are consistent with Bloom’s (2000) account of the whole object bias and the salience of objects – that objects are special, and by association their names are special too. It is not clear, however, that our data help elucidate the underlying source of the object bias (whether it is conceptual or linguistic in nature, or related to our theory of mind abilities), but they suggest a new way in which this bias may be expressed. Previous data suggest that children find it easier to map novel words to whole objects than to properties of objects. Crucially, our data suggest that they also find it easier to retain these new mappings over time.

The difference in long-term retention data between the object label and the shape label conditions is of particular interest. Shape and object categories are similar in many ways. In the current study, the same language was used in both conditions at exposure (e.g., “Can you give me the green *koba*?”) and at test (“Can you show me which one is a Koba?”). In addition, the child was asked to label the whole ‘object’ rather than a property of the object in the shape condition, which might have induced them to perceive the shape word as an object label. Finally, there is a well evidenced ‘shape bias’ in word learning: children tend to generalize names for objects on the basis of shape rather than size, color, or texture (e.g. Diesendruck & Bloom, 2003; Horst & Twomey, 2013). Thus it would appear that children attend to shape when learning object-labels. It is therefore surprising that children failed to retain shape-labels after a week while object-labels were retained. What could possibly explain this?

Bloom's (2000) *shape-as-cue* account may be helpful here. Bloom (2000) argues that the shape bias exists, not because of a direct association between object labels and same-shaped objects, but because children believe that object labels refer to object categories, and that shape is a reliable cue to that category membership. This proposal relates specifically to artifacts (i.e., manufactured object designed and manufactured to perform a specific purpose). Artifacts usually have a specific shape in order to perform a specific function. Booth, Waxman and Huang (2005) propose something similar. This account might help explain why shape-labels are not retained long-term despite the shape bias. It may be that children's propensity is for retaining artifact labels.

Finally, we consider another important aspect of word retention raised in the fast mapping literature: the rate of forgetting. What do our data contribute to Vlach and Sandhofer's (2012) argument that words are forgotten over time? For shape, color and texture words retention in the long-term was lower than retention in the short-term - there was a significant deterioration in recognition suggesting that word retention follows a normal forgetting curve. However, object-label retention did not deteriorate significantly over time. Does this suggest that some word types are not forgotten, challenging Vlach and Sandhofer's (2012) claims? We think this is unlikely. The most plausible explanation is that all words are forgotten, but at different rates. Object-labels are associated with a flatter forgetting curve than other word types. It seems likely that after a longer delay the retention of object-labels would fall. That said however, Markson and Bloom (1997) report object-label retention still being high after one month.

Conclusion

Our data suggest that while color, shape and texture words are fast mapped and retained for a number of minutes, only object-labels are fast mapped and retained long-term. These data are consistent with Bloom's theory that objects, and by association their names, are special and that the shape bias stems from the fact that shape is relevant to the categorization of artifacts in particular (the shape-as-cue account). Do our data suggest that brief exposure only leads to long-term retention of object-labels? While this is a possibility, such a strong conclusion is perhaps premature. There is evidence that different biases operate in different perceptual contexts (Jones & Smith, 2002) or with different conceptual kinds (Booth & Waxman, 2002) – to the shape of artifacts when extending object labels, but also to the property (color or texture) of substances when extending substance terms. One avenue for future work would be to see if children retain object-labels when exposed to novel objects, and color or texture terms when exposed to substances.

Perhaps more importantly our data suggest that care is needed when interpreting children's behaviour on *any* learning task if performance is *only* assessed after a brief delay. In the present study the difference between object-labels and other word types only emerged in the long-term. It would therefore seem sensible that in future studies we investigate long-term retention, as well as short-term retention to gain a deeper understanding of the processes involved in referent selection and word *learning*.

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