WORDS AND FACTS:

CHILDREN'S FAST MAPPING,

RETENTION AND EXTENSION

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Contents

Abstract

Fast mapping describes the cognitive skill of mapping new information onto its appropriate referent, from minimal exposure. It has been researched primarily in the field of word learning and evidence suggests that a pre-school child can link a novel word with its referent and retain this link up to 1 month later (e.g. Markson & Bloom, 1997). In 4 experiments, I investigated the retention of fast mapped novel words and facts after 1 week in 3- and 4-year-old children. In the fifth and final study, I investigated extension of object labels and facts.

In study 1, participants demonstrated an impressive rate of retention of a link between a novel object label and its referent novel object after one week. In contrast, retention of colour labels, shape labels, texture labels and linguistic facts was no better than chance, despite good short-term performance. These data suggested that object labels are retained more easily than other word types and facts.

Studies 2, 3 and 4 investigated why facts were not retained after one week in Study 1. Studies 2 and 3 explored whether fast-mapped facts are only retained in the long term if they are associated with novel rather than familiar objects. Neither study found any significant differences between conditions suggesting that the familiarity of the referent object has limited effect on the long-term retention of fast mapped facts. Study 2 evidenced poor retention whereas, Study 3 found good long-term retention in all conditions. Study 4 examined whether the experimenter's naming of familiar objects and the participant selecting the target object, during exposure to a novel fact, affects retention. Retention of facts was weak and no different from chance in all conditions. These results indicated that long-term retention of fast-mapped words and facts was much more difficult than the early literature suggested. A thorough analysis suggested several factors may have affected retention e.g. repeat testing and gestural cues.

A final study examined extension of object labels and facts to other similar-shaped novel objects. Children spontaneously extended a newly learned novel object label, but not a specific fact ("my uncle gave this to me"). However, they extended a more generalisable fact, ("it comes from a place called Modi") to other members of the same object category, to the same extent as object labels. This indicated that facts can be as extendable as words and supports the conclusion that learning words and facts utilize similar cognitive mechanisms.

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CHAPTER 1

General Introduction

Word Learning

Young children learn words easily and quickly. By the age of seventeen, the average English-speaker knows more than 60,000 words (Bloom, 2001). Yet word learning is a complex inductive task (Quine, 1960). Even for a relatively simple novel word that directly links to a referent in the environment, there are several steps to word learning. The child needs to separate out the novel word from the stream of speech on hearing it for the first time. S/he needs to work out the referent for the novel word from the current scene (that typically contains many possible referent objects or features) and encipher and link both of these pieces of information. Finally, the child needs to store these two newly encoded representations in memory. Bloom (2000) cites the example of learning times tables arguing that they similarly involve the linking and retention of arbitrary and abstract pieces of information. Yet this task requires a significant amount of direct teaching, repetition and rehearsal. In contrast, word learning appears effortless.

How children learn the meaning of words has spawned a multitude of explanations. Some propose domain-specific mechanisms support word learning (Markman, 1989; Behrend, 1990; Behrend, Scofield, & Kleinknecht, 2001; Waxman & Booth, 2000) whilst others favour automatic processing (Samuelson & Smith, 1998). Other theories are at neither end of this spectrum. Some explain word learning as a result of domain-general mechanisms. For example, Bloom (2000) proposes that a number of different general processes are utilised in word learning. Childers and Tomasello (2003), Akhtar, Carpenter and Tomasello (1996) and Baldwin (1993) argue that word learning is the product of one general mechanism: social pragmatism. The social-pragmatic approach to word learning argues that to learn words children need flexible and powerful social-cognitive skills to understand the communicative intentions of others in a wide variety of interactive situations.

One mechanism thought to contribute to efficient word learning is "fast mapping" and is recognised by most researchers, regardless of their theory of word learning. Fast mapping describes quick learning from minimal input and, like most of the subsequent research, was first investigated in the field of word learning (Carey & Bartlett, 1978). Previous research has tested the fast mapping of different types of words - colour, shape, texture and object labels (Carey & Bartlett, 1978; Heibeck & Markman, 1987; Markson & Bloom, 1997; Waxman & Booth, 2000). All these words have a direct link with a referent in the real world. This research has indicated that young children can demonstrate comprehension of a novel word by selecting the correct referent from an array, following just a few exposures to the new word. In addition, fast mapping has been shown to extend beyond word acquisition, such as linguistic facts (Markson & Bloom, 1997; Waxman & Booth, 2000). These data suggest that when children are introduced to a linguistic fact, linked with a novel object, they can identify the appropriate referent from an array of novel objects.

Researchers have focussed on different aspects of fast mapping. A key area of interest has been whether fast mapped words or facts are remembered i.e. does fast mapping produce real learning? Long term retention has been investigated relating to fast mapped colour labels (Carey & Bartlett, 1978), fast mapped object labels (e.g. Markson & Bloom, 1997; Waxman & Booth, 2000; Horst & Samuelson, 2008; Vlach & Sandhofer, 2012) and fast mapped linguistic facts (Markson & Bloom, 1997; Waxman & Booth, 2000). These studies evidence retention of the link between a referent and a novel word or novel fact up to one month after the initial exposure.

Outline of Work

This thesis investigates fast mapping, long term retention and extension of words and linguistic facts in pre-school children. Of the words tested, object labels predominate but colour, shape and texture labels are also investigated in the first experiment. Of key interest here is whether 3- and 4-year-olds can learn a word or a linguistic fact about an object from minimal exposure and demonstrate retention of these novel words and facts after a significant time delay (1 week). There are five experiments in total and each has its own dedicated chapter. The first experiment compared the short and long term retention of fast mapped facts and labels for different lexical domains pertaining to a whole object or one of its feature (labels for colours, shapes, textures and objects). Experiments 2 and 3 compared the fast mapping and long term retention of object labels and facts associated with either familiar or novel objects. Experiment 4 investigated whether different methods of introducing the novel fact to the participant could affect their long term retention of the novel fact: namely, the child selecting the target object and the experimenter labelling the target object. Experiment 5 explored children's willingness to extend newly mapped object labels and two different kinds of facts to other members of the same object category.

In this introductory chapter I begin with a description of fast mapping and how it was first established in the field of word learning. Then there is a general overview of the literature broadly covering all aspects of fast mapping research. A more detailed analysis follows, focussing on studies that have investigated long term retention of words (and facts).

What is Fast Mapping?

'Fast mapping' was a concept first proposed by Carey and Bartlett (1978) to describe the initial stage of word learning: what is learnt from the first few encounters with a new word, "a small fraction of the total information that will constitute a full learning of the word" (p.18). Carey and Bartlett's method to test fast mapping exposed preschoolers to just a single casual encounter with an unknown colour word. The children's knowledge of the novel colour word was assessed one week later using a variety of tasks to elucidate the degree of understanding the children had retained from this single exposure. The reported results suggested that some learning was evidenced – children could demonstrate comprehension of the new word by selecting the correct referent from an array when prompted (for more detail on Carey & Bartlett's 1978 study, see below and Chapter 2). So there would appear to be several aspects of fast mapping: a partial understanding that is made quickly and easily, derived from minimal and incidental exposure and retained for a significant period of time.

Carey and Bartlett distinguish between the fast mapping and the extended mapping process. Fast mapping describes the learning that takes place after just one exposure (or just a few exposures) to a novel word, whereas the extended mapping is the learning that takes place after several more encounters with the novel words over an extended time period. It is important to note here that the learning Carey and Bartlett (1978) describe as the fast map is tested after one week, rather than within a few minutes of the initial encounter with the novel word, suggesting whatever is learned is retained for a significant period of time. The extended map was tested following two more encounters with the novel word several weeks later.

Subsequent researchers have focused on and investigated different aspects of fast mapping. For example, some have emphasised retention (e.g. Markson & Bloom, 1997). Some have focused on the 'partial understanding': how much the children learn from their encounter with the novel word (e.g. Carey & Bartlett, 1978; Heibeck & Markman, 1987; Waxman & Booth, 2000). Others have focused on the incidental nature of the exposure and the ability of children to make the correct map: linking the novel word with the appropriate referent (e.g. Heibeck & Markman, 1987). For some, fast mapping and referent selection have become synonymous (Horst & Samuelson, 2008; Horst, Scott & Pollard, 2010). Horst and colleagues (2008, 2010) have highlighted the importance of retention for word learning but separate the concept of retention from the map itself.

These quite different approaches to investigating fast mapping, using quite different experimental methods, have muddied the waters in terms of trying to define the concept of fast mapping. This thesis considers words and facts 'fast mapped' if exposure to the novel word or fact and the link to its referent is minimal – about the only common thread in the literature. Exposure is considered minimal if the child encounters the novel information up to 4 times. So, Markson and Bloom's (1997) study, where children are introduced to a novel word (and a novel fact) three times during the exposure session, is deemed to be fast mapping. In contrast, Vlach and Sandhofer's (2012) memory supports condition, where children are exposed to a novel word 6 times, is not regarded as fast mapping. The nature of this exposure (incidental versus ostensive) is not considered paramount here. Like Horst and colleagues (2008, 2010), long-term retention is emphasised but viewed separately from the concept of fast mapping.

Overview of the Fasting Mapping Literature

Building on Carey and Bartlett's 1978 seminal study, researchers have focused on different aspects of the fast mapping concept.

Word learning principles

These studies have focused on the initial step of the fast mapping process: how does the child decipher the referent of the novel label? Children appear to use a variety of semantic, syntactic and social cues to narrow down possible meanings for novel words they hear, and these have been investigated using fast mapping tasks. For example, syntax helps children work out whether a speaker is referring to an object, a substance or an action in a scene they are viewing depending upon the prefix or suffix used. If the speaker describes "an X" the speaker must be describing an object or a feature of an object (Brown, 1957). Social cues such as speaker's eye gaze, pointing and touching can help children work out which object the speaker is referring to and increase the salience of the referent object (Baldwin, 1991; Booth, McGregor & Rohlfing, 2008). In addition, other principles have been proposed.

Markman proposed the mutual exclusivity principle – a previously labelled feature is an unlikely referent for a novel name – and many researchers have investigated this principle (Markman, 1987, 1989; Golinkoff, Hirsh-Pasek, Bailey & Wenger, 1992; Wilkinson & Mazitelli, 2003; Wilkinson, Ross & Diamond, 2003; Halberda 2003, 2006; Horst, Scott & Pollard, 2009). A subtly different approach was proposed by Golinkoff *et al.*: 'the novel name-nameless category (N3C) principle' which states that a novel word is likely to apply to an unnamed, rather than a named, object, property or feature (Golinkoff, Mervis, & Hirsh-Pasek, 1994; Mervis & Bertrand, 1994). If using the mutual exclusivity principle, children will attend to familiar (previously labelled) features, discounting them in turn. Whereas the N3C principle suggests that children will attend to the novel items as potential referents for the novel word. The use of either one of these principles has greatly influenced the experimental paradigm used to test word learning. For many word-learning researchers, tests of fast mapping have become synonymous with referent selection tasks. The child is presented with an array of objects, one novel and some familiar, and asked to hand the experimenter the 'X', where 'X' is an unfamiliar non-word (Golinkoff, Hirsh-Pasek, Bailey & Wenger, 1992; Wilkinson, Ross & Diamond, 2003; Horst & Samuelson, 2008).

Another principle employed by young children in word learning is the whole object assumption – a novel name is likely to apply to a whole object rather than its constituent parts or features. How do word learners know which part of an object a novel count noun is referring to? For example, when presented with the word 'house' it could relate to the whole house or any part of it, e.g. the roof, the chimney etc. Evidence shows that children and adults tend to interpret new words as referring to whole objects, not to parts of objects, properties of objects or the stuff that objects are made of (Markman & Hutchinson, 1984; Waxman & Markow, 1995; Bloom & Markson, 1998).

The nature of the initial encounter

Other researchers have investigated the nature of the encounter with the novel word, for example ostensive versus incidental exposure (Jaswal & Markman, 2003; Vlach & Sandhofer 2012), widely spaced versus highly concentrated exposures (Childers & Tomasello, 2002) or concurrent versus successive exposure to multiple words (Wilkinson, Ross & Diamond, 2003). Others have investigated the nature of the child's encounter with the referent object and its effect on subsequent word learning. For example, Houston-Price, Plunkett and Harris (2005) found that 18-month-olds' learning was equally rapid when taught labels for moving versus still images. And Kucker and Samuelson (2012) demonstrated that when 24-month-old infants were familiarized with the array of novel objects prior to a referent selection task, infants retained the novel mapping from the referent selection task after a delay.

Different populations

Other fields of research have compared fast mapping in normal populations with populations with specific syndromes or conditions, e.g. Wilkinson and Green (1998) investigated fast mapping in individuals with mental retardation; Lederberg, Prezbindowski and Spencer (2000) investigated fast mapping in deaf preschoolers; McDuffie, Yoder and Stone (2006) investigated fast mapping in autistic children; and both McDuffie, Sindberg, Hesketh, and Chapman (2007) and Bird, Chapman and Schwartz (2004) explored fast mapping in adolescents with Downs Syndrome.

Several studies have compared fast mapping ability in different age groups. Markson and Bloom (1997) compares performance in adults, 3-year-olds and 4-year-olds, and Markson (1999) extended this research to 2-year-olds. Heibeck and Markman (1987) compared performance in 2-year-olds, 3-year-olds and 4-year-olds. Golinkoff, Hirsh-Pasek, Bailey and Wenger (1992) evidenced fast mapping in adults and children, and others have looked at when fast mapping can first be identified – Halberda (2003) demonstrated fast mapping ability in 17-month-olds, Houston-Price, Plunkett and Harris (2005) in 18-month-olds. Friedrich and Friederici (2011) showed that 6-month-olds could demonstrate learning of a novel object label and some of this learning could be evidenced 24 hours later.

What is fast mapped?

Other researchers have explored the type of information that is fast mapped. For example, following a fast mapping encounter can the child reproduce a novel word or merely comprehend it? Most of the research treats comprehension as evidence of fast mapping and ignores production. The data indicate that production is very difficult for young children following only one or two incidental encounters with a novel word, particularly after any kind of significant delay (Carey & Bartlett, 1978; Dollaghan, 1985; Heibeck & Markman, 1987; Gershkoff-Stowe, 2002). However, they do seem to be able to comprehend a novel word – on hearing the novel word again they can pick the appropriate referent from an array of familiar and unfamiliar referents. This echoes a well-established finding in memory research where recall is more difficult than recognition (e.g. Brown, 1965; McNulty, 1965).

Some have gone onto test how full the understanding of the novel word is. For example Golinkoff, Hirsh-Pasek, Bailey and Wenger (1992), Waxman and Booth (2000) and Behrend, Scofield and Kleinknecht (2001) have all shown that children know to extend fast mapped object labels to other similar objects. This suggests that, even if children can't reproduce the novel word, they do understand the name-referent link well enough to know how it generalises to other same-category objects. Extension is explored in more detail in Chapter 6.

Some researchers have concentrated on the nature of the learning that does take place from one or two exposures to a novel word - the 'partial understanding' Carey and Bartlett (1978) described. Swingley (2010) underlines the importance of investigating the initial building blocks – what elements of the novel word are encoded and remembered from the first encounter with the novel word? This partial understanding can include, but is not limited to, elements of semantic knowledge, syntactic knowledge, phonology, pronunciation and recognition of words in speech.

For example, Carey and Bartlett (1978) and Heibeck and Markman (1987) attempted to test children's semantic understanding of a novel word. Did they grasp that the novel word, to which they had been introduced to just once, described a colour (or shape or texture in Heibeck & Markman, 1987) even if they were not certain which specific colour (or shape or texture) the new word referred to? Yuan and Fisher (2009) demonstrated long-term storage of syntactic information about a novel word, even when the initial presentation event provided no semantic content. And several researchers have demonstrated that very young children (under 1-years-old) learn the phonological forms of many words that they hear frequently (e.g., Jusczyk & Hohne, 1997) and it is generally assumed that these word sounds are unrelated to meaning for such young children. Gelman and Brandone (2010) refer to the fast mapping of semantic 'skeletal placeholders' and that these will be extended gradually over time. They propose that acquiring the notion of 'kind' is fundamental to initial mappings of object labels. Friedrich and Friederici (2011), using the neurophysiological method of ERPs to watch brain activity, demonstrated that, after a delay of one day, 6-month-olds did not fully forget object-word pairs, although results indicated they were less stable than immediately after encoding. Instead of reviewing what aspects of a single word are encoded, other researchers have investigated mappings of multiple words at a time (Rice, 1990; Golinkoff *et al.*, 1992; Wilkinson & Green, 1998; Wilkinson, Ross & Diamond, 2003; Horst & Samuelson, 2008).

Other studies have investigated which semantic word categories can be mapped and whether some types of words are fast mapped better than others. For example, Heibeck and Markman (1987) compared fast mapping of colour, shape and texture words. Jaswal and Markman, (2001) contrasted common nouns and proper names; Childers and Tomasello (2002) investigated verbs and object labels; and Booth and Waxman (2009) have compared adjectives and count nouns. Others have looked at the phonotactic probability and the neighbourhood density of the novel word and their effects on how well the novel term is fast mapped (Storkel & Lee, 2011; McKean & Carolyn, 2013). This is the likelihood of specific sound combinations within a language (phonotactic probability) and the number of words differing from the target by one phoneme (neighbourhood density).

Fast mapping beyond word learning

The concept of fast mapping originated in the field of word learning. Markson and Bloom (1997) proposed that fast mapping was applicable to areas outside word learning, contending that the processes required for word learning are not special to the domain of language. They evidenced fast mapping and long-term retention of linguistic facts one month after exposure. Waxman and Booth (2000) and Behrend, Scofield and Kleinknecht (2001) have similarly evidenced the fast mapping of linguistic facts, albeit following a shorter time delay. Markson and Bloom (1997) also tested the fast mapping of visual facts and found that they were not retained after a month's delay like linguistic facts. This suggests that, although fast mapping operates beyond word learning, it is not unlimited.

In contrast, Waxman and Booth (2000) argued that word learning and fact learning may indeed result from different domain-specific processes as different principles of extension seem to apply to facts and words: children spontaneously extend newly learned words to novel exemplars within a category; they do not do this with newly learned facts. Childers and Tomasello (2003) counter-argued that facts are a poor comparison as they vary in whether they are tied to particular individuals and that a more appropriate comparison is a conventional nonverbal action on an object ('what we do with things like this') since they are routinely generalized categorically to new objects. They demonstrate that 2½-yr-old children extend novel nonverbal actions to new objects in the same way that they extend novel words to new objects. The findings provide support for the view that word learning represents a unique configuration of more general learning processes.

Other more recent research has demonstrated that fast mapping is applicable to learning outside the domain of language altogether. Riggs, Mather, Hyde and Simpson (2014) have evidenced that actions are fast mapped and can be reproduced, as well as comprehended, following a single demonstration and a significant delay. Indeed, these data suggest that fast mapping (and retention) of actions may well be easier for children than the fast mapping of words. This claim is supported by Hahn & Gershkoff-Stowe (2010) who found that children and adults learned to map arbitrary actions more readily than novel labels to a set of unfamiliar objects.

Retention

Finally, some researchers have looked specifically at retention to establish whether the fast mapped information is committed to memory (Markson & Bloom, 1997; Horst & Samuelson, 2008; Vlach & Sandhofer, 2012). It is this aspect of fast mapping that is the focus of this thesis. Clearly, retention is absolutely essential for word learning and was an important element of Carey and Bartlett's (1978) study. Even if what is mapped is only a partial understanding of the full meaning of the word or a specification of some of its phonology, this information must be retained if the extended mapping process is to have any chance of success: future interactions with a novel word can only build on fast mapping, if something is retained long term from that mapping process.

Yet most studies in fast mapping have tested participants immediately following the presentation of the novel word, as they focus on children's ability to pick the target referent under varying circumstances (e.g., Golinkoff *et al*., 1992, 1994; Wilkinson *et al*., 2003). Of the few studies that do leave some delay between exposure to the novel word and test, even fewer studies have imposed a delay of more than a few minutes (e.g., Oviatt, 1980; Heibeck & Markman, 1987; Horst & Samuelson, 2008). Indeed, retention is generally disregarded as an aspect of fast mapping (Horst & Samuelson, 2008). Yet, researchers often employ the terms 'fast mapping' and 'word learning' interchangeably, contrary to Carey's (2010) assertion that 'Never did anybody believe that children typically create full lexical representations upon just one or even a few exposures to a new word'(p.184). Words cannot be considered learnt without some thought to retention.

Detailed Analysis of Fast Mapping and Retention

So far, there has been a brief overview of the entire fast mapping literature. However, as the focus of this thesis will be fast mapping followed by retention, a more detailed review of the studies that have investigated these aspects of fast mapping is necessary here. Not all of the significant research in this field has been explicitly labelled as 'fast mapping', but if their procedure includes a test for retention following minimal or incidental exposure, they are addressed below. Horst and Samuelson (2008) were similarly interested in retention and provided a thorough literature review. However, Horst and Samuelson were interested in retention following referent selection tasks, specifically, and dismissed many studies that did not conform to a very precise procedure. The scope here is broader.

This detailed literature review is laid out chronologically, in the most part, and is divided into two main sections: "The Early Years" (relating to studies pre-2008) and "Recent Years" (relating to studies since 2008). Prior to 2008, the fast mapping studies that investigated long term retention found evidence that fast mapped words and facts were retained for significant periods of time following the initial exposure. The presumption was that fast mapping inevitably led to long-term learning. However, starting with Horst and Samuelson (2008), recent studies have explored the relationship between fast mapping and retention, and have suggested that fast mapping is not always associated with long term retention.

The Early Years: 1978-2007

Before 2008 there were relatively few fast mapping studies that investigated retention following a significant delay. And all of these studies evidenced, or at least appeared to evidence, that fast mapping of novel words was associated with long term retention. This evidence is reviewed broadly in chronological order.

Retention in Comprehension tasks

Carey and Bartlett (1978) introduced the concept of fast mapping and their original study has been extremely influential in subsequent research. They exposed nineteen 3-year-olds to an unknown colour word on a single occasion, and tested participants' retention of this novel word 7-10 days later. The novel word was 'chromium' and it designated a colour (olive green). During normal classroom activities, each child was asked by their teacher to retrieve a tray: "You see those two trays over there? Bring me the chromium one. Not the red one, the chromium one." 7-10 days later children's knowledge of the new colour word was assessed using four different tests: to see if they could differentiate olive from other similar colours (sorting task), produce the word 'chromium' (naming task), correctly pick olive from an array of nine colours when asked to point to the 'chromium' one (comprehension task) and demonstrate they knew that 'chromium' signified a colour (hyponym task).

8 of the 19 participants (47%) could correctly identify chromium in the comprehension task. This headline result is generally reported as evidence that 'words' can be learned and remembered from minimal and incidental exposure. Also children demonstrated a marked improvement in performance on the sorting task compared to the baseline assessment, which was conducted one week prior to the exposure to chromium. This suggests that exposure to the novel colour word had improved children's understanding of the 'category' of colours. However, the experimental and control groups' comprehension data were not significantly different (47% v 30%) so retention of the link between the novel word and its referent was not evidenced here. And, even though the experimental group's improvement in the sorting task was significantly higher than the negligible improvement demonstrated by the

control group, the control group made far fewer errors at baseline compared to the experimental group, casting some doubt over the results.

Carey and Bartlett went on to test the same children ten weeks later. Following another two presentations to chromium and another week's delay between exposure and test, performance was better, although not really convincingly so (for more detail see Chapter 2). Further, by the second cycle of testing, children would have experienced the test question once before, which is likely to have improved performance. So Carey and Bartlett introduced the possibility that a novel colour word, or some element thereof, could be retained for a significant period of time after minimal exposure but their results were insufficiently strong to provide emphatic evidence of long term learning.

Heibeck and Markman (1987) extended Carey and Bartlett's (1978) research. They attempted to overcome some of the methodological difficulties Carey and Bartlett experienced. They tested words from different semantic domains (shape and texture, as well as colour) and they tested younger and older participants (2-, 3- and 4-year-olds). Children in the colour condition were directed to two books on a chair and were asked, "could you bring me the 'chartreuse' one, not the red one, the chartreuse one?" for example. A variety of novel colours and familiar colours were used across the data set. The shape and texture conditions were almost identical, merely exchanging trays and boxes for books and novel and familiar shape and texture terms respectively.

Across all age groups, the comprehension data suggested that shape words (83%) were fast mapped better than colour words (64%) and that both were fast mapped significantly better than texture words (36%) which, in contrast to the shape and colour terms, were retained at levels no better than chance. In addition, no developmental differences were detected: 2-year-olds performed as well as the older children. Overall, Heibeck and Markman (1987) evidenced fast mapping at levels significantly above chance for colour and shape words. However, the delay between exposure and test was only ten minutes. Even though this suggests some level of retention (Horst &

Samuelson, 2008 would argue this requires long term memory, at least for 2-year-olds) it is relatively short term compared to testing after one week or even after one day.

Performance in Production and Hyponym tasks

In addition to testing for comprehension, Carey and Bartlett (1978) and Heibeck and Markman (1987) tested for production and for a partial understanding of the novel word - using a 'hyponym' task. Both studies found poor production performance – children could not produce the word when asked to label the target. Good production of fast mapped words has not been reported since. Children seem to be unable to recall a novel word, especially after any kind of significant delay, if they have been exposed to the novel label only a few times without any kind of training or rehearsal.

Dollaghan (1985) found that only 45% of 31 participants could reproduce a minimum of two phonemes of the novel word 'koob' containing three phonemes. This seems quite poor production performance given the procedure: participants were exposed to the novel object label, then tested immediately for comprehension followed by the production test straight after ("What's this? What is its name?"), hence hearing 'koob' twice in short succession immediately prior to being asked to reproduce it. However, when they are asked to identify the target on hearing the novel label (comprehension task) they are much more successful, suggesting their recognition memory is better. This is consistent with the finding that comprehension vocabulary is superior to productive vocabulary in young children (e.g., Benedict, 1979).

Carey and Bartlett (1978) and Heibeck and Markman (1987) also conducted a 'hyponym' task, which was trying to assess if some partial understanding of the novel word had been understood and retained, even if the full word had not been mapped. They tried to assess whether the children had established the semantic domain of the novel word e.g. had they understood that the novel word designated some kind of colour even if they had not mapped the word to the specific target colour.

Carey and Bartlett's results were poor – few children answered the hyponym tasks correctly. This seems strange given that performance on the comprehension tasks was much better. Comprehension performance suggested participants understood not only the category to which the novel word belonged but also the specific colour, shape or texture with which it was associated. The poor performance in Carey and Bartlett's hyponym task was probably due to the children failing to understand what was being asked of them and how to answer correctly. Carey and Bartlett's 1978 study asked participants "Is purple a colour? Is cold a colour? Is noisy a colour? Is chromium a colour?" The child had to answer all four questions correctly to be treated as knowing chromium was a colour word and only 4 of the 19 children could do so.

Heibeck and Markman (1987) designed an easier task and found much better performance. 100% of children in the shape, 89% in the colour and 56% in the texture condition answered the hyponym task correctly. They presented participants with a familiar item, asking them to provide a contrast for the novel word. For example, "See this book? It isn't chartreuse because it's ….." They argued that if children answered with a colour term, it could be inferred that they had understood that the novel label was also a colour term. However, this interpretation is far from obvious. Given that the books (in the colour condition) were only recently introduced with a reference to colour in the introductory session ten minutes before, it seems that the most likely word a participant would say is a colour word. It's not clear at all from this test that the children understood the category domain of the novel word.

Subsequently, few researchers have tried to assess knowledge less than the full word, and the most basic knowledge tested has been comprehension – can the participant identify the target from an array on hearing the novel word?

Retention of object labels by very young children

Oviatt (1980) did not use a fast mapping paradigm (minimal exposure) but she did test retention after a delay (albeit only fifteen minutes) and the participants were very young so it is worth mentioning here. Oviatt introduced very young children (under 1s, 1-year-olds and 1½-year-olds) to a novel object label or a novel action word twenty-four times during the exposure period. The infants' comprehension of the novel word was then tested after either three minutes or after fifteen minutes by asking, “where's an X” and their looking responses to the target object were compared to a control group's spontaneous looking responses. Oviatt found that there was a large improvement in comprehension as age increased. The results were all-or-nothing: infants who were successful in the comprehension task after three minutes were also successful after fifteen minutes and vice versa. This suggests that retention is not affected by the length of the delay between exposure to the novel word and test, at least within certain limits, and has contributed to the view that words, once learned, are not forgotten.

Woodward, Markman and Fitzsimmons (1994), comprising four different studies, aimed to demonstrate that infants before the onset of the vocabulary spurt (13-month-olds) can learn a single new word efficiently and easily. Their studies were not designed specifically to assess fast mapping – they refer to fast word learning rather than fast mapping and the novel object label was introduced ostensively nine times over the course of the training session (as opposed to minimal exposure) – but the final study (Study 4) tested comprehension after a 24-hour delay. Given the significant delay prior to testing and the young age of the participants, this research is explained here.

During the training session in Study 4, sixteen 13-month-olds and sixteen 18-month-olds were introduced to the novel word ‘tukey’ relating to one of two novel objects (counterbalanced) - a large plastic paper clip or a small plastic strainer. The infant heard “That's a tukey. See, it's a tukey. Look, it's a tukey.” whilst just one of the novel objects was in sight. This was repeated twice during a 3- to 5-min session, yielding nine repetitions of the word tukey. The experimenter also drew attention to and commented on the unlabelled object nine times to try to make both objects equally salient.

A different experimenter, ignorant of the target, tested participants twenty-four hours later to assess their comprehension of 'tukey'. Eight comprehension test trials followed – four new label trials and four familiar label trials (trial type order counterbalanced). The new label trials presented children with a clip and a strainer - the original objects from the training session or a pair of generalization exemplars in different colours. The child was asked for the 'tukey' (e.g., "Can you put the tukey in there?"). Each child was asked twice about the training pair and twice about the generalization pair. For each child, right and left placement and pair were counterbalanced. The familiar label trials followed a similar pattern and asked children to choose between two familiar objects with known labels (e.g., dog, spoon). Performance significantly above chance in both age groups provided validation of the comprehension measure. In Studies 1 and 3, preference control trials were included to assess the possibility that children were simply choosing the target object because it had been made more interesting by labelling it (Baldwin & Markman, 1989; Schafer & Plunkett, 1998; Horst & Samuelson, 2008; Axelsson & Horst, 2013). As no such preferences were found in either study, the preference control test was omitted from the fourth Study.

In Woodward *et al*. (1994) new label trials, both 13-month-olds and 18-month-olds retained the novel object label significantly greater than chance after a twenty-four hour delay (13-month-olds at 67% and 18-month-olds at 77%, chance=50%). These results suggest that children as young as 13 months can retain a word learnt from limited and ostensive exposure for a significant period of time.

Retention of object labels evidenced by 2-year-olds

Goodman, McDonough and Brown (1998) consisted of three studies, the last of which tested comprehension after a 24-hour delay. Twelve 24-month-olds and twelve 30-month-olds participated in Study 3, comprising a training session and a test session. The training session made use of 'semantically constraining' familiar verbs to allow the children to work out which novel object was the referent from a set of four novel object pictures. The verb used was familiar and constraining but the object was novel. For example, on hearing “Mommy feeds the ferret. Show me the ferret” the 2-year-olds would understand ‘feed’ but not ‘ferret’ and might be able to work out the referent as 'feeds' constrains the target to an animate object and a picture of a ferret would be the only animate object on display. Following three familiar training trials, each child was introduced to a total of six new object labels by way of six sentences containing six familiar verbs and six related pages of pictures. At the end of the training session, the experimenter completed a final review of each page stating the original sentences while pointing to the correct pictures. Horst and Samuelson (2008) argue that this explicit link made between the novel word and the novel object by the experimenter, prevents the experiment being considered a fast mapping study. However, that there was minimal exposure to the new word (only three enunciations of the novel word over the course of the training session, including the final review) and testing occurred after a significant delay (24 hours rather than just a few minutes) makes this experiment worth considering here.

The test session a day later was challenging. The test booklet contained six pages of four pictures consisting of (1) the target picture - in a different page quadrant to Day 1; (2) a picture that had served as a target item of a different sentence on Day 1; (3) a distractor picture that had been on the same page as the target on Day 1 (4) a completely novel distractor picture. Participants were asked to identify all six targets e.g. "Show me the ferret." In order to choose the target from the test array, the child would need to have retained the link between the novel object label and its referent. A vague memory of the location of the target, or a vague connection that the object label connected to one of the novel objects, would be insufficient to select the target at more than chance levels.

Participants’ answers during the training session and the testing session were collated. Both age groups clearly inferred (65-73%) the correct referent for the novel word during the training session (chance was 25%). In addition, they also retained the novel object labels (58-70%) – they could correctly identify the target, significantly more than chance, 24 hours after the initial exposure. Goodman *et al*., (1998) provide convincing evidence that children as young as 24 months can retain an object label for a significant time period (24 hours), even when the child has only encountered the object label three times, and had been introduced to six new words and their referents within a few minutes of each other. It would not be hard to believe that adults would struggle with this task!

Retention beyond word learning

Markson and Bloom (1997) defined fast mapping as learning from a few incidental exposures and the retention of this knowledge for a long period of time. They saw long term retention as a fundamental aspect of fast mapping. They were the first to combine a procedure that involved minimal and incidental exposure to object labels (and facts), and compared immediate retention with retention after a significant delay (up to one month later). Retention levels (for object labels and linguistic facts) were significantly above chance in all time delay conditions providing the strongest evidence to date of fast mapping associated with long-term retention.

Markson and Bloom (1997) tested 48 adults 47 3-year-olds and 48 4-year-olds. Each participant was introduced to an array of ten objects (four familiar and six novel) under the guise of playing a measuring game, where some objects was used to 'measure' other objects. Every participant was exposed to two new pieces of information: a novel object label ('koba') and a novel fact. The novel word and novel fact were introduced three times, each relating to one of the six unfamiliar objects (counterbalanced), over the course of a 20-minute training session. For one of the novel objects they were told, "Let's measure the koba. We can count these to see how long the koba is. We can put the koba away now." In a similar way, half the participants were introduced to a fact presented linguistically ("the thing my uncle gave to me") about one of the other novel objects. The remaining participants were introduced to a fact presented visually (a sticker was placed on one of the novel objects). Participants were not asked to repeat the word or fact and no effort was made to ascertain whether they even noticed that a new word was being introduced. Participants' comprehension of the novel object label and fact were then tested in one of three different time delays: immediately, one week or one month following the training session. The original array of ten objects was laid out and all the participants were asked: "Can you see a koba here?" Then, half the participants were asked "which one did my uncle give me?" (linguistic fact condition) and the other half were handed a small sticker and asked to put it where it should go (visual fact condition).

Adults and children could remember significantly better than chance which of the novel objects 'koba' related to, in all three delay conditions – 55%-93% of participants could retain the novel word-object link. Similarly, all three age groups could remember significantly better than chance (1 in 6) which of the novel objects "my uncle gave to me" across all time delays (62%-100%). In addition, neither adults nor children demonstrated a significant decline in retention of the novel object label or linguistic fact over the month. However, this convincing performance did not extend to the visual fact condition ('sticker') beyond the immediate condition. Adults' and children's performance significantly deteriorated over time and only adults demonstrated retention significantly better than chance after one month. Overall, these results suggested that fast mapping was not restricted to word learning, but neither was it universally applicable. The finding that fast mapping is not restricted to word learning is consistent with Bloom's theory (2000) that word learning is achieved from the interaction of several general cognitive processes that are not special to the domain of language. Markson (1999) extended this research to include 2-year-olds using a simpler methodology and evidenced long-term retention in these younger children following minimal exposure to the novel object label and fact and a significant delay between introduction and test.

In order to demonstrate that learning words is different to learning facts, Waxman and Booth (2000) introduced 48 4-year-olds to a novel object label or a novel fact and tested for retention (and extension) of this new word or fact either immediately or one week later. At the very start of the training phase the experimenter picked up the target novel object and said ‘Look at this one. This one is so special to me. And you know what?' At this point, she applied either a word (`It is called a koba') or a fact (`My uncle gave it to me') to the target. The children then interacted with the target object along with a further five novel objects and four familiar objects, one at a time, for a few minutes. At the end of the training phase, the experimenter assessed whether the child had established a mapping to the target, asking ‘Can you hand me the one that is a koba?' (Word condition) or ‘Can you hand me the one that my uncle gave to me?' (Fact condition). The test phase was administered immediately afterwards for half the children and one week later for the other half. The ten objects from the training phase were presented and the child was asked `Can you hand me the one that is a koba?' (Word condition) or `the one that my uncle gave to me?' (Fact condition). Every single participant demonstrated retention of the novel object label or novel fact in both time delay conditions. And over 90% of the children in the Word condition went on to demonstrate accurate extension of the newly learnt word indicating they had correctly understood that the object label was applicable to other similar objects, not just an association between a word and a specific object. So the participants in this study, from just one exposure to the novel word and its associated referent, could retain this new object label for a significant period of time (one week).

However, there are some important methodological considerations here for the retention of fast mapped words (and facts). Waxman and Booth (2000) did not ask the children to work out the referent of the new object label - the exposure to the novel word-novel object link was ostensive. Also, they made the target object particularly salient by introducing it first and calling it ‘special’. And finally, to ascertain whether the children had established the mapping to the target at the end of the training phase, every participant was exposed to the test question before the test phase. This review of the name-object link prior to test is likely to have assisted participants' ability to retain this link over time. As Waxman and Booth were concerned with demonstrating differences between words and facts, and their methodological approach was consistent across conditions, these aspects of their procedure are of little relevance to their conclusions. However, they are important when attempting a meta-analysis across different studies to determine when minimal exposure to words (and other information) is followed by retention.

Retention following ostensive versus incidental exposure

Jaswal and Markman (2001) found that fast mapping accuracy in 3-year-old children was the same irrespective of whether direct (ostensive) or indirect (incidental) exposure was used. Jaswal and Markman (2003) investigated whether their 2001 findings would hold true when participants were tested after a significant time delay of two days. 32 young 3-year-olds were randomly assigned to one of two conditions. In the indirect learning condition, participants needed to infer the referent for one new common name ("Do you think you can find a blicket?") and one new proper name ("Do you think you can find Toma?"). In the direct learning condition, the experimenter introduced the name for each referent ostensively ("I'm going to show you [a] Blicket."). Participants were exposed to the novel word four times in the presence of one novel animate object (e.g. a stuffed mosquito) and one novel inanimate object (e.g. a shuttlecock).

Children in both the indirect and direct learning conditions were tested using a generalisation test 2-3 days later. Children saw three objects presented on a tray: a target, a generalisation stimulus, and a distractor. The target was the same object from the exposure session that they had selected (indirect learning condition) or the one that had been labelled for them (direct learning condition). The generalisation stimulus was another member from the same category as the target. The distractor stimulus was an object from a category different from that of the target and generalisation stimuli but of the same animacy. Participants were asked to perform four actions with the target name used in the exposure session e.g. “Can you put [a] Blicket down the chute?”

In the indirect condition, participants selected the distractor only 19% of the time in the common name condition and 4% of the time in the proper name condition, both significantly less than would be expected by chance (33%). Direct learning did not result in a more stable mapping with participants choosing the distractor at similar levels (15% and 8%, respectively). So Jaswal and Markman’s (2003) data would suggest that 3-year-olds can retain two fast mapped words from minimal and indirect exposure, up to two days after the introducing event. This appears to provide strong evidence for the retention of fast mapped words under challenging circumstances – each child was exposed to and tested on two words, the new words were only spoken four times and only linked with the target novel object once, and the participants were young (only just 3-years-old). For half the participants the introduction to the novel word was incidental rather than ostensive and the time delay between exposure and test was significant: at least 48 hours.

However, there are other interpretations. At test, the array consisted of only three novel objects and two of these objects, the target and the generalisation stimulus, could be treated as correct answers – at least in the common name condition. Children had never seen the alternative object (the distractor). So the participants may have been choosing the object they had seen before rather than the alternative object that was completely new to them. That they had retained a robust link between the novel word and its referent is less certain here.

Summary: the findings from the early studies

A generous interpretation of the first thirty years of research into fast mapping and retention suggest the following statements. Firstly, labels for properties of object, object labels and proper names are fast mapped and retained (Carey & Bartlett, 1978; Heibeck & Markman, 1987; Jaswal & Markman, 2003). Secondly, retention after a significant delay can be achieved by children as young as 1-years-old (Oviatt, 1980; Woodward, Markman and Fitzsimmons, 1994; Goodman, McDonough & Brown, 1998). Thirdly, young children can map and retain several words in a single session (Goodman et al., 1998; Jaswal & Markman, 2003). Fourthly, retention does not deteriorate over time (Oviatt, 1980; Markson & Bloom, 1997; Waxman & Booth, 2000). And finally, long term retention can be achieved as easily from indirect exposure to the novel word as direct exposure (Carey & Bartlett, 1978; Markson & Bloom, 1997; Jaswal & Markman, 2003). This is certainly how a summary review of the literature has been reported (e.g. Bloom, 2000).

However, the evidence does not really support such a generous view. Some effort has been made here to explain the underlying complexity of the data and demonstrate that the story is not quite so straightforward. There is evidence of long term learning but often from procedures that do not mirror the minimal and incidental exposure enshrined in Carey and Bartlett's (1978) original study. Long term retention of labels for object properties, at least colour and shape, are hinted at by Carey and Bartlett (1978) and Heibeck and Markman (1987) but not actually demonstrated. Fast mapped novel object labels and linguistic facts do seem to be retained for a significant time period following minimal exposure based on studies published between 1978 and 2008. More current research will now be considered.

Recent Years

Since 2008, there have been a number of fast mapping studies that test retention. Significantly, some report children failing to retain novel object labels (Horst & Samuelson, 2008; Vlach & Sandhofer, 2012) suggesting that the retention of fast mapped object labels is, perhaps, not as robust as previously thought.

Object labels not retained without ostensive exposure and gesturing

Horst and Samuelson (2008) investigated retention of fast mapped object labels. They define fast mapping as the ability to determine the referent of a novel word from minimal and incidental exposure, and treat it as synonymous with referent selection. They were particularly interested in young children's ability to retain fast mapped words after a delay. Horst and Samuelson (2008) introduced young 2-year-olds (24-months) to novel words using a standard referent selection paradigm and a single exposure – from an array of two familiar objects and one novel object, the infant was asked to "Get the X!", where X represented one of eight non-words such as 'blicket' or 'cheem'. The children were then tested following five minutes of free playtime in another room. Horst and Samuelson posited that a five minute delay was sufficiently long to ensure that word learning was based on retrieval from long-term memory. In their first three studies (Experiments 1A, 1B and 1C), Horst and Samuelson found that their participants were excellent at referent selection – infants selected the novel object when asked to get the novel name significantly more than chance – but, surprisingly, there was absolutely no evidence of retention (or extension/production) above chance levels after just five minutes.

Despite the relatively short time delay between exposure and assessment, Experiment 1A (unlike 1B and 1C) was a very challenging test. The infants (n=16) underwent sixteen referent selection trials in which they were asked to get an object - for eight novel names and for eight familiar names. So the child was introduced to a large quantity of novel object labels in quick succession and had to undergo a large number of referent selection trials in total – both novel name trials and familiar name trials. In addition, the test array comprised three novel objects: the target and two foil items. The two foil items consisted of an object that had been named on another trial during the exposure session and a distractor - a novel object that the infant had seen during familiarisation trials but had not been labelled. This ensured that all the novel objects in the test array were equally familiar to the child and, with the inclusion of an object that had previously been named, the choice of target at test provided good evidence that the child had retained the specific name-object link. In other studies, Horst and Samuelson argued, the target choice may have resulted for other reasons. The child may have simply chosen the object they remembered being associated with some novel word without retaining the precise object-label link. The target object may have been made salient by simply being the only one labelled (Baldwin & Markman, 1989; Schafer & Plunkett, 1998; Axelsson & Horst, 2013). Finally, the target may have been more salient because it was the only novel object participants had encountered during the introductory session.

Finally, four of the eight novel names were tested on extension trials, rather than retention trials, where exemplars of the target, the previously named object and a distractor made up the test array. So the children had to retain eight precise novel word-object links following a single exposure to all the new words in a short time period, and be able to extend the novel labels, in order to be able to answer the test session correctly. Adults may struggle under such circumstances so perhaps it's not so surprising that 2-year-olds failed to retain so many novel words in one sitting.

However, Experiment 1B and, particularly, 1C's results were much more surprising. Horst and Samuelson simplified their procedure in the hope of attaining some evidence of retention of fast mapped words. Experiment 1B was easier, introducing 32 participants to sixteen referent selection trials comprising only one novel label trial, but they still found no retention. Experiment 1C was even simpler. It comprised just three referent selection trials and only one of these introduced a novel word. At test, the 20 participants had to pick the target from three objects, comprising the target (named in the exposure session) and two previously seen but unnamed novel objects (used in the other two retention trials that requested a familiar name and object). Again, there was no retention after just a five-minute delay between introduction and test. This was unexpected given the data reported in the literature testing the same or younger age groups (e.g., Heibeck & Markman, 1987; Woodward *et al*., 1994; Markson, 1999; Goodman *et al*., 1998), and indicates that the retention of fast mapped words is less robust than the previous literature seemed to suggest.

Horst and Samuelson (2008) suggest that long term retention may be evidenced in other studies due to the nature of the foil items presented in the test array. If distractor novel objects presented at test have never been seen before then correct responses may only be on the basis of the familiarity of the target object (Schafer & Plunkett, 1998). If the distractor novel objects presented at test have never been named before then correct responses may result from a memory that the target object was named, without knowing whether it was labelled with the target name in particular. When Horst and Samuelson (2008) apply their stringent set of criteria at test, which ensures retention is based solely on a representation of the specific name-object mapping in long-term memory, retention is not evidenced.

Horst and Samuelson's (2008) Experiment 2 went on to explore whether 32 young children could demonstrate retention with such a strict set of criteria applied at test. The participants were once again introduced to eight novel name-object mappings but the salience of the novel words was increased during referent selection by repeating the novel object label several times. In addition, for half the participants, "follow-in" labelling succeeded the referent selection trials: the experimenter named the object the child had chosen with "Yes, that's the X". For the remaining half of participants, ostensive naming followed each referent selection trial: the experimenter held up and pointed to the target while saying "Look, this is the X". Consistent with the findings of Experiments 1A, B and C, the two-year-olds in both conditions chose the target object significantly more than expected by chance on familiar and novel referent selection trials. There was no evidence of retention after a 5-minute delay in the follow-in condition. However, infants were able to demonstrate retention significantly above chance for the first four novel names presented in the referent selection trials, when referent selection was augmented with ostensive naming.

Horst and Samuelson's findings suggest several conclusions. Firstly, retention of fast mapped object labels is not unlimited and does not occur in all circumstances. The failure to find any retention in Experiments 1A, 1B and 1C indicates that retention of fast mapped object labels is not necessarily straightforward. (Vlach and Sandhofer (2012) support these findings with older children – their article is discussed later in this chapter). That only four of the eight fast mapped names were remembered after the five-minute delay in Experiment 2, indicates that even when pre-requisite conditions are met, there is a limit to the quantity of new words a young child can retain, at least in any one session. In addition, retention occurring in the ostensive labelling condition but not the follow-in labelling condition is surprising given the subtle difference between the two conditions. In the follow-in condition, participants were holding and looking at the object when the experimenter labelled it once more after the referent selection task. The crucial difference in the ostensive condition was the experimenter holding up and labelling the object. Horst and Samuelson contend that at the mechanistic level this helps young children to focus on the target and reduce the competition from distractors, namely the familiar objects present at the time of referent selection. Note that simply hearing the novel word several more times just before the labelling event was not sufficient to produce retention. However, more than one exposure to the novel word may still be necessary for retention as the novel object label was repeated several times in both the ostensive and follow-in conditions.

Horst and Samuelson's (2008) data and conclusions seem to suggest that retention of fast mapped object labels is only possible for young 2-year-olds following ostensive labelling, where the adult holds the object whilst naming it. However other studies have evidenced fast mapping and retention in similarly aged children. For example, Heibeck and Markman (1987) tested 2-year-olds following a ten-minute delay and reported learning of colour and shape words above chance levels without any ostensive labelling. Markson's PhD (1999) included a simplified version of the Markson and Bloom's (1997) study with 2-year-olds and reported retention of object labels and facts after one month as well as one week. Horst and Samuelson (2008) explain other similar variances with the literature (although they do not refer to these studies in particular) by suggesting that the foil items in the test array help children choose the target during the retention test (see above) and/or the failure to label more than one object increases the salience of that object such that participants choose it at test but are not really remembering the word-label mapping in these other studies.

However, particularly with regard to Markson's (1999) study this seems an unduly harsh criticism. Although, Markson only labelled one of the objects in the introduction array, another of the novel objects was linked with a novel fact (and, in an additional study, that novel fact contained a novel word). It seems unlikely under these circumstances that the novel object linked to a novel word would have been particularly salient and more so than the novel object linked with a fact. If the infants had failed to retain the specific name-object mapping in this experiment and merely remembered that one of the two 'salient objects' had been linked with a novel name or a novel fact, one would have expected children to have chosen the fact target in place of the object label target in approximately 50% of cases and vice versa. In addition in the Markson (1999) experiments (and in Markson & Bloom, 1997), the introductory and test array were the same, exposing children to ten objects (six novel and four familiar) and the children interacted with all the objects for similar amounts of time during the lengthy introductory session, ensuring that the participants were as familiar with the unnamed novel distractors as they were with the previously labelled target and the target linked with a novel fact. Horst and Samuelson only found retention with ostensive labelling but this was using a methodology that introduced eight words, one after another, in a short space of time. This is a particularly demanding test scenario.

In addition, it's important to point out that Horst and Samuelson (2008) only tested participants after a short delay – just five minutes. Even if this gap is sufficiently long to suggest the use of long-term memory there is no guarantee that the novel word will be retained in long-term memory. Both Markson and Bloom (1997) and Vlach and Sandhofer (2012) indicate that what is retained in the short term is not necessarily retained after longer periods of time. Indeed Markson and Bloom (1997) indicate that retention can deteriorate from one week to one month for fast mapped information (visually-presented facts). It is retention in the long term that is the focus of this thesis. I now go on to consider recent evidence that informs our understanding of what factors may influence retention.

Familiar objects deter retention

Horst, Scott and Pollard (2010) replicated and extended some aspects of Horst and Samuelson (2008) to demonstrate that it is the familiar objects at referent selection that compete for 2-year-olds's attention and hinder retention. Using a similar experimental method they introduced 2-year-olds to four novel object labels by way of a referent selection task, followed by ostensive labelling. The only varying factor was the number of familiar objects present during referent selection: 2, 3 or 4. As expected, there was good performance across the board at referent selection. However, only in the condition that presented just two familiar objects did retention follow on from referent selection, at a rate significantly greater than chance.

The authors contend that the children must be using the mutual exclusivity principle rather than the N3C principle as it is familiar objects, rather than novel objects, that compete for their attention. If participants were focussed on novel objects only (as suggested by the N3C principle) then the number of familiar objects in each condition would be irrelevant and should have no effect on retention. In addition, total response time increased steadily with the number of objects at referent selection – response time by object was roughly constant. This suggests that participants are looking at, and presumably eliminating, each familiar object as a possible referent in accordance with the mutual exclusivity principle. If participants were looking for and focussing their attention on the novel object as per NC3 (novel name, nameless category) then presumably the total response time in each condition would be roughly equal as the number of novel objects per condition is held constant. So, it would seem from Horst, Scott and Pollard's (2010) data that, increasing the number of familiar objects in the exposure array deters retention, whilst limiting their number aids retention.

Gestural cues help retention

Booth, McGregor and Rohlfing (2008) investigated the effect of a hierarchy of gestural cues on word learning in 2½-year-olds. Depending upon the experimental condition, toddlers were given up to four different cues to work out the link between the target object and the novel count noun uttered by the speaker: eye gaze alone; gaze plus pointing at the object; gaze, pointing and touching the object; and gaze, pointing, touching and moving the object. Each participant was tested for comprehension (and production) of the novel object labels both straight after the introductory session and 3-5 days later. The experimental method can be criticised using some of the arguments posited by Horst and Samuelson (2008) and the participants were exposed to each novel word twelve times prior to their first round of testing, going beyond minimal exposure. However, participants were tested on three different novel label-object mappings and 3-5 days represents a significant time delay, so this research may still provide valuable insight into factors that affect retention following a substantial delay.

Each level of gestural cues was associated with increasing levels of comprehension suggesting that the more gestural cues, the more the participants comprehended the novel word. However, the largest and the only statistically significant improvement in word learning was achieved when the experimenter pointed at the target object compared to just looking at it. The authors interpret this as support for a socio-pragmatic account of word learning as pointing is considered to be so closely linked to referential intent of the speaker.

Of particular interest is that comprehension of the three novel words was as good after 3-5 days as it was immediately after being exposed to the novel words and that this performance after a delay was significantly greater than both chance performance and the baseline performance of a control group. In addition, the increasing level of gestural cues effectively changes the exposure to the novel word-object mapping from incidental to ostensive which supports the suggestion that ostensive naming of the novel object does help mapping and retention of the novel object label (Horst & Samuelson, 2008). However, it is important to note that even children in the ‘gaze only’ condition, where the experimenter only looked at the target whilst saying the novel word, were able to comprehend the new word after a 3-5 day delay significantly more than chance and baseline. This indicates that long term retention of a novel object label at a greater level than chance is possible (albeit at a lower level) even when the introduction to the new word is not ostensive. Booth, McGregor and Rohlfing's (2008) data suggest that gestural cues aid long-term retention.

Familiarisation with the target novel object aids retention

Using a similar procedure to Horst and Samuelson (2008), Kucker and Samuelson (2012) demonstrated that familiarization with the target novel object (two minutes of interaction) prior to a referent selection task is associated with retention after five minutes in two-year-olds. They contrasted this with familiarization to the novel word - participants pressed buttons on a computer screen that elicited the sound of novel words - prior to the referent selection task, which was not associated with retention. There are methodological issues in trying to compare object familiarization and word familiarization - is a child playing with novel object for two minutes equivalent to hearing novel words for two minutes and, if so, how many and how frequently? Kucker and Samuelson go some way to try to mitigate these and other problems in follow-up experiments. The second experiment follows the same procedure as the object familiarization condition, merely excluding the object familiarization, and there is no retention after five minutes. This would seem to suggest that object familiarization does assist retention. And what is really of interest here is the apparent disconnect between referent selection and retention i.e. the difference in results when children are assessed immediately and after a delay, however short.

Other studies have suggested that auditory familiarization can also enhance referent selection and retention (Swingley, 2007; Estes, Evans, Alibali & Saffran 2007). Kucker and Samuelson (2012) attempt to reconcile their results with these findings and suggest that perhaps the auditory dominance evidenced by Sloutsky and Robinson (2008) means that their word familiarization condition did not provide participants with any extra useful information – the sound of the word had already been processed – but participants were left knowing only one half of the link: the word, not the object. In contrast, the object familiarization condition helped participants link and retain the connection between the sound of the word and the object to which it referred.

Generating the novel object label aids retention

Vlach and Sandhofer (2012) tested 3-year-olds and adults and found that fast mapping did not result in retention after a significant delay unless memory supports were provided. The procedure of their first experiment closely followed that of Markson and Bloom (1997). Like Markson and Bloom they found good immediate performance: most children and nearly all adults were able to correctly map the novel word 'koba' to the target object. However, performance after one week and one month was significantly lower. The rate of forgetting the novel word across time mirrored the natural course of forgetting: a curvilinear pattern, approaching a theoretical asymptote of zero in which the rate of forgetting is most rapid initially, slowing over time (see Wixted, 2004, for a review).

Experiment 2 tested 3-year-olds only and provided them with a varying and cumulative number of memory supports in three conditions. Firstly, in the ‘one memory support’ condition (saliency only), the experimenter made the target more salient by telling the participant it was special before it was labelled (similar to Waxman & Booth, 2000). In the ‘two memory supports’ condition (saliency and repetition), the experimenter referred to how special the object was and casually labelled the target object six times e.g. "let's measure this koba", "how long is this koba?" In the ‘three memory supports’ condition (saliency, repetition and generation), the experimenter additionally asked participants to generate the word for the target object ("Can you say koba?"). The percentage of kids accurately remembering the mapping appeared to vary over time and across different memory support conditions. There was a significant difference in retention between testing delays in the one- and two- memory support conditions but not in the three-memory support condition. Only children in the condition with the most memory supports had high retention over time, without significant forgetting.

The effects of the different memory supports were not apparent immediately, or after one week, but the memory supports did affect long-term performance at the one-month test. Vlach and Sandhofer (2012) posit that these results indicate that 'small changes in an experimental paradigm can alter the manner in which word mappings are remembered and forgotten over time' (p.5). They also argue that studies that have found significant retention of word mappings do so by using memory supports embedded in the procedure that overcome the natural propensity to forget novel word-object mappings. It is important to note that the word-learning evidenced in Vlach and Sandhofer's second experiment does not really qualify as fast mapping: the word-object link was introduced to children 6 times which does not meet the minimal exposure criteria set here.

However, it is still not clear how Markson and Bloom (1997) found such good retention data when their methodology is so similar to Vlach and Sandhofer (2012). One clear difference is that Markson and Bloom (1997) repeated the word-object link twice more compared to Vlach and Sandhofer's (2012) single exposure in Experiment 1. But Vlach and Sandhofer's (2012) second experiment suggests that repetition of the word-object link is not sufficient to achieve retention. Of course it may be that Markson and Bloom (1997) reports a finding that is not very robust and therefore is not easily replicated. If, as Vlach and Sandhofer (2012) claim, "word mappings, just like other types of learned information, are forgotten over time" (p.4), it would seem children's characteristically rapid rate of word learning requires an alternative explanation.

<u>Summary: the findings from the later studies</u>

The literature since 2008 demonstrates two key issues relating to fast mapping and retention. Firstly, the retention of fast mapped object labels is not nearly as robust a finding as might have been assumed previously. This casts doubt over the retention of other fast mapped word categories and retention of information outside word learning such as linguistic facts.

Secondly, very minor changes to an experimental procedure seem to encourage or deter retention. Ostensive labelling, gestural cues, the number of familiar objects, familiarization with the target novel object or the target novel word and the participant generating the novel word all seem to contribute to retention. Gestural cues are a particularly interesting factor that affects retention as gestural cues can easily be embedded or missing from an experimental procedure without being documented.

Overall Summary

The data on the retention of fast mapped words are complex and do not tell a clear story. There are examples in the literature of impressive retention rates of one or more novel object labels after a significant delay following minimal exposure and reportedly few memory aids (e.g. Markson & Bloom, 1997; Goodman *et al*., 1998). Some only report good retention using more extensive exposure to the novel word-object link (e.g. Woodward *et al*., 1994; Booth *et al*., 2008). Other studies report retention significantly greater than chance from minimal exposure, but they use a procedure that includes clear memory supports (e.g. Waxman & Booth, 2000; Horst & Samuelson, 2008; Vlach & Sandhofer, 2012). In addition, Horst and Samuelson (2008) and Vlach and Sandhofer (2012) both evidence young children's failure to retain object labels. Horst and Samuelson report retention failure after just a 5-minute delay. Vlach and Sandhofer (2012) report retention failure despite following Markson and Bloom's (1997) procedure almost exactly. A number of factors seem to assist retention including ostensive labelling, gestural cues, familiarization with the referent and the novel label and generating the novel label. However, the number and strength of the factors that may assist memory appear to vary from one experiment to the next.

Discrepancies in the literature do not just affect the retention of fast mapped object labels. Other word categories such as colour and shape terms have also been subject to conflicting data. Carey and Bartlett's (1978) headline results suggest that children can retain a fast mapped colour word after a considerable delay. Heibeck and Markman (1987) demonstrated good performance for fast mapped shape and colour labels after ten minutes. In contrast, O'Hanlon and Roberson (2006, 2007) report that children struggle to remember colour and shape terms without training.

Linguistic facts, outside the domain of word learning, seem to be the one area where the data are a little clearer, albeit there are only two studies that investigate the long-term retention of facts. Both studies demonstrated retention after at least a week's gap between exposure and test (Markson & Bloom, 1997; Waxman & Booth, 2000). However, the procedures used in these two studies were markedly different and long term retention of facts has not been reported since. That the more recent data indicate that the retention of fast mapped object labels is not such a robust finding as first thought, casts doubt over the retention of other fast mapped information.

The next step is to investigate the fast mapping and retention of these different types of words and information using just one experimental procedure and ascertain whether there are any differences in fast mapping and retention for different word categories and facts. This is the purpose of Experiment 1.

CHAPTER 2 – EXPERIMENT 1

Investigating Short and Long-Term Retention of Fast Mapped Colour, Shape and Texture Labels, Object Labels and Linguistic Facts

Introduction

As can be seen from the literature review in Chapter 1, research into long-term retention of fast mapped words is limited, a variety of different procedural techniques have been employed and studies show no consistency in the types of words (and facts) that they explore. Further, the literature often makes broad-brush assumptions about what specific studies have demonstrated that are not borne out by a more careful analysis of the data. Finally, the results obtained have varied both across categories of words and within word categories. So, for example, object labels appear to be retained following fast mapping, whereas texture labels do not (different findings between different word categories). Object labels are retained in some fast mapping scenarios but not in others (different findings within a word category).

There is evidence for long-term retention of object labels (e.g. Markson & Bloom, 1997; Booth, McGregor & Rohlfing, 2008), although it's not always observed (Horst & Samuelson, 2008; Vlach & Sandhofer, 2012). This variation is not simply explained by age differences. Evidence suggests that very young children can demonstrate retention of object labels following a significant time period (Woodward, Markman & Fitzsimmons, 1994, tested 13- and 18-month-olds following a 24-hour delay). However, other research suggests that older children do not retain object labels (Vlach & Sandhofer, 2012, tested 3-year-olds).

Linguistic facts appear to be fast mapped and retained following a significant time delay - both Markson and Bloom (1997) and Waxman and Booth (2000) demonstrate retention after at least a week following exposure and no evidence to the contrary is available in the literature. However, the evidence is limited to just two published studies, which may suggest the finding is less than robust. Finally, the evidence regarding the retention of fast mapped feature words (namely colour, shape and texture) is scant. It would appear that shape words and colour words are fast mapped whilst texture words are not (when data are compared to chance) and that retention for shape words and colour words is evidenced ten minutes after the initial exposure (Heibeck & Markman, 1987). Carey and Bartlett's (1978) results hint at significant long term retention following minimal incidental exposure to a novel colour word, and their work is generally referred to as evidence for long term retention of fast mapped words. However, interpretations of their evidence often go beyond the data and deserve further analysis here.

Carey and Bartlett (1978)

Carey and Bartlett (1978) were the first to look at the rapid learning of words and coined the term 'fast mapping'. They tested nineteen 3-year-olds following a single exposure to an unfamiliar colour word in a natural setting. Following a baseline assessment of colour terms, which categorised the children as ten 'good namers' and nine 'poor namers', the classroom teacher introduced a new word 'chromium' to each child, during a private conversation within the context of a normal classroom activity. For example, in the course of setting up for snacks, the teacher might take a child aside and say, "You see those two trays over there. Bring me the chromium one. Not the red one, the chromium one." By contrasting "chromium" with "red" the teacher indicated that chromium was a colour word and the situation enabled the child to identify its intended referent, the colour olive.

In the first phase (Cycle 1), participants' comprehension of the word 'chromium' was assessed 7-10 days after the initial introduction to the novel word. The comprehension task required the children to identify blue, chromium and yellow, from an array of nine colours that comprised seven basic colours and two novel colours, maroon and olive. A comprehension control group, consisting of 10 good and 10 poor namers (mean age = 3;2) received the comprehension task to establish how children would respond to a request to "find the chromium one" without having ever been exposed to 'chromium'. Cycle 2, 10 weeks later, exposed the same children to "chromium" an additional two times (again by a teacher in the course of a normal classroom activity), occurring two days apart. Comprehension testing occurred 7-10 days later (Cycle 2), to assess learning after a more extended exposure to the word.

Carey and Bartlett (1978) reported 47% of children in the experimental condition could correctly choose olive on being asked to identify ‘chromium’ from an array of colours at Cycle 1. This was higher than but not significantly different from performance in the control group (30%). Ten weeks later at Cycle 2, 63% of children chose the target colour. This performance was reported as significantly different from that of the control group at $p<0.08$.

The headline results from Carey and Bartlett (1978) are generally reported as demonstrating fast mapping and retention (e.g., Dollaghan, 1985; Golinkoff, Hirsh-Pasek, Bailey & Wenger, 1992; Markson & Bloom, 1997; Jaswal & Markman, 2003; Fischer, Call & Kaminski, 2004; Vlach & Sandhofer, 2012). When researchers do refer to methodological issues with the Carey and Bartlett study (e.g. Heibeck & Markman, 1987; Horst & Samuleson 2008), they simply point out that the results did not differ significantly from the control group after the first cycle of testing. Carey and Bartlett (1978) also acknowledge that performance did not differ from the control group in Cycle 1. The conclusion that the Carey and Bartlett (1978) study does not evidence long term retention is rarely highlighted.

There are a number of other issues with the Carey and Bartlett study. Firstly, some answers where participants chose the incorrect colour were treated as correct in the comprehension data. As long as participants’ answers were consistent with the possibility that they had (1) interpreted the new word chromium as a synonym for green or (2) that they had difficulty differentiating the olive colour from grey or brown (‘perceptual confusion’), they were treated as correct answers. This had the effect of increasing the comprehension of olive by one participant from eight to nine at Cycle 1 and by two from ten to twelve at Cycle 2. This seems a rather generous interpretation of participants’ answers and, given the small number of participants involved (total=19), has the effect of rendering the Cycle 2 results significantly different to the control group. Secondly, the critical value was set at 0.08, higher than the 0.05 benchmark typically used in psychology experiments, with no explanation. It seems that the difference in performance between the experimental group and the control group would not be significant if probability was set at 0.05.

Finally, the paper seems to report conflicting data. The results outlined above are detailed in a table in the main body of the report. However, a detailed review of the Appendix suggests different data. Firstly, it states that eight subjects learnt nothing at all over both cycles: ‘No Learning (n=8). If 8 of 19 (42%) subjects learned nothing at all then only 11 of 19 (58%) learnt something (yet comprehension accuracy of 62% for Cycle 2 was reported earlier). Additionally, by adding the results of individual subjects together, it seems that only 6 of the 19 children (32%) could correctly choose olive in the comprehension task at Cycle 1. By Cycle 2, following a 10-week gap and two further exposures to chromium, 9 of the 19 children (47%) understood the unfamiliar word when tested seven to 10 days later. It’s unlikely that either of these results would differ significantly from chance.

This detailed review of Carey and Bartlett’s (1978) findings is not an attempt to discredit their work. Their study was a hugely important first step and presented a new method to test word learning that has generated a host of subsequent research. It also introduced the possibility of a fast mapping process - that learning may occur from minimal exposure to a new word and be retained following a significant delay. Review of the individual performance of the pilot data and the main study, suggest that some children really had learnt the new word and attempted to produce it. However, there is a prevailing view that Carey and Bartlett (1978) evidences fast mapping and long term retention: this is generally how it is reported in the word learning literature (e.g. Bloom, 2000). Carey and Bartlett’s own conclusions are far more cautious, suggesting signs of initial learning rather than full mapping and retention of the newly learnt word. That there is very little evidence to suggest long-term retention of new colour words learnt via a fast mapping process, is a fundamental motivation for Experiment 1, so it is important to demonstrate that further work is required.

Even if it is assumed that Carey and Bartlett's data demonstrate fast mapping and retention, it conflicts with psycholinguistic research into learning colour terms (e.g. O'Hanlon & Roberson, 2006), which suggests that comprehension of colour terms is difficult for children and requires a significant amount of direct teaching and repetition. O'Hanlon and Roberson (2007) tested 3-year-olds and compared their ability to learn novel shape words following exposure involving one of three types of linguistic contrast (corrective, semantic or referential). Like their 2006 study investigating colour words, the results suggest that learning shape words is difficult for pre-school children and retention following minimal exposure is unlikely. This is in contrast to Heibeck and Markman (1987) where shape words were learned readily by 2-, 3- and 4-year-olds from just one, incidental exposure (albeit when testing occurred just ten minutes after presentation) and the implicit assumption that these data would hold after a delay (Bloom, 2000). So, it would seem that convincing evidence for the significant long term retention of fast mapped labels for object properties has yet to be established.

The research so far has furthered our understanding of fast mapping, but the multitude of methodologies means it is unclear what types of information (words, facts, etc.) may be fast mapped and retained in the long term and, crucially, it is impossible to compare rates of long term retention across word types and facts. The aim of the present study was straightforward: to compare, under minimal incidental exposure conditions, the fast mapping and retention of object labels, colour, shape and texture terms and linguistic facts following both a short delay (five minutes) and a long delay (6-9 days).

Method

Participants

447 children (3 and 4 years old) took part in Experiment 1. 5 children in the Week condition took part in the training session but were not available

for the testing session. Of the remaining 442 children (see Table 2.1), roughly equal numbers of boys and girls participated (220 male and 222 female) with a mean age of 49 months. All the participants attended state-run nursery schools or primary schools in North London, UK.

Table 2.1: Experiment 1 – Age and gender of participants

	Participants	Colour Label	Shape Label	Texture Label	Object Label	Fact
Short Delay (5 mins)	n	44	44	44	44	44
	mean age (yrs)	4.1	4.0	4.1	4.0	4.0
	age range (yrs)	3.4-4.9	3.2-5.0	3.5-5.0	3.0-5.0	3.2-5.0
	gender (M,F)	22,22	22,22	22,22	22,22	22,22
Week Delay (6-9 days)	n	44	44	46	44	44
	mean age (yrs)	4.1	4.1	4.1	4.1	4
	age range (yrs)	3.1-4.9	3.1-4.9	3.1-4.9	3.0-4.9	3.1-5.0
	gender (M,F)	22,22	22,22	22,24	22,22	22,22

Design

This study used a between participants experimental design. There were two independent variables – Information Type and Test Interval. Information Type designated the kind of information to which the participant was introduced: either a word or a fact. There were five Information Type conditions: ‘Colour Label’, ‘Shape Label’, ‘Texture Label’, ‘Object Label’ and ‘Fact’. ‘Fact’ referred to linguistic facts.

There were two Test Interval conditions: ‘Short Delay’ and ‘Week Delay’. They differed in the time delay between the introduction to the new word or fact and the testing of retention of that new word or fact. In the ‘Short Delay’ condition, participants were tested on their retention of the novel information approximately five minutes after the encounter with the novel word or fact. In the 'Week Delay' condition, participants were tested 6-9 days after the encounter with the novel word or fact.

The dependent variable was Comprehension Accuracy – selecting the target item from an array of five objects.

Stimuli

Twenty-five items were used in the study: five objects in each of the Information Type conditions (a table and photos of all the materials used can be found in Figure 2.1). In all of the conditions, except the object condition, the objects were familiar to children of this age group. In each of the word conditions, two of the items exhibited a familiar property and three exhibited an unfamiliar property. Familiar and novel features and objects were chosen based on results from pilot testing. For example, 40 preschoolers were tested for comprehension and production of six basic colours. The two colours that were associated with the highest production and comprehension scores (close to ceiling), blue and pink, were used as the familiar colours in the colour condition.

In the colour condition in the current experiment, children were presented with two objects in familiar colours, a pink shoe and a blue ball, and a further three objects whose colours were unfamiliar: an olive pen, a beige car and a teal sock (see Figure 2.1a). The novel word 'koba' was applied to one of the three novel colours. The novel colours were counterbalanced across participants (as were all the target referents in each of the Test Interval conditions). All the other features were familiar: the objects themselves were familiar (a shoe, a ball, a pen, a car and a sock) and had common textures (soft, hard, smooth and rough). This was to help participants to map the new word to the novel colour rather than assume it was a label for the whole object or a label for another type of property of an object.

The other conditions also presented an array of five objects in a similar way. The shape condition presented participants with two familiar shapes, a star and a circle. The three unfamiliar shapes were created, one using completely curved edges, one with completely straight edges and one with a mixture of straight and curved edges (see Figure 2.1b). All the shapes were in familiar colours and textures and were effectively two-dimensional – shapes cut out from flat material. The novel word, ‘a koba’, was applied to each of the three unfamiliar shapes, rotated in fixed order.

The texture condition presented five familiar objects in familiar colours. Two featured familiar textures, a hard marble and a soft teddy, and three featured novel textures, a “bobbly” glove, a “spiky” hairbrush and a “prickly” ball (see Figure 2.1c). The novel word, ‘koba’, was applied to each of the unfamiliar textures in turn.

The object condition presented five objects, all in familiar colours. Two of the objects were familiar, a duck and a pen. Three of the objects were novel, all sourced from a DIY store and painted in familiar colours – blue, red and green (see Figure 2.1d). The novel word, ‘a koba’, was applied to all three unfamiliar objects in turn, rotated in fixed order.

Finally, the fact condition presented five familiar objects in familiar colours – a pink teddy, a green duck, a purple car, a blue pen and a red sock (see Figure 2.1e). The novel fact, “it comes from a place called koba”, was applied to all five familiar objects rotated in fixed order. The objects used in the fact condition were all familiar as it was assumed that children will apply a novel fact as readily to a familiar object as a novel object (See Bloom, 2000, for a similar argument). In contrast, for words, the mutual exclusivity principle and N3C principle (novel name-nameless category) apply.

Figure 2.1: Experiment 1 – Stimuli and their features

***Fig 2.1a** Colour*

***Fig 2.1b** Shape*

***Fig 2.1c** Texture*

***Fig 2.1d** Object*

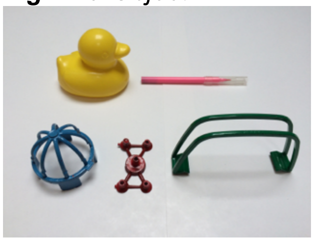


***Fig 2.1e** Fact*

***2.1f** Summary of stimuli by condition*

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

The same array of objects was used in both Test Interval conditions, although these object sets differed across Information Type conditions. Ideally the same array of objects would have been used across the Information Type conditions, but given that I was testing for mapping of novel object labels this would have meant using novel objects in all conditions. This was untenable for a number of reasons. First, it is extremely difficult (if not impossible) to find or construct an unfamiliar 2D shape that is also a convincing unfamiliar 3D object. Moreover, even if I had found or constructed such an object it would then have been extremely difficult to impose both an unfamiliar colour and an unfamiliar texture onto this novel object/shape. Finally, and most importantly, familiar objects had to be used in the colour/shape/texture conditions (and not novel unfamiliar objects as in the object label condition) so we could be sure that good performance in these conditions reflected mapping of colour/shape/texture terms and not because children were applying what they thought was a novel object label to a novel object. When encountering a novel word in the presence of a novel object, children and adults operate under the assumption that the novel word applies to the whole novel object rather than to an object part, property of the object or the substance that the object is made of (Bloom & Markson, 1998)

The word conditions included familiar and unfamiliar objects/properties in the arrays presented to participants. The familiar objects/properties were included to provide the participant with some context. The experimenter only applied the new word to one of the three novel objects or novel properties as children are reluctant to apply a new word to a category that already has a label (e.g., Markman and Wachtel, 1988). In the Fact condition all the items were familiar as a new fact is equally likely to apply to a familiar or unfamiliar item (Markson & Bloom 1997).

<u>Procedure</u>

Participants were tested individually. The child was invited to play a fun “game” with the experimenter and sat next to her at a table. Each participant underwent an exposure session, a distracter task and a test session. The non-word ‘koba’ was used as the novel word in all the word conditions. In the fact condition, the novel fact also contained this novel word: “(it) comes from a place called Koba”. This ensured that all conditions involved a novel phonological form (Markson & Bloom, 1997).

Exposure session

Each participant underwent an exposure session in which they interacted with an array of five objects and were introduced to a new word "koba" relating to one of the target objects (counterbalanced across the three target objects in the word conditions and the five target objects in the fact condition). All participants were introduced to the new word or fact and its intended referent by being asked to select the appropriate target. The experimenter used a familiar feature or object to help the child choose the target correctly. On hearing the new word the participant had to "make an inference and act upon it, ensuring some level of active processing" (Dollaghan, 1985). Each of the Information Type conditions followed a very similar format. An example from the colour condition is detailed below.

Colour Label Condition: The child was presented with a clear plastic box containing five familiar objects in different colours. Two of the objects exhibited the familiar colours blue and pink, three of the objects exhibited the unfamiliar colours teal, beige and olive. The child was asked to take the objects out of the box one at a time and count them. This ensured that the child attended to each object individually and interacted with each object for roughly equal amounts of time.

Familiarity test: The experimenter then asked the child to point to the two objects displaying familiar colours: "Can you see something blue? Can you point to it for me? Can you see something pink? Can you point to it for me?" These questions provided a context (that we were talking about colours) and served to confirm that the participant was familiar with these colours. If the child answered either of the familiarity questions incorrectly they were given one more chance to pick the correct object. If they chose the wrong object again the child was shown the correct item and told, "It's this one isn't it?" The experimenter praised participants and restated the two familiar items: "Yes, that's right. This is a blue ball. This is a pink shoe".

Selection test: Next came the crucial part of the exposure session in which the new word was introduced. The experimenter asked the child to select the target. In the colour (and texture) condition, the experimenter used a familiar object name to help signal the correct referent. The target was also signalled by the use of a novel label. A novel label is likely to be interpreted by listeners as a label for a novel feature rather than a familiar feature (Markman, 1987, 1989; Golinkoff *et al*., 1992, 1994). A third of the participants were asked, “Can you give me the koba sock?” where koba represented the colour teal. A third of participants were asked “Can you give me the koba car?” where koba represented the colour beige and the final third were asked “Can you give me the koba pen?” where koba represented the colour olive. If the child did not pick the target, the experimenter told the child “No not that one, it’s this one” and pointed to the correct object for the child to give to the experimenter. The object array was then placed to one side.

Participants responses to the familiarity and selection tests were recorded. Regardless of their answers they completed the exposure session and usually went on to complete the distracter and test session as well (unless it was clear that the child had no understanding of the task or its context). Their suitability for inclusion was considered later.

The exposure session followed a very similar course for the remaining conditions.

Texture Label condition: The texture condition was identical to the colour condition. After the child was asked to get the objects out of the box and count them s/he underwent the familiarity test. Each participant was asked: “Can you see something hard? Can you point to it for me? Can you see something soft? Can you point to it for me?” The participants were praised and the two familiar items were restated - “Yes, that's right. This is a hard marble. This is a soft teddy”. Then participants underwent the selection test. They were asked, “Can you give me the koba glove (*or hairbrush or ball*)?” It is important to note here that the grammatical structure of the texture condition was identical to the colour condition, but different from the shape and object conditions.

Shape and Object Label conditions: In the shape and object label conditions, participants were asked to retrieve the objects from a clear box, count them and identify the familiar shapes (the star and circle) or objects (the

duck and pen). After the experimenter praised participants and restated the two familiar items, participants were asked to give the experimenter the 'koba', identified by its colour. The precise wording in each condition was:
<u>Shape condition</u> - "Can you see a star? Can you point to it for me? Can you see a circle? Can you point to it for me?" The participants were praised and the two familiar items and their colours were restated - "Yes, that's right. This is a red star. This is a blue circle". Then participants underwent the selection test: "Can you give me the green koba?" (or *purple* or *pink* koba).
<u>Object Label condition</u>: "Can you see a duck? Can you point to it for me? Can you see a pen? Can you point to it for me?" The participants were praised and the two familiar items and their colours were restated - "Yes, that's right. This is a yellow duck. This is a pink pen". Then participants underwent the selection test: "Can you give me the blue koba?" (or *red* or *green* koba).

It is important to note here that the wording in the object and shape conditions was identical grammatically, although different from the colour and texture conditions.

Fact condition: The fact condition was slightly different to the other word conditions. There were five familiar objects and any one of these objects could be linked to the new fact: 'it comes from a place called Koba'. To ensure participants were familiar with all five items they were asked to identify each of them following the counting task. Participants were asked "Can you see a teddy? Can you point to it for me?" and so on for the other four objects in the array (the duck, the car, the pen and the sock). The participants were praised and the familiar objects and their colours were restated: "Yes that's right, that's a a pink teddy, there's a green duck, that's a purple car, this is a blue pen and that's a red sock." The selection test introduced the participant to the novel fact. For example, the experimenter said, "Can you give me the purple car that comes from a place called Koba?" (counterbalanced across participants for all five objects). In all other respects, the fact condition procedure followed the same format as the other Information Type conditions.

Distracter task

A distracter task was included so that participants in the Short Delay condition would have some delay between the exposure session and the testing session. The participants might find it unnatural or odd if asked to point to ‘koba’/‘a koba’ /‘the thing that comes from a place called Koba’ immediately after being asked to give the experimenter the target object and may answer inappropriately. Also, it was hoped that the distracter task would divert participants from perceiving the task as a word-learning exercise.

The distracter task lasted about five minutes. The child had to find a soft toy puppy hidden in the experimenter’s bag and was told that the puppy did not have a name. The child was asked if s/he would help the experimenter by thinking up a name for the puppy. This name was written on a piece of paper, folded up and added to a container. The child was told that when the experimenter had finished her time at the school she would pick one piece of paper out of the container and that would be the name of the puppy.

Comprehension Test Session

For children in the Short Delay condition the testing session followed immediately on from the distracter task. For children in the Week Delay condition the distracter task marked the end of the first session. The child then participated in the testing session 6-9 days later.

During the test session the participant was presented with the original array of five objects and the familiar features or objects were restated. The child was then asked to point to the target. The phrasing in the colour and texture conditions was identical and the phrasing in the shape and object label conditions was identical. The precise wording in each condition was as follows:

<u>Colour condition</u> - “Look at all these things. This one's pink and this one's blue. Can you show me which one is ‘koba’? Can you point to it?”

<u>Texture condition</u> - “Look at all these things. This one's hard and this one's soft. Can you show me which one is ‘koba’? Can you point to it?”

Shape condition - “Look at all these things. This one is a star and this one is a circle. Can you show me which one is ‘a koba’? Can you point to it?”
Object Label condition - “Look at all these things. This one is a duck and this one is a pen. Can you show me which one is ‘a koba’? Can you point to it?”
Fact condition - “Look at all these things. This is a teddy, this is a duck, this is a car, this is a pen and this is a sock. Can you show me which one comes from a place called Koba? Can you point to it?”

If the participant chose the target item their answer was recorded as correct. If, however, the participant chose any of the other four objects, the answer was recorded as incorrect. In the Week Delay condition, the experimenter identified participants to be tested from a list of names, which only noted the condition in which the child participated, not their target object, and answers were recorded on this list. Therefore, in the Week Delay condition the experimenter was unaware of the correct answer whilst conducting the test session.

Results

Familiarity Test: Participants’ understanding of the familiar words was tested and they demonstrated high levels of accuracy across all conditions providing comfort that the children did know the familiar word-referent links (70-99%). Each correct answer in the word conditions received a score of 1 and each correct answer in the Fact condition received a score of 0.5 so that every participant had a score out of 2 across conditions. These scores were compared using an ANOVA. Performance did not differ by Time Interval ($p=0.992$). Children’s ability to recognise the familiar items did differ significantly by Information Type (Welch’s $F(4, 213.49)=16.40$, $p<.001$, $\omega^2=0.13$). However, the effect size indicated that this difference was small and performance in every condition was significantly above chance. Games–Howell post hoc tests revealed that the texture condition, where 70%

of children could accurately identify the familiar items, was significantly worse than all the other Information Type categories ($p<.001$ for all tests).

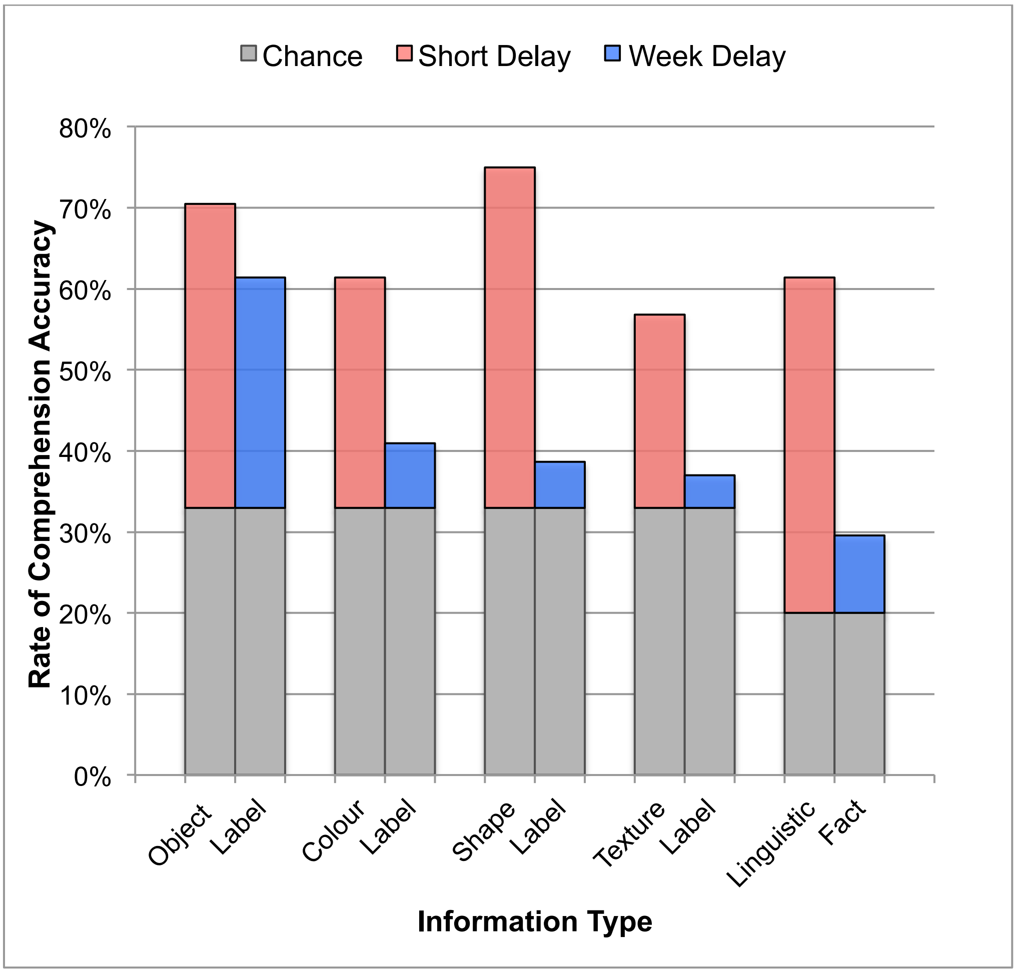
Selection Test: Performance was high across all conditions demonstrating that children understood the task as expected and could accurately link the novel word or fact to the target object. Target selection by Information Type was lowest in the shape condition at 76%, compared to 89%, 89%, 90% and 97% in the object label, colour, texture and fact conditions respectively. These rates of accuracy did differ significantly across Information Type condition but not across time delay condition. The underlying data were analysed using a hierarchical three-way log-linear analysis that produced a significant two-way interaction: Information Type x Referent Selection Response, $\chi^2(4)=18.18$, $p=0.001$. This indicated that the ratio of correct to incorrect referent selection responses differed across the five information types. As a consequence, it was considered whether the participants who had answered the referent selection test incorrectly should be excluded from the data.

Firstly, did the referent selection results have any impact on the comprehension results? A Spearman correlation showed a significant negative correlation ($p=0.022$) between referent selection and comprehension responses. This suggested that participants' performance in the referent selection test did significantly affect their performance in the comprehension test. The correlation was negative, so participants' comprehension was better if they chose wrongly at referent selection. Presumably, being corrected by the experimenter aided retention.

Secondly, did the referent selection results have a strong impact on the comprehension results? Effect size was measured using the square of the correlation coefficient (r^2), which was 0.01. This indicated a negligible effect size: the correlation accounted for only 1% of the data. Because referent selection had only a very weak effect on the comprehension data, all the participants were retained in the analysis, regardless of their answers in the Selection Test. However, the data excluding participants with incorrect referent selection answers were separately analysed (see final paragraph in the Results section) and this confirmed that there was no significant impact on the pattern or interpretation of results, supporting the decision to retain their data.

Comprehension Test: Participants were tested in a comprehension task, after either 5 minutes (Short Delay) or one week (Week Delay), to see if they retained the novel word-object link or the novel fact-object link. Comprehension accuracy is summarised in Figure 2.2 below.

Figure 2.2: Experiment 1 - Rates of Comprehension Accuracy



Actual performance was compared to chance performance for each of the ten Information Type x Time Delay conditions. A binomial comparison demonstrated a significant variation to chance performance ($p \geq 0.001$) for all the Information type conditions in the Short Delay. In the Week Delay, there were no significant differences to chance in any of the Information Type conditions, except Object Labels, where retention accuracy was significantly greater than chance ($p \geq 0.001$) after one week.

A three-way loglinear analysis produced a final model that retained the Time Delay x Comprehension Response and the Information Type x Comprehension Response interactions. The likelihood ratio of this model was χ^2 (8)=4.59, p=0.801. This non-significant result indicates that the model is a good fit of the data. The Time Delay x Comprehension Response interaction was significant, χ^2 (1)=24.87, 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 and indicated that the odds of children retaining the newly learned word or fact were 2.33 times more likely after a short delay than after a week's delay.

The Information Type x Comprehension Response interaction was also significant χ^2 (4)=10.11, p=0.039. This indicated that the ratio of correct to incorrect responses differed across the five information types. Further analysis compared object labels to the sum of the remaining Information Type data to avoid a large adjustment to the critical value from multiple post hoc comparisons. This was deemed appropriate for three main reasons.

Firstly, a summary level review of the data shows that retention follows a similar pattern for all word types in both time delays except object labels when tested after one week. The bar chart (Fig. 2.2) shows that children retain the novel word/fact-object link when tested after 5 minutes for all the information types at about 60-70%. However, when tested after one week children's performance dropped to about 30-40% when they were introduced to a colour, shape, texture word or fact. Accurate retention at the 60-70% level was only maintained for object labels in the Week Delay Condition.

Secondly, individual chi-squares were calculated to compare each of the Information Type categories, other than object labels, to demonstrate that none of these comparisons were significantly different so it was appropriate to view them collectively. Chi-squares for comprehension data after a short delay and after a week delay were prepared for colour x shape, colour x texture, colour x fact, shape x texture, shape x fact and texture x fact. Even without adjusting the critical p value for multiple comparisons not one of these chi-squares gave a significant result (p values ranged from 0.07 to 1.00).

Thirdly, comparisons to chance support treating the 'Other' Information Types as one block of data. Chance was 1 in 3 (0.33) for the word conditions as children were unlikely to select a familiar object or familiar feature as a referent for a novel word (Markman, 1987, 1989; Golinkoff *et al.*, 1992). In the fact condition, chance was 1 in 5 (0.20) as any of the five familiar objects were equally likely to be a referent for the novel fact (Markson & Bloom, 1997). A binomial comparison to chance was calculated for each of the ten groups of data – the five Information Type conditions in each of the two Time Delay conditions. These results are summarised above and showed that retention was significantly above chance for all words and facts when children were tested after a short time delay. However, after a week's delay, only children who had been introduced to an object label could demonstrate comprehension at levels significantly greater than chance.

The data were collapsed across all the Information Types other than object labels. The results are indicated in Table 2.2, below.

Table 2.2: Experiment 1 - Rates of Comprehension Accuracy (Object Labels and "Other Information Types")

	Object Labels	**Other Information Types**
Short Delay	31 of 44 71%	112 of 176 64%
Week Delay	27 of 44 61%	65 of 178 37%

Comprehension performance of object labels were compared to "Other Information Types" using a Chi-square test. In the short delay, there was no significant difference in performance between object labels and Other Information Types: χ^2 (1, N=220)=0.72, p=0.396. In the Week Condition, χ^2 (1, N=222)=8.98, p=0.003, demonstrating that children's comprehension of object labels was significantly better than Other Information Types when there was a substantial delay between exposure and test. The odds ratio indicated that the children were 2.76 times more likely to retain an object label than another word type or fact after a week's delay.

Finally, the data were analysed excluding participants with incorrect referent selection answers and the pattern of results was almost identical. A three-way log linear analysis produced a final model that retained a significant Time Delay x Comprehension Response interaction (χ^2 (1)=22.55, p<0.001) and a significant Information Type x Comprehension Response interaction (χ^2 (4)=10.02, p=0.040). These results supported the inclusion of all participants in the main analysis, regardless of their answer at referent selection.

Discussion

This experiment investigated whether different types of information about a novel object are fast mapped and retained for a significant period of time. 3- and 4-year-olds' comprehension of a novel object label, colour label, shape label, texture label and a novel linguistic fact was assessed. They were tested following a short delay (5 minutes) or a long delay (6-9 days) after the initial exposure. Comprehension was good in all conditions when children were tested after five minutes. Accuracy was significantly above chance in all conditions and there were no significant differences between conditions when participants were tested following a short delay. However, only comprehension of the object label was sustained after one week - performance on all the other conditions had fallen to chance levels. Thus it would appear that colour, shape, texture labels and facts, were not retained long term on the basis of a single, incidental exposure.

Methodological Issues

Before discussing the findings it is important to consider other possible interpretations of the data. Firstly, it is possible that the differences in wording at exposure ("...can you give me the koba X?" versus "...can you give me the X koba?") and testing ("...can you show me which one is koba?" versus "...can you show me which one is a koba?") were responsible for the results. This seems unlikely. If differences in the grammatical structure of the sentences introducing the novel word/fact affected retention here then differences in retention after five minutes might be expected. There were no differences. Note that while retention was good in the short term (57-75%) it was not at ceiling – so differences in performance could be detected. Moreover, 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 seems 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 colour, 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 seems highly unlikely. There is one notable and potentially relevant difference between the object label condition and the other conditions – only the object label condition presented a mixture of familiar and unfamiliar objects during the exposure and test sessions (rather than just familiar objects). Perhaps long term retention of novel information only occurs in cases where novel objects are present. This possibility is discussed later.

Finally, Experiment 1 did not include a vocabulary test. It is possible that the 44 participants who took part in the object label condition following a week's delay had a significantly higher vocabulary than the other participants who took part in the experiment, and that this is the reason for their superior performance. Similarly, that facts were not retained after one week may have been due to participants in this condition having a significantly poorer vocabulary. Mervis and Bertrand (1994) reported that the onset of rapid vocabulary learning co-occurred regularly with the observation of what they defined as fast mapping (selection of a novel toy in the presence of a novel word). Vocabulary size, rather than chronological age, was most highly associated with fast mapping in their research.

However, Mervis and Bertrand (1994) tested 16- to 20-month-olds, when children are at the very start of word learning. By the time children are 3- and 4- years old vocabulary is sufficiently large and the principles that allow children to fast map are sufficiently established (mutual exclusivity, N3C etc.) that the link between the ability to fast map and vocabulary size no longer exist. Indeed, several important studies into fast mapping have not conducted vocabulary tests with children of 2-years-old and above: for example, Behrend, Scofield and Kleinknecht (2001), Carey and Bartlett (1978), Childers and Tomasello (2002), Goodman, McDonough and Brown (1998), Heibeck and Markman (1987), Jaswal and Markman (2001, 2003), Markson and Bloom (1997) and Wilkinson, Ross and Diamond (2003). Another important consideration is that age differences at this stage of development are likely to be associated with quite large vocabulary differences and studies do not tend to report any age differences in fast mapping ability once children have reached the age of about two years old and this includes studies that have tested after a significant delay (Childers & Tomasello, 2002; Markson & Bloom,1997). In addition, the Experiment 1's procedure ensured that participating children did know the objects and features that were deemed familiar and performance was almost at ceiling. The familiarity of items was also assessed during pilot testing.

The source, number and allocation of participants to each Information Type x Time Interval condition would have minimised the risk that any major differences in vocabulary arose across conditions. A large number of participants were tested and they were sourced from several schools across three boroughs in North London and children from each school were evenly distributed across each condition. Significant differences in vocabulary across conditions is no more likely than significant differences in other factors that can influence performance such as socioeconomic background and intelligence. Such factors are routinely controlled for in cognitive developmental psychology experiments by using a sufficiently large sample size and allocating participants to each condition randomly, as was implemented here. So, in summary, the likelihood of vocabulary differences arising between conditions is small and even if they did arise, it seems unlikely they would have affected the results significantly.

Comparison Of Data With The Literature

Having addressed the methodological issues inherent in this first experiment, I now discuss the findings. A broader discussion of what the results may mean and implications for theories of word learning, fast mapping and retention is postponed until the final Discussion chapter at the end of this thesis (Chapter 7), once the findings from the other experiments undertaken in this thesis can also be considered. The purpose of this discussion section is to compare the results to those evidenced in the literature and consider the possible reasons for a variation in results.

The fast mapping and retention of words found in the current study are broadly consistent with the data cited in the literature. Good short term retention by 3- and 4-year-olds of object labels and feature words is evidenced in a large number of studies (e.g. Heibeck & Markman, 1987; Markson & Bloom, 1997; Waxman & Booth, 2000). Of the novel words, only long-term retention of object labels and colour terms have ever been tested before. The results here concur with Markson and Bloom's (1997) findings that fast mapped object labels are retained in the long term (and the findings of Woodward, Markman & Fitzsimmons, 1994; Goodman, McDonough & Brown, 1998; Waxman & Booth, 2000; Childers & Tomasello, 2002; Jaswal & Markman, 2003). That colour terms have not been retained does not contradict Carey and Bartlett (1978) as their findings are inconclusive. In addition, O'Hanlon and Roberson (2006, 2007) indicate that pre-school children find learning colour and shape terms difficult, and that long-term recognition and recall requires several exposures over a number of weeks. However, despite these consistencies some differences between the findings here and those evidenced in the literature persist and are addressed below.

Inconsistencies With The Literature

Texture terms retained in the short-term: texture words were retained in the short-term significantly above chance. In contrast, Heibeck and Markman (1987) found poor comprehension of texture terms even after just ten minutes. This may have been due to methodological differences. For example, the difference in delay between exposure and test may have been enough to secure retention here (where the delay was just five minutes) and prevent retention in Heibeck and Markman (1987) where the delay between exposure and test was 10 minutes. Vlach and Sandhofer (2012) suggest that fast mapped words are subject to rates of forgetting. Perhaps labels for textures are forgotten more rapidly than labels for visual features such as colours and shapes.

Another potential reason for the difference in results between the two studies is that children were asked to identify the familiar texture terms. This may have helped create a context of talking about texture and facilitated a mapping between a novel texture term and a novel texture. Also, Heibeck and Markman (1987) presented different stimuli at introduction and at test. Using the same object array in both the introductory and test sessions may have helped participants remember the item that was associated with the novel texture label.

Failure to replicate retention of linguistic facts: the most important difference between the results found here and those reported in the literature is that this study does not report the long-term retention of facts. This contradicts both Markson and Bloom's (1997) and Waxman and Booth's (2000) findings that linguistically presented facts are retained in the long term following limited exposure to the new fact. There are several possibilities that may explain participants' failure to retain facts after a week's time delay.

Why were Facts not Retained?

Facts were not retained after a time delay and this conflicts with the literature that has found that linguistic facts are retained at the same rate as object labels and that they are retained at levels significantly above chance.

Differences between the object label condition and the fact condition

In all the conditions that introduced a new word, familiar items were labelled at the start of the exposure session. For example, the familiar objects were labelled in the object label condition and the familiar shapes were labelled in the shape condition. This may have helped provide a context for 'labels', facilitating mapping of novel labels and, in the case of object labels, facilitating retention. However, in the fact condition, no such context was provided for facts about objects. The introductory session in the fact condition involved naming objects and their colours and this did not provide a context for 'facts'. However, if this lack of context did affect the participants, it affected their ability to retain the novel fact. Clearly it did not affect their ability to work out the correct referent for the fact during the introductory session, nor their short-term retention of the fact (Short Delay condition), since they performed well in both these tasks. In addition, it is important to note that context was provided in each of the colour, shape and texture conditions by referring to colour, shape and texture just prior to the introduction of the novel term, yet no long-term retention was found in any of these conditions. Also, neither Markson and Bloom (1997) nor Waxman and Booth (2000) appear to provide a context in their fact conditions yet still demonstrate the retention of both object labels and facts.

Differences between this study and the literature

It is important to consider the methodological differences between the present results and the literature in determining the reasons for the inconsistent findings. Firstly, Markson and Bloom (1997) presented their fact three times during a 20-minute introductory session. Here, the fact was introduced once during a 2-minute exposure session. Kucker and Samuelson

(2012) demonstrated that interaction with objects prior to labelling can enhance retention of a newly learned object label. Perhaps a prolonged interaction with objects can also support retention of linguistic fact-object links. Markson and Bloom's (1997) lengthier introductory session may have helped participants to focus their attention on the objects they encountered and, crucially, to believe that the objects and any facts about those objects held some significance (otherwise why would this adult be demonstrating them and requesting the child to interact with them for so long!). That the experimenter repeated the fact three times may also have produced or augmented this effect. Horst, Parsons and Bryan (2011) suggest that contextual repetition promotes word learning. However, Waxman and Booth (2000) also evidenced long-term retention of facts after presenting the fact just once within a much shorter introductory session of just seven minutes.

Secondly, Waxman and Booth (2000) introduced the fact ostensively, drawing attention to the target object by proclaiming "Look at this one. This one is so special to me" just before introducing the novel fact: "And you know what? My uncle gave it to me". Perhaps this is why they found that facts were retained after a week's delay. In addition, participants were asked the test question at the end of the training session as well as one week later. A referent selection task requires the child to choose the correct novel object labelled with the novel word or fact. This gives the experimenter some comfort that the child has at least recognised that the target object is linked with the novel word during the exposure session. Because Waxman and Booth (2000) did not employ a referent selection methodology, they wanted to ensure that participants had understood which object was a 'koba', before going onto test them for comprehension either immediately or one week later. Participants who answered the test question incorrectly at the end of the training session were excluded from the data. And for those who answered correctly, and went on to be tested a week later, the test question at the end of the exposure session would give children a clear sign about which aspect of the introductory session they need to remember. The ostensive definition, the focus on the target object and the test question at the end of the training session, may all have contributed to helping participants encode and remember the new information about the object. However, Markson and Bloom (1997) found that facts were retained without employing any of these strategies to aid retention.

Of course, it is possible that fast mapping and retention is achieved when a sufficient number of factors come together to aid encoding and recognition after a significant delay. Not all of these factors may be required at once, just a sufficient number to produce long-term retention. So, perhaps Markson and Bloom (1997) did not need to draw special attention to the target object and use ostensive definitions because their longer introductory session and repeated presentations of the fact-object link were enough to produce long-term retention. Similarly, the focus on the target object, ostensive definition and the test question at the end of the training session may have been sufficient in Waxman and Booth (2000)'s study to produce retention without requiring a longer introductory session and repeated exposures of the novel fact.

A third difference in methodologies is that both Markson and Bloom (1997) and Waxman and Booth (2000) presented participants with an array of ten objects, six novel and four familiar. The fact array in Experiment 1 reported here comprised only five objects, all of them familiar. Could this difference in the total number of familiar objects presented explain the difference in retention?

Horst, Scott and Pollard (2010) have argued that the number of familiar objects deter retention by competing for the child's attention when they are presented along with a novel object and its label. Horst *et al*., (2010) provide persuasive evidence that young children solve a referent selection task by concentrating on the objects for which they have a familiar label, discounting each in turn until the novel object is the last remaining object. They demonstrated that 2-year-olds could retain four novel object labels after five minutes when they were presented with stimuli sets comprising just two familiar objects and one novel object. But no retention was found when the referent selection array comprised three or four familiar objects. And crucially, an analysis of reaction times revealed that the total reaction time was directly and linearly related to the total number of familiar objects presented in the object array at the time of exposure, suggesting that children were spending roughly equal amounts of time attending to each familiar object. These results suggest that 2-year-olds are using the mutual exclusivity principle to solve the referent selection task - if an object already has a name it cannot also be the referent of the novel name, thereby concentrating on the objects with names first. However, Horst *et al*.'s (2010) findings may not apply to 3- and 4-year-olds. In addition, whilst it makes sense for children to look at, and discount, objects for which they know a label as possible referents for a novel label, no such logic is known to apply to novel facts. Finally, It seems unlikely that the total number of familiar objects presented to participants would have been a key factor in preventing retention of linguistic facts in the current study. Five familiar objects were presented, just one more familiar object than the four familiar objects in Markson and Bloom's (1997) and Waxman and Booth's (2000) arrays.

So far I have considered procedural differences between this study and the literature, to try to pinpoint the reason for the failure to replicate the long-term retention of fast mapped linguistic facts. There are, however, a few procedural steps that are common to both Markson and Bloom's (1997) and Waxman and Booth's (2000) data but differ from the current methodology. Arguably, it is these differences in procedure that are the most likely to reveal the causes for retention of fast mapped facts cited in the literature and the failure to retain facts reported here.

Procedural steps common to Markson and Bloom (1997) and Waxman and Booth (2000), not followed in Experiment 1

There are four aspects that are common to both Markson and Bloom's (1997) and Waxman and Booth's (2000) data but differ from the current methodology. Firstly, both Markson and Bloom (1997) and Waxman and Booth (2000) introduced their participants to the fact "my uncle gave it to me" whereas the fact introduced here was "(it) comes from a place called Koba".

Perhaps introducing a novel fact that also incorporates a novel word is sufficiently complex to prevent long term retention. However, this seems an unlikely reason for the failure to report good retention of fast mapped linguistic facts in the current experiment. Markson and Bloom (1997) tested a further 45 adults and children, introducing them to "(it) came from a place called Koba" and found that retention after one month was at the same level they had found for the uncle fact and the koba object label data, and was significantly above chance.

Secondly, in contrast to the current experiment, neither Markson and Bloom (1997) nor Waxman and Booth (2000) employed a referent selection task: participants did not have to choose the object to which the novel fact was attached as part of the task. Not having to choose the target object may reduce the impact of competition provided by the familiar objects (Horst *et al*., 2010). In Markson and Bloom (1997), the child was told the fact about the target object during a measuring game – it was not quite ostensive exposure (from the procedure it is not clear how explicit the experimenter made the link between the fact and its referent), but nor was it incidental. In Waxman and Booth (2000), the child's attention was specifically drawn to the fact and its associated target object and the target object was emphasised.

Thirdly, participants were exposed to an array of ten objects that comprised 4 familiar and 6 novel objects in the introductory session in Markson and Bloom's (1997) and Waxman and Booth's (2000) experiments. In contrast, this experiment presented all children in the fact condition with an array of only familiar objects. It is possible that the mere presence of novel objects helped children to learn something new about any one of the objects.

Finally, in both Markson and Bloom (1997) and Waxman and Booth (2000) the new fact was applied to novel objects only. However, in this study, the novel fact was applied to just familiar objects. Only familiar objects were used in the fact condition - including novel objects in the array was not deemed necessary. As Markson and Bloom (1997) pointed out, novel facts could equally well apply to either familiar or novel objects (and hence chance levels were 1 in 10 in the fact condition compared to 1 in 6 in the object label condition). However, it is possible that young children may only be able to fast map and retain facts after a long delay that relate to a novel object and that novel linguistic facts operate much like novel object labels in this respect. This experiment provides the first evidence that facts can be retained after a short delay when linked with a familiar object – all fact data cited in the literature only ever link a fact with a novel object. But it is possible that this link between a fact and a familiar object cannot be sustained for a significant time period by 3- and 4-year-old children.

Perhaps, in the absence of all other knowledge, any information about a novel object (a label or a fact) may be of sufficient importance to a child that it will be mapped quickly and retained for a significant time period. [This also opens up the possibility that novel colours, shapes and textures may be fast mapped and retained if they are applied to novel objects]. That facts might be retained if applied to novel objects could be due, at least in part, to the issues outlined above: the mutual exclusivity or N3C principles may apply to facts as well as words and children cannot learn an additional fact about an object from a quick, incidental exposure, for which they already know one or more facts. Whether 'novel' needs to be defined as an object for which they simply do not have a label or as an object about which they know absolutely nothing is a matter for further exploration.

Summary

A number of reasons may explain the failure to retain facts reported here. However, it is important to note that whatever the reasons, the current experiment provides strong evidence that, under very similar exposure and testing conditions, participants can recognise object labels after a significant delay between exposure and test, but not colour terms, shape terms, texture terms or linguistic facts. It seems that fast mapping may be a process that exists along a continuum and that different types of words and information are more easily retained than others. The differences in procedures detailed above may suggest that a varying combination of factors can assist or hinder retention along this continuum.

CHAPTER 3 – EXPERIMENT 2

Are Fast Mapped Facts Retained when Applied to Novel Objects but not when Applied to Familiar Objects?

Introduction

Experiment 1 found that 3- and 4-year-old children could retain an object label, from a single incidental exposure one week earlier. The participants were introduced to a novel count noun (‘koba’) in a framework similar to a referent selection task. When asked “Can you show me which one is a koba?’’ the majority of children could recognise and point to the appropriate novel object after a week’s delay. Their performance was significantly greater than chance and significantly greater than the performance of the participants in the other four conditions: colour terms, shape terms, texture terms and novel facts. In contrast, all participants performed well in the Short Delay condition, when tested five minutes after the exposure session.

An issue arising from Experiment 1 is that facts were not retained in the week delay condition. This directly contradicts the two studies in the literature that have investigated the long-term retention of facts. Both Markson and Bloom (1997) and Waxman and Booth (2000) found that linguistically presented facts were retained in the long term following limited exposure to a new fact. There are several possibilities that may explain participants’ failure to retain facts after a week’s time delay and these are detailed in the Discussion section of Experiment 1 (Chapter 2).

Of all these differences, a procedural step common to both Markson and Bloom (1997) and Waxman and Booth (2000) but not implemented in Experiment 1, is the most likely explanation for participants’ failure to fast map and retain facts in Experiment 1. Firstly, in contrast to Experiment 1, neither Markson and Bloom (1997) nor Waxman and Booth (2000) employ a referent selection task: the participant does not need to choose the target object from an array of objects based on information provided by the experimenter. It is possible that this more ostensive introduction to the novel fact helps participants fast map and retain the fact for a significant period of time. Secondly, in Markson and Bloom’s (1997) and Waxman and Booth’s (2000) research, participants in the training session were exposed to an array of 10 objects (4 familiar and 6 novel objects). In contrast, Experiment 1 presented all the children in the fact condition with an array of five familiar objects. It's possible that the mere presence of novel objects helped children to learn something new about any one of the objects. Or maybe it has something to do with the total number of objects, novel or familiar.

Finally, in both Markson and Bloom (1997) and Waxman and Booth (2000) the new fact was applied to novel objects only. In Experiment 1, the novel fact was applied to just familiar objects. Although it has been assumed that children will happily link facts with familiar objects as easily as novel objects (Markson & Bloom, 1997), it is possible that young children may only be able to fast map and retain a fact that is linked with a novel object. Perhaps, in the absence of all other knowledge, any information about a novel object (a label or a fact) may be of sufficient significance to a child that it will be mapped quickly and retained for a significant time period. Alternatively, facts might only be retained when applied to novel objects because word-learning principles such as mutual exclusivity and/or N3C (novel-name, nameless-category) may apply to facts as well as words. It is possible that children cannot fast map, and retain in the long-term, an additional fact about an object for which they already know one or more facts.

It is this latter difference between Experiment 1 and the other research into long-term retention of linguistic facts that is the most striking. Wilkinson, Ross and Diamond (2003) suggest that the novelty of the objects presented can affect young children's ability to fast map object labels. Participants were exposed to two novel count nouns associated with two different novel objects. Using a referent selection task, half the participants were asked to choose the 'pafe' and then the 'shede' from an array of objects, consisting of familiar objects and one novel object. For the other half of participants, on introduction to their second new word, the object array included a 'never seen before' novel object plus the just-named novel object. They were tested immediately after three exposures to both novel object labels. Performance was better in young children when, on hearing the second novel object label, the exposure array included the previously named novel object. Wilkinson *et* *al*. (2003) suggest that this forces the child to focus on the novel objects and distinguish the differences between them rather than simply acknowledging that the target object is simply unfamiliar. Older participants (> 3½-years-old) were unaffected but neither retention nor facts were tested.   Horst, Samuelson, Kucker and McMurray (2011) also found that 2-year-olds favoured completely novel objects over previously named objects in a referent selection task. Perhaps, novelty does impact older children's ability to fast map and retain facts when testing occurs after a significant delay.

Given that novelty is a key issue in word learning and that one of the few differences between the literature and Experiment 1's methodology is that the linguistic fact was attached to a novel rather than a familiar object, this possibility was explored here. Experiment 2 was designed to demonstrate whether the fast mapping and retention of linguistic facts might only apply to novel objects. The retention of fast mapped object labels was also tested for comparison purposes. Experiment 2 was therefore designed to address the following research question: are facts fast mapped and retained when applied to novel objects but not familiar objects?

124 pre-school children were introduced to a novel object label or a novel fact linked with either a novel object or a familiar object. There were three conditions: object label paired with a novel object; linguistic fact paired with a novel object; and linguistic fact paired with a familiar object. Depending upon the condition, participants were required to select novel or familiar objects from an array on the basis of their colour. For one of these objects the child was told a label (koba) or a linguistic fact ('it comes from a place called Koba'). Their knowledge of the link between this label or fact and the target object was tested one week later.

Method

Participants

126 3- and 4-year-olds took part in this study. Two children in the Fact Familiar condition were excluded as they did not perform sufficiently well on the colour task to continue. Of the remaining 124 participants, 58 were boys and 66 were girls with a mean age of 4 years and 2.4 months. All participants attended a state-run nursery school in North London, UK. The number, mean age, age range and gender of all the participants that took part in Experiment 2 are summarised below in Table 3.1. There were no significant gender or age differences between conditions.

Table 3.1: Experiment 2 - Number, age and gender of participants

	Object Label	**Fact, Novel Object**	**Fact, Familiar Object**
n	42	40	42
mean age (yrs)	4.21	4.25	4.15
age range (yrs)	3.36 - 4.91	3.52 - 4.92	2.99 - 4.15
gender (M,F)	19, 23	19, 21	20, 22

Design

This study used a between participants experimental design. There was one independent variable – Information Type. Information Type designated the kind of novel information the child was exposed to and the type of object to which the novel information was attached. There were three Information Type conditions: Object Labels, Facts applied to Novel objects (Fact, Novel Object) and Facts applied to Familiar objects (Fact, Familiar Object). In the object label condition, a novel count noun was paired with a novel object, in the Fact, Novel Object condition a novel fact was linked with a novel object and in the Fact, Familiar Object condition a novel fact was linked with a familiar object.

All participants were tested one week (6-9 days) after the initial exposure to the novel object label or novel fact. The dependent variable was Comprehension Accuracy – picking the target item from an array of five objects, as for Experiment 1.

Stimuli

Five cards displaying five different colours (blue, red, green, purple and pink) were used for the Colour task. These colours had been shown to be the most well known colours during pilot testing.

The Exposure session involved five objects. The Object Label condition and the Fact, Novel Object condition presented the same five novel objects. All of them were sourced from a large DIY store. These novel objects will be referred to as a leafguard (blue), nodes (red), bridge (green), gutter (purple) and connector (pink). The Fact, Familiar Object condition presented five familiar objects. These were a ball (blue), a sock (red), a duck (green), a car (purple) and a teddy (pink). Both the novel and familiar objects were in the same colours as the ones tested in the colour task. All the objects can be seen in the photo in Figure 3.1 below.

Figure 3.1: Experiment 2 - Stimuli
Fig. 3.1a. Object Label and Fact, Novel Object conditions

From top, clockwise:
Gutter (purple)
Leafguard (blue)
Nodes (red)
Connector (pink)
Bridge (green)

Fig. 3.1b. Fact, Familiar Object condition

From top, clockwise:
Teddy (pink)
Car (purple)
Ball (blue)
Sock (red)
Duck (green)

Procedure

All participants in each of the three conditions underwent a Colour task, an Exposure session and a Testing session. These are described below.

Colour task

This task tested participants' ability to produce and comprehend five basic colours: blue, red, pink, green and purple. It was used to ensure that participants could readily identify these five basic colours so that they would not encounter any difficulties during the exposure session, when asked to identify objects in these colours. It also served to distract the participant from perceiving the task as a 'word learning' task. The introduction of the new word was to be incidental.

Five colour cards displaying these colours were laid out in random order. Participants were asked: "Look at all these cards. They're all different colours aren't they? Do you know any of them?" The participant was given a chance to say any of the colours they knew. For any remaining colours that the child did not name, the experimenter pointed to the individual colour and said "What about this one?" Any colours produced correctly by the child were recorded. A test of comprehension followed this test of production. The experimenter said, "I am going to say a colour. Will you point to the card that you think shows that colour? Can you see red?" The participant's answer was praised (if correct) and recorded and the card was returned to the array so there was always five colour cards to choose from. The experimenter went on to ask the child to identify pink, green, blue and purple in the same way. The order of the presentation of the colours varied randomly from participant to participant.

Exposure Session

The Exposure Session followed on from the colour task immediately. During the exposure session, participants were introduced to a novel word 'koba' or the novel fact "… comes from a place called Koba", applied to an object. The purpose of this session was to expose the participant to a novel word or fact connected with a novel or familiar object so that the child's retention of that object label or fact could be tested one week later.

In the Object Label condition, the experimenter asked the participant "While I put these cards away (from the colour task) can you take all these things out of the box for me and put them on the table in front of you?" The objects were the five novel objects described and depicted in Figure 3.1.a. above and were presented in a transparent plastic box. Once all the novel objects were laid out on the table, the experimenter said, "Look at all these things. How many are there? Can you count them for me?" If the child was hesitant to count then the experimenter suggested they count them together, pointing to each object in turn. This exercise was to ensure that each object was attended to and that their first experience with the experimenter involved a familiar, easy task. The selection test followed straight after.

Selection test: The experimenter said, "These things are all different colours aren't they? They are the same colours as the ones we were just looking at. Can you show me the green one? Can you show me the red one?" Then came the exposure to the new object label. The target object was always the third object referred to. The experimenter said, "Can you show me the blue koba?" followed by: "Can you show me the pink one? Can you show me the purple one?" The order in which the colours were requested and, therefore, the target object that was labelled koba, was rotated in turn.

The procedure for the Fact, Novel Object and the Fact, Familiar Object conditions were identical apart from the wording used for the novel fact. The participants were asked to retrieve the objects from the box and were then asked to count them in exactly the same way as described above. For the Fact, Novel Object condition the objects were the same as those used in the Object Label condition. For the Fact, Familiar Object condition, the five objects were all familiar as depicted in Figure 3.1.b. in the Stimuli section. They were also initially introduced to the child in a transparent box.

The experimenter then went on to ask the participants to choose the various coloured objects. For the target object, always the third object, the experimenter said, "Can you show me the blue one that comes from a place called Koba?" in both the Fact, Novel Object and the Fact, Familiar Object conditions for a fifth of participants. The remaining participants were asked for the pink, red, green or purple one that 'comes from a place called Koba' alternately.

All participants' responses to the target question were recorded in all conditions. If the child picked the incorrect object, the experimenter said "No, not that one, the blue one (or whichever colour was appropriate)." If the child did not select the correct object on their second attempt, they were shown the correct object and the experimenter said, "It's this one".

Comprehension Test session

The testing session occurred one week (6-9 days) after the exposure session. During the testing session, participants were tested on their comprehension of the novel object label or fact that they were introduced to during the exposure session. As the focus was on long-term retention and Experiment 1 had suggested that performance was good in all conditions in the short term, no testing immediately after exposure was carried out.

The experimenter laid out the array of five objects used in the exposure session on a table. Children in the Object Label condition were asked, "Can you show me which one is a koba? Can you point to it?" and children in the Fact, Novel Object and Fact, Familiar Object conditions were asked, "Can you show me which one is from a place called Koba? Can you point to it?" All participants' answers were recorded. The experimenter used a list of participants' names and the condition in which they had participated to find children after a week and to ensure the appropriate object array was laid out. This also had the advantage that the experimenter did not know which object was the target at the time of testing.

Results

Colour Task: Performance in the colour task was very good across all conditions. Average performance for production scores across all three Information Type conditions was 95% and for comprehension scores was 99.5%. There were no significant differences between conditions in production scores or comprehension scores for any individual colour ($p>.54$) or for the set of five colours [production: $F(2,121)=0.76$, $p=0.469$; comprehension: $F_{Welch}(2,121)=2.60$, $p=0.083$) .

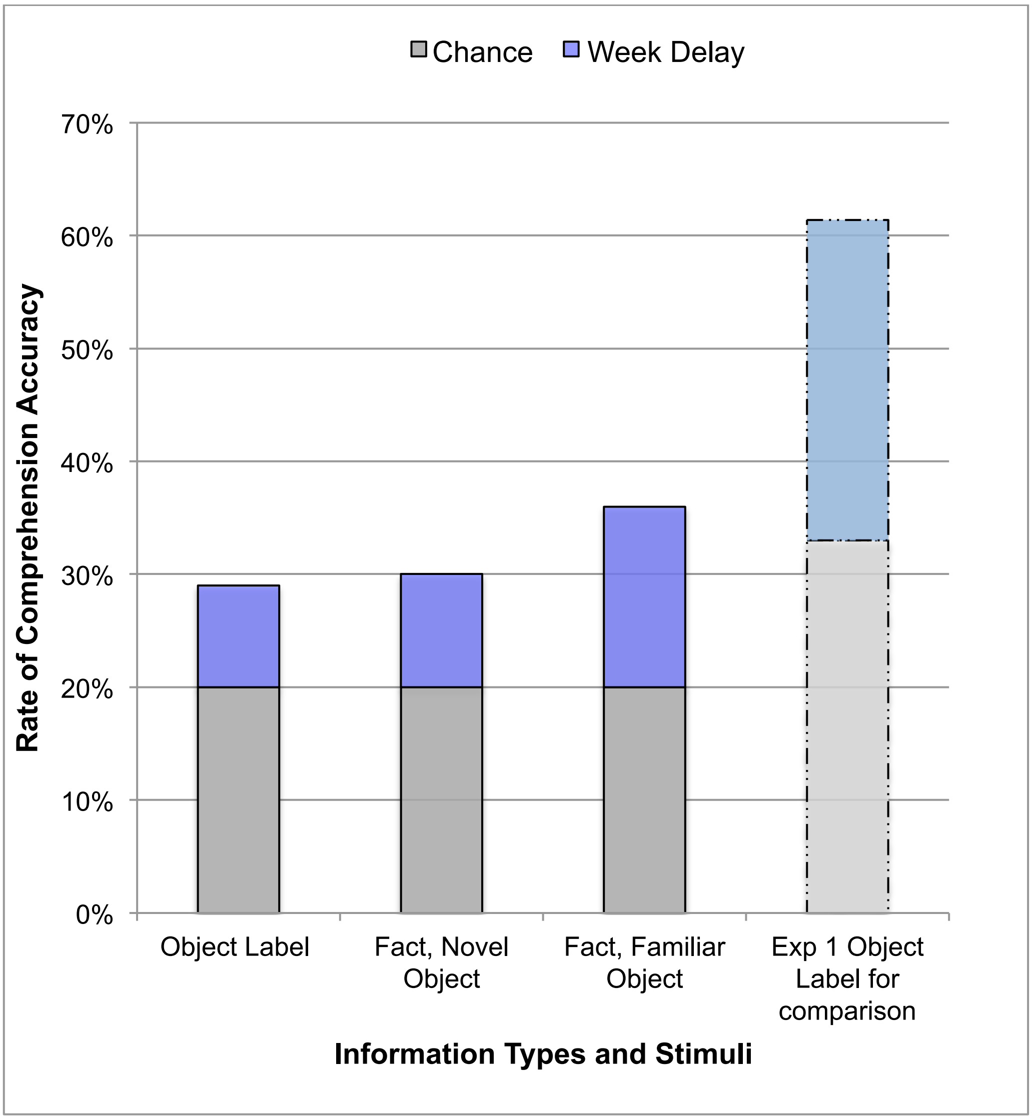
Selection Test – Immediate: When selecting the target during the exposure session, performance was good across all conditions (98%) and there were no significant differences between conditions ($p>.05$).

Comprehension Test – after one Week: Participants were tested in a comprehension task one week later to establish if they retained the novel word-object link or the novel fact-object link. Of particular interest was whether there were any differences in participants' ability to retain facts after a long delay, relating to the familiarity of the referent. There were five objects in each condition, any of which could have been the target, so chance was 1 in 5 (20%). Comprehension accuracy and chance are summarised in Figure 3.2 below.

As can be seen from Figure 3.2, the ratio of correct to incorrect responses was very similar across conditions. There was not a significant association between the familiarity of the referent and comprehension of the novel word/fact-object link after one week: $\chi^2(2)=0.56$, $p=0.76$.

A binomial test comparing performance to chance revealed mostly non-significant results: neither object labels nor facts were retained significantly above chance when they were applied to novel objects ($p>0.05$). In contrast, in the Fact, Familiar Object Condition, 15 out of 42 (36%) children correctly identified the target object in the comprehension test after a week's delay. A binomial test revealed that there was a significant preference for the target object in comparison to chance, $p\leq0.05$.

Figure 3.2: Experiment 2 – Participants' Comprehension Answers



Discussion

The current study found no long-term retention of object labels or facts to novel objects above chance levels. This is the first evidence that children are unable to retain the link between a novel linguistic fact and a novel object after a significant time delay (Experiment 1 failed to evidence retention of a novel fact but this was a fact linked with a familiar object). The object label data contradict Experiment 1 and the numerous studies that have demonstrated the fast mapping and long-term retention of object labels

(Markson & Bloom, 1997; Waxman & Booth, 2000; Childers & Tomasello, 2002; Goodman, McDonough & Brown, 1998; Jaswal & Markman, 2003; and Woodward, Markman & Fitzsimmons, 1994). This may indicate a problem with the procedure.

The task during the Exposure Session asked the participants to identify each object by its colour. This task immediately followed on from the colour task where the participants had also been asked to identify cards by their colour. The child could happily choose the correct colours (and, therefore, object) without ever hearing or processing the new word or fact. The participants may have focused on completing this goal-oriented task to the extent that other information provided was ignored. There is no evidence that the participants processed the novel word or fact at all, even in the short-term. Even though the object condition in Experiment 1 similarly asked children to identify the object by its colour there were subtle differences. Firstly, the initial conversation in the Exposure and Test Sessions in Experiment 1 centred on objects not colours. Secondly, the Exposure Session in Experiment 1 was not preceded by a colour task. The colour task may have helped 'prime' participants in Experiment 2 to concentrate on colour and ignore non-related conversation.

There may have been some other factor that prevented retention of any of the object labels or facts in Experiment 2. In more recent years, the failure to retain object labels in the long term does find increasing support (e.g. Horst & Samuelson, 2008; Booth, McGregor & Rohlfing, 2008; Horst, Scott & Pollard, 2010; Axelsson, Churchley & Horst, 2012; Kucker & Samuelson, 2012; Vlach & Sandhofer, 2012). All of these studies have demonstrated that fast mapped object labels are not always retained and, in some cases, seemingly innocuous adjustments to the experimental procedure can result in retention. For example, Horst *et al*., (2010) showed that increasing the number of familiar objects presented during a referent selection task prevented retention. And Booth *et al*., (2008) demonstrated that socio-pragmatic cues from the experimenter aided retention (e.g. pointing at the target), whilst attentional factors, such as the child looking at and handling the object, did not enhance retention levels. Horst and Samuelson (2008) and Axelsson *et al*., (2012) demonstrate that ostensive labelling aids retention in a referent selection task. Kucker and Samuelson (2012) suggest that insufficient familiarization with the objects during the exposure session deter retention.

At any rate, Experiment 1's fact data and Experiment 2's results indicate that neither linguistic facts nor object labels are fast mapped and retained for significant periods of time in all circumstances. The process appears to be considerably less certain than one would expect from reading Markson and Bloom (1997) and Waxman and Booth (2000). There are clear limits to retention of fast mapped information, even for object labels. Surely, this is an obvious point? There would seem to be a number of contexts and situations where children would not map and remember a new count noun because they are distracted or the task that they are engaged in is sufficiently engrossing to take up their attention. But much of the literature, certainly prior to 2008, suggests that children are able to learn some information, particularly object labels and linguistic facts, very easily and in the most distracting of circumstances.

Markson and Bloom (1997) and Waxman and Booth (2000) point to the ease of retention. Markson and Bloom (1997) show retention after a staggering amount of time – one month – and Waxman and Booth (2000) hardly even refer to retention – merely stating that 100% of participants retained the novel object label or fact, as if it is a foregone conclusion. Akhtar (2005) demonstrates that children as young as two were equally good at learning a novel object label when there was a distracting activity as when there was not. They were also able to learn the word when the object was not explicitly labelled. Jaswal and Markman (2001) and (2003) demonstrate that word learning in indirect contexts is as good as learning from ostensive labelling, even after a significant time delay of two days. Hall, Quantz and Persoage (2000) argue that indirect labelling situations may have advantages to word learning over ostensive situations, by focusing attention on grammatical form for example. And there are countless other examples.

Despite the differences in procedure between Experiment 1 and Experiment 2 described at the beginning of this Discussion section, there isn't anything obvious about the current study's procedure that would prevent fast mapping and retention of object labels. It demonstrates that even quite subtle changes to methodology can affect children's ability to learn an object label from quick incidental exposure. Perhaps this experiment supports the view that the retention of fast mapped words (and facts) is not a particularly stable process. Certainly, Experiment 1 and Experiment 2 taken together suggest that object labels and facts, in particular, are not readily fast mapped in all contexts.

Finally, what of the original aim of the current experiment to establish whether linguistic facts can be retained when linked with novel, as opposed to familiar, objects? There were no significant differences between conditions suggesting that the novelty of the referent object has no effect on retention. In addition, a fact linked with a familiar object was retained at levels greater than chance yet a fact linked with a novel object was only retained at chance levels, further supporting this conclusion.

But what are we to make of the retention of a fact linked with a familiar object at levels greater than chance? This finding seems odd given that object labels were only retained at chance levels and, on the face of it, this result appears to contradict Experiment 1. Perhaps a fact can be retained after a long delay when the object it is linked with is familiar. This experiment provides the first tentative evidence that this is the case – all fact data cited in the literature only ever link a fact with a novel object.

36% (15 of 42) of children in this experiment were able to retain the link between a novel fact and a familiar object, a result that was significantly above chance ($p=0.013$). The corresponding ratio in Experiment 1 was 30% (13 of 44), a result that was not significantly different from chance ($p=0.086$). What is striking is how similar these results are. Both are clearly on the threshold of a significant difference with chance. The fact data in Experiment 1 dip just below this threshold and the current study just exceeds it. It is also important to point out how alike the procedures were for the fact condition in

Experiment 1 and the Fact, Familiar Object Condition in Experiment 2. Both involved introducing a link between a novel fact and one of five familiar objects during a conversation that asked the participant to select one of the familiar objects based on its colour. What seems of greater importance here is to notice the marked difference between the retention of facts to familiar objects found here at 30-36% and the general levels of retention reported in the literature and in Experiment 1 for object labels of at least 60%. Indeed, Waxman and Booth (2000) report 100% retention after one week!

Summary

There were no significant differences between the Object Label, Fact, Novel Object and Fact, Familiar Object conditions. Object labels and linguistic facts linked with novel objects were not retained at a rate significantly different from chance. Given that the children in the current study could not demonstrate accurate comprehension of object labels after one week this suggests that the experimental procedure was insufficiently sensitive to detect differences between conditions. Taken together with the failure to find a significant difference between conditions, and the similarity in findings between Experiments 1 and 2, the conclusion here is that, despite retention of facts linked with familiar objects being significantly more than chance, it is unknown whether the familiarity of the referent object affects retention. The evidence is inconclusive.

CHAPTER 4 – EXPERIMENT 3

Does the Novelty of Objects Affect the Fast Mapping and Long-Term Retention of Facts?

Introduction

Experiment 2 attempted to answer the question: “Do young children fast map facts only when they are applied to novel objects?” It was designed to resolve the apparent contradiction between Experiment 1’s findings and the results reported in the literature. Linguistic facts were not retained after a week’s delay in Experiment 1, whereas, Markson and Bloom (1997) and Waxman and Booth (2000), both reported good long-term retention of novel linguistic facts. One of the main differences between Experiment 1’s methodology and the literature was that both the Markson and Bloom and Waxman and Booth studies linked their novel linguistic fact with a novel object whereas the novel fact was linked with a familiar object in Experiment 1. Experiment 2 compared the long term retention of fast mapped novel object labels, facts linked with novel objects and facts linked with familiar objects to establish whether object novelty was the cause of the diverging results.

However, Experiment 2 found no convincing retention data for fast mapped facts after a week’s delay, regardless of the familiarity of the object with which the fact was associated. No long-term retention was found for object labels either. The failure to demonstrate long term retention of object labels contradicts a number of previous studies (Markson & Bloom, 1997; Waxman & Booth, 2000; Childers & Tomasello, 2002; Goodman *et al.*, 1998; Jaswal & Markman, 2003; Woodward *et al.*,1994 and Booth, McGregor and Rohlfing, 2008). It similarly contradicts the results reported in Experiment 1, and raises the concern that Experiment 2’s procedure was flawed in some way.

Why did Experiment 2 fail to evidence any long-term retention?

One possibility is that Experiment 2’s colour task and selection procedure did not require the child to process the novel object label or fact in order to select the correct target object during the exposure session. A referent selection task requires a participant to choose the target object on the basis of what it is called – on hearing a novel name they choose the novel object as its referent using word learning principles such as the mutual exclusivity or N3C principles. Unless the participant hears and processes the novel word they cannot select the appropriate target correctly. Experiment 1 used an adaptation of the standard referent selection task and similarly required participants to select the target novel object on the basis of its novelty and its colour. In Experiment 2, the children could easily have chosen the target object without even hearing the novel object label or novel fact. There is no evidence that they did so as no data were collected immediately or after a short delay from exposure. However, Markson and Bloom (1997) and Waxman and Booth (2000) did not use a selection task in their exposure session and still found long-term retention of object labels and facts. In addition, Experiment 1's Fact condition did not require participants to select the target on the basis of the novel fact (but on the basis of its name and its colour) and found good retention after a delay of 5 minutes, suggesting that the fact had at least been heard and processed to some degree.

There is another related but subtly different procedural step that marks a difference between Experiment 2 and all previous investigations into the long term retention of fast mapped facts. Experiment 2 engaged participants in a task that asked them a series of closed (as opposed to open-ended) questions, and the participants found these questions easy to answer – they were asked to find a card and then an object of a certain colour. The new information (the novel word or novel fact) was not relevant to answering the colour question. The participants were 'primed' to answer these colour questions prior to the introduction of the novel word or fact from several practice trials. The children selected five cards by being asked about their colour in the colour task and needed to select a further two objects in the Exposure session based on their colour. Such a task where participants have to answer a host of questions with clear right or wrong answers, that are not in any way related to the extra information they are being told, may have distracted participants from hearing or processing the novel object label or fact. Participants may have been so focused on listening out for and responding to colour commands after a few questions that they simply tuned out any other information, either novel object labels or novel facts. And notice the wording of the question during the Exposure session: "Can you give me the blue koba?" or "Can you give me the red one, that comes from a place called Koba?" for example. Participants heard the colour command prior to the novel word or fact. The children started grabbing for the appropriately coloured object before they had heard the full sentence request so may have paid scant attention to the novel object label or fact. Or perhaps, the kinds of cognitive processes that commit knowledge to long term memory (e.g. attention, perception of importance, interest etc.) were not sufficiently activated to produce long term retention in this kind of scenario.

Finally, Experiment 2 only presented participants with an array of like objects, either all novel or all familiar, just like the Fact condition in Experiment 1. This contrasts with Experiment 1's object label condition, along with the other studies that have established retention of object labels or facts after a significant delay, which presented participants with a mixed array. Perhaps this mix of objects provides participants with an important contextual clue – something akin to lexical contrast. The child's implicit thinking may be along the lines of: "oh there are some objects here, some of which I know (at least names for them) and some of which I do not. Because I can see some objects that I know about, that makes me interested in the objects I don't recognise. I wonder if this person will tell me anything about them. I should keep an ear out".

The next steps

Given that Experiment 2 failed to demonstrate any long-term learning or any differences between conditions, Experiment 3 was designed to re-test the ideas explored in Experiment 2. Experiment 3 adopted a different procedure to try to obtain some long term learning in at least one of the conditions. A mixed array was presented and there was an immediate condition to confirm that the participants had, in some way, processed or at least heard the new word or fact. In addition, the procedure avoided using a task that was associated with clear-cut right and wrong answers such that children might ignore all other information when focusing on the task in hand.

Experiment 3 was designed to approximate Waxman and Booth's (2000) procedure, in an attempt to establish fast mapping of object labels and at least some facts. Having obtained no fast mapping of any Object Labels or Facts in Experiment 2, the focus was on achieving some positive results. Waxman and Booth (2000)'s procedure was mimicked, as the details of Markson and Bloom's (1997) methodology are not sufficiently detailed to replicate with precision. Pilot testing, attempting to replicate Markson and Bloom's object label data, failed to produce any long term retention; and Vlach and Sandhofer (2012) reported similar difficulties with Markson and Bloom's procedure. The key features of Waxman and Booth's (2000) procedure that were replicated here were (i) ostensive labelling, (ii) emphasising the target object (salience) (iii) a task that did not involve a specific right/wrong answer, (iv) a mixed array, and (v) testing both at the end of the training session and one week later (repeat testing).

As for Experiment 2, the aims of Experiment 3 were to (a) replicate the long term retention of fast mapped object labels found in Experiment 1 and (b) establish if children can fast map and retain novel facts differently depending upon the novelty of the object to which the fact is applied. Two groups of 3-and 4-year-old children were introduced to a novel linguistic fact ("..it comes from a place called Koba"). For one group, this fact was linked with a novel object; for the other group the fact was linked with a familiar object. A third group of children was introduced to an unfamiliar object label referring to a novel object. Unlike Experiment 2, the stimuli set was a mixed array comprising four novel and four familiar objects, so the same object array could be used in all three Information Type conditions. This had the additional benefit that any differences in results between conditions could not be due to differences in stimuli. Exposure to the novel fact (or object label) was ostensive, the target object was emphasised and each child was asked the test question twice during the course of the task. Participants' comprehension of the novel fact (or object label) was tested immediately and one week later.

Method

Participants

The number, mean age, age range and gender of all the participants that took part in Experiment 3 are summarised below in Table 4.1. There were no significant gender or age differences between Information Type conditions or Time Interval conditions. 93 children (3- and 4-year-olds) took part in this study. The mean age was 4 years and 3.7 months. One boy in the Fact, Novel Object condition and two boys in the Fact, Familiar Object condition were not available for testing 6-9 days later so their data were excluded from the Week Delay condition. Therefore, there were a total of 90 participants in the Week Delay condition. The mean age of 51.7 months was maintained. All participants attended a state-run primary school (nursery and reception years) in North London, UK.

Table 4.1: Experiment 3 - Age, gender and numbers of participants

	Object Label	**Fact, Novel Object**	**Fact, Familiar Object**	**Total**
Immediate				
n	31	31	31	93
mean age (yrs)	4.26	4.39	4.28	4.31
age range (yrs)	3.35-4.95	3.35-4.99	3.35-4.94	3.35-4.99
gender (M,F)	15, 16	17, 14	17, 14	49, 44
Week Delay				
n	31	30	29	90
mean age (yrs)	4.26	4.39	4.28	4.31
age range (yrs)	3.35-4.95	3.35-4.98	3.35-4.94	3.35-4.98
gender (M,F)	15, 16	16, 14	15, 14	46, 44

Design

This study used a mixed experimental design. There were two independent variables – Information Type and Time Interval. Information

Type was a between participants variable and Time Interval was a within participants variable.

There were three Information Type conditions: Object Labels, Facts applied to Novel objects (Fact, Novel Object) and Facts applied to Familiar objects (Fact, Familiar Object). In the object label condition, a novel count noun was paired with a novel object. In the Fact, Novel Object condition a novel linguistic fact was paired with a novel object. In the Fact, Familiar Object condition a novel linguistic fact was paired with a familiar object. There were two Time Interval conditions: Immediate and Week Delay. All participants were tested both immediately after the exposure session and one week later (6-9 days). The dependent variable was Comprehension Accuracy – picking the target item from an array of eight objects.

Stimuli

The fast mapping task introduced a novel object label or fact applied to an object in the exposure session and tested comprehension of this novel object label or fact in the test session. The fast mapping task presented the participant with eight objects, four familiar and four novel (the task array). All of the conditions (Information Type and Time Interval) presented the same mixed task array of eight objects in both the Exposure Session and the Test Session. All the objects and their colours used in the fast mapping tasks in Experiment 3 are depicted in a photo of the array below - Figure 4.1.

Figure 4.1: Experiment 3 - Stimuli

From top left, clockwise:
Teddy (pink), Leafguard (blue),
Sock (red), Ball (blue),
Wheel (red), Duck (green),
Connector (pink), Bridge (green)

The four novel objects were sourced from a large DIY store and were painted in familiar basic colours: blue, red, green and pink. These novel objects are referred to as a leafguard (blue), a wheel (red), a bridge (green) and a connector (pink). The four familiar objects were also in the same familiar basic colours: a ball (blue), a sock (red), a duck (green) and a teddy (pink). The objects were placed upon a plain white towel.

Procedure

All participants in each of the three Information Type conditions underwent a fast mapping task comprising an exposure session and a testing session. Each participant was introduced to a novel count noun or novel linguistic fact in the exposure session and their comprehension of this novel word/fact was assessed in the testing session, both immediately and one week later.

Exposure Session

Participants were presented with a transparent box containing the eight objects, four novel and four familiar (Figure 4.1). Participants were asked to get all the objects out the box and to lay them out on the table in front of them. The experimenter said, “Look at all these things. How many are there? Do you want to count them?” If the child was hesitant to count the objects the experimenter said, “Let's count them together” and counted the objects, pointing to each of them in turn. This ensured that participants touched and looked at each object, for broadly equivalent amounts of time.

Following this brief introduction to the objects, the experimenter started the main task. The experimenter said, “Look. Here I have a towel” and laid out a white towel, placing the eight objects in a row by the side of the towel. The stimuli were placed in a fixed order (sock, bridge, teddy, leafguard, duck, wheel, ball, connector) to help with rotating the target object. This fixed order was not apparent to the participant. Then the experimenter said, “I want to put all of these things onto my towel so that it makes a fun picture. Can you show me where to put them so it looks really good? We'll do it one at a time so we don't miss any out.” The experimenter picked up the sock and said, “Let's start with this one.” The experimenter waited for the child to take the sock and put it somewhere on the towel. If the child was unsure of what to do, the experimenter suggested a couple of places the sock could go and demonstrated with a couple of the objects how to make a picture (this was necessary for only a couple of participants across all the conditions). After the child had placed the sock somewhere on the towel, the experimenter picked up the bridge and asked, “Where would you put this one?” After the child placed the bridge on the towel the experimenter picked up the teddy, then the leafguard, then the duck, then the wheel, then the ball and finally the connector, asking “And how about this one?” waiting for the child to place the object before going on to the next one. The experimenter did not refer to any of the familiar objects by name and the child did not have to select any of the objects – the experimenter gave each object to the child one by one.

During this task, with the experimenter picking up each object in turn and handing it to the participant to place on the towel, the experimenter introduced some new information about the target object. In the Object Label condition, on picking up the target object, the experimenter said “This is really special - it's called a koba - where do you want to put this one?” In the Fact, Novel Object and Fact, Familiar Object conditions the experimenter said, when picking up the target object, “This is really special - it's from a place called Koba - where do you want to put this one?” The target object was each of the novel objects (the bridge, leafguard, wheel, and connector) in turn in the Object Label and Fact, Novel Object conditions. In the Fact, Familiar Object condition the target object was each of the familiar objects in turn (the ball, the sock, the duck and the teddy). Following this exposure to the novel object label or novel fact the experimenter said, “That's brilliant thank you. I think that looks really great.”

The task was specifically designed so that there was no obvious right or wrong answer, in which participants could ascertain the rules and then focus on that aspect of the task, as appeared to happen in Experiment 2. The participants could lay out the objects as they saw fit. The intention was that participants would be alert to any new information they heard about any of the objects if they were not side-tracked by the task requirements. In addition, attention was drawn to the target and its associated novel name/fact ("this is really special"), mimicking Waxman and Booth's (2000) paper that found good retention data.

Test sessions

Participants' comprehension of the novel object label and novel fact were tested both immediately and after one week.

Immediate test session: All participants took part in the Immediate condition's test session and this followed straight on from the exposure session. In the Object Label condition, the experimenter said "We're going to put these away [*referring to the mixed array of eight objects laid out on the towel*]. But just before we do, can you show me which one is called a koba?" Participants handed their chosen object to the experimenter and their answers were recorded. If the child chose the incorrect object (i.e. an object that was not the target) the experimenter corrected them so that they could still participate in the Week Delay condition. The experimenter said, "No, it's not that one, it's this one" and handed the target to the participant. Neither the novel object label nor the novel fact were repeated. In the Fact, Novel Object and Fact, Familiar Object conditions the experimenter asked the child "We're going to put these away. But just before we do, can you show me which one comes from a place called Koba?" Participants' answers were recorded and inaccurate choices were corrected as they were in the object label condition. The experimenter ended the test session by saying, "Can you help me and put the things away now? They go back in the box. And we can fold the towel." The child and the experimenter tidied away the array of objects. The experimenter thanked the participant for their time and escorted him or her back to the classroom.

Note that the delay between the test question and the introduction to the novel word/fact varied depending upon the target in the Immediate Test session. For example, for the quarter of participants in the Fact, Familiar Object condition where the target was the sock, the gap between introduction and test was a little longer than the participants for whom the connector was the target. When the sock was the target, the participants experienced the remainder of the exposure session prior to testing. They heard seven further requests, such as “where would you put this one?” or “how about this one?” and placed seven more objects on the towel before being asked the test question. In contrast, for the quarter of participants in each of the Object Label and the Fact, Novel Object conditions for whom the connector was the target, the novel object label/fact was presented at the very end of the Exposure session and the test question followed on immediately after. The maximum difference in delay was no more than a minute and the even distribution of participants across each target would have minimised any associated effects on results.

Week Delay: All the participants who underwent the exposure and Immediate test sessions, and were available 6-9 days later, participated in the Week Delay test session. This test session was very similar to the Immediate test session. The object array (four novel and four familiar objects) was laid out on the towel before the child was called into the room. When the child was in front of the objects, the experimenter asked “Can you show me which one is a koba? Can you point to it?” in the Object Label condition. In the Fact, Novel Object and Fact, Familiar Object conditions, the experimenter asked “Can you show me which one is from a place called Koba? Can you point to it?”

Results

Comprehension Summary

There was good retention (74%-94%) in all of the Information Type and Time Interval conditions. Comprehension accuracy and chance are summarised in Figure 4.2. The children could identify the referent of the novel object label or fact, both immediately and after one week, at well above chance levels (25%).

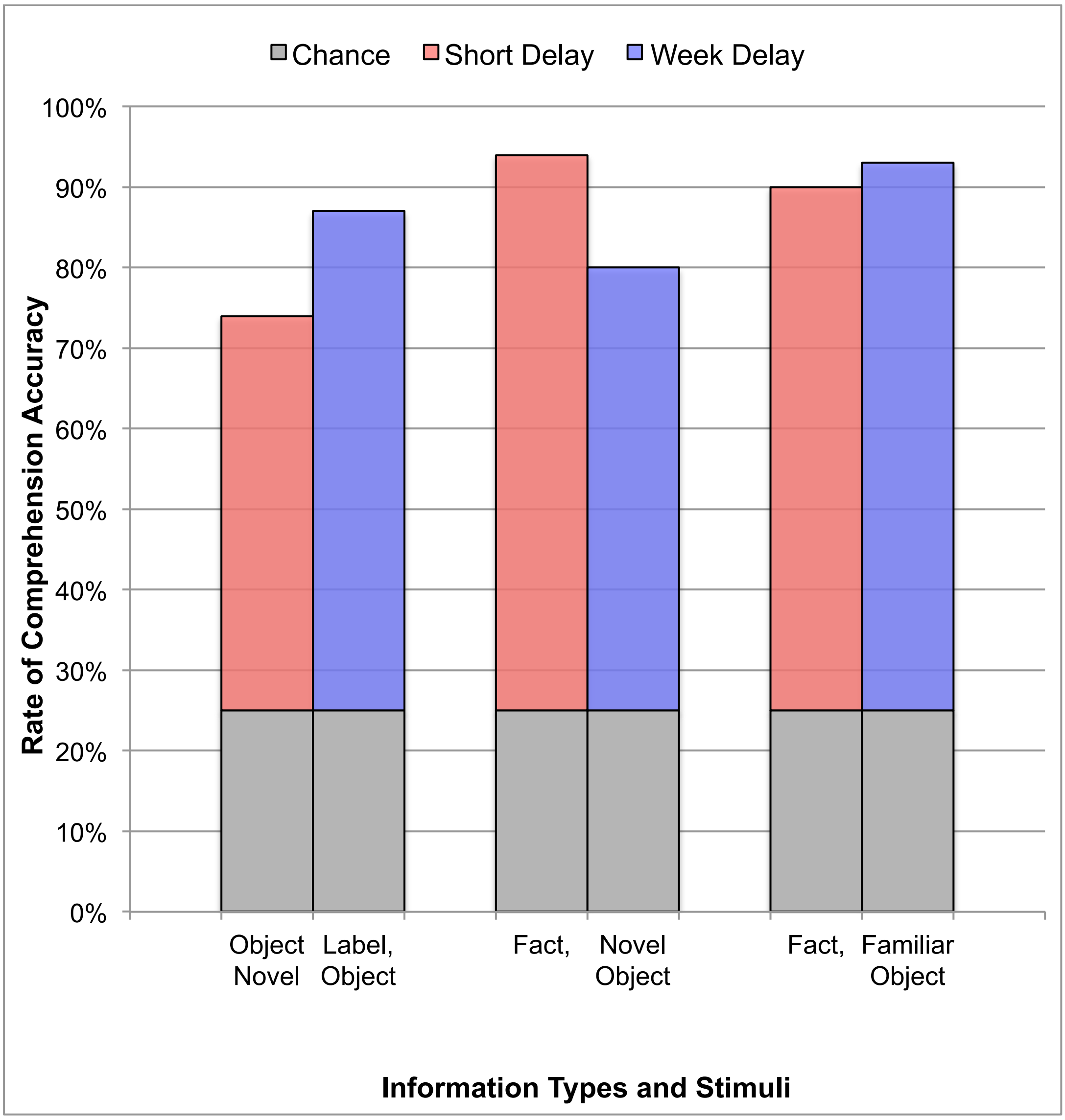
As there were four novel objects in the Object Label condition, any of which could have been the target, chance was 1 in 4 (25%). The mutual exclusivity principle and the N3C principle are well established for the learning of new count nouns and most children will assume a novel object label applies to a novel object (e.g. Markman & Wachtel, 1988; Mervis & Bertrand, 1994). In the Fact, Novel Object and Fact, Familiar Object conditions, chance may have been 1 in 8 (12.5%). Logically, the fact may have been attributable to any one of the novel or familiar objects presented (see Markson and Bloom, 1997). However, a conservative approach was adopted and chance was set at 25% across the Fact, Novel Object and Fact, Familiar Object conditions as well, in case on hearing a novel fact for the first time a child applied it to novel objects in preference to familiar objects.

As the Immediate and Week delay data were collected from the same participants, a log linear analysis across all Information Type and Time Interval conditions could not be prepared as scores need to be independent. So a separate chi-square analysis was prepared for each of the Time Interval conditions.

Immediate Test of Comprehension Accuracy

As can be seen from Figure 4.2, comprehension accuracy in the Immediate condition was high in all Information Type conditions (at least 74%). A binomial comparison with chance in the Short Delay condition, showed that comprehension was significantly above chance levels in all conditions ($p<0.001$). The rate of comprehension accuracy was very similar across conditions. There was not a significant association between the familiarity of the referent object and comprehension of the novel fact-object link when participants were tested immediately after exposure, $p=0.111$ (Fisher's Exact Test). This p value is quite close to the critical value of 0.05 and this is driven by the relatively poor object label comprehension compared to the fact comprehension, when tested immediately after exposure.

Figure 4.2: Experiment 3 - Participants' Comprehension Answers



Week Delay Test of Comprehension Accuracy

Figure 4.2 shows that comprehension accuracy in the Week Delay condition was also high in all Information Type conditions (at least 80%) and very similar across conditions. A binomial comparison with chance showed that comprehension was significantly above chance levels in all conditions following a Week Delay ($p<0.001$). There was not a significant association between the familiarity of the referent object and comprehension of the novel word/fact-object link after one week, $p=0.318$ (Fisher's Exact Test).

Comparison of Immediate and Week Delay Tests

Performance in the Immediate condition was contrasted with performance in the Week Delay condition using the McNemar test, a suitable nonparametric test for related samples (Siegel, 1988). A McNemar test showed that the proportions of correct to incorrect answers were not statistically different between the Immediate and Week conditions for each of the Information Type categories: Object label condition, $p=0.289$; Fact, Novel Object Condition, $p=0.289$; Fact, Familiar Object Condition, $p>0.999$ (2 sided).

Discussion

This experiment found good retention (74%-94%), at well above chance levels (25%), for all words and facts following both time delays. There were no significant differences between the Immediate Delay and the Week Delay conditions. Neither were there any significant differences between the Information Type Conditions, in either time delay. Participants retained fast mapped linguistic facts to familiar objects as well as novel objects, providing the first convincing evidence that children can link facts with familiar objects and retain that link for a significant period of time. Experiment 2 did demonstrate retention of facts to familiar objects after a week's delay at levels significantly greater than chance but the absolute rate of 36% is low compared to the rates of retention achieved here – 93% for facts linked with familiar objects.

Object labels were fast mapped and retained in the long term. This was a successful replication of the object label data found in Experiment 1 and several other studies in the literature (e.g. Markson & Bloom, 1997; Woodward *et al*., 1994; Vlach & Sandhofer, 2012). Clearly, in contrast to Experiment 2, the experimental method permitted long term retention. The experimental task was sufficiently well understood by the participants and the task demands did not distract them from fast mapping or retention.

Facts were fast mapped to both familiar and novel objects and were retained in the long-term, regardless of the novelty of the object to which they were applied. Retention of facts to novel objects, after a significant time period, is consistent with the literature (Markson & Bloom, 1997; Waxman & Booth, 2000). The findings also demonstrate that, at least in some circumstances, novel facts about familiar objects can be fast mapped and retained. The literature has suggested that there is no logical reason why a novel fact could not be applied to a familiar object (Markson & Bloom, 1997), but the data reported here are the first to evidence such mapping and retention. It would seem that young children can link a novel linguistic fact with a familiar object from just two exposures and retain that link for at least one week. Knowing a label for an object does not seem to preclude children learning other information about it – principles such as mutual exclusivity do not appear to operate beyond word-learning. However, there must be some limit to how much information any one child can retain. And it is important to note that some researchers would not regard the current experiment as a fast mapping paradigm. For example, Horst would argue that fast mapping only occurs when the task involves referent selection with no aids to retention such as emphasising the salience of the target object or ostensive naming (Horst & Samuelson, 2008).

The link between a linguistic fact and a familiar object was remembered one week later by 93% of participants. This is higher than but not significantly different to the proportion of participants who retained the link between a linguistic fact and a novel object (80%). This suggests that 3- and 4-year-old children can retain a linguistic fact associated with a familiar object as well as they can with a novel object. Of course, given that results were close to ceiling, it is possible that there are differences in how well children retain linguistic facts associated with novel as opposed to familiar objects but that the experimental method was insufficiently subtle to tease out these differences.

Looking at these data in light of the previous experiments provides a confusing picture. Following minimal exposure and a week's delay, linguistic facts were not retained in Experiment 1 or in Experiment 2 and they were retained here in Experiment 3. How can such variations be explained? Perhaps it is possible to identify procedural steps that are common to all the studies that have established long term retention of object labels and facts, but are not present in the experiments that have failed to evidence retention. Similarly, there may be methodological approaches shared by experiments that have failed to demonstrate retention that are absent from research where long term retention is established. An analysis of the experimental methods reported in this thesis, in light of the literature, may suggest factors that are influential in determining long term retention.

Inconsistencies with Experiment 1 and Experiment 2

This experiment found long-term retention of facts and this is consistent with the literature. However, facts were not fast mapped and retained in either Experiment 1 or Experiment 2 after a week's delay. This raises the question: why are fast mapped linguistic facts prone to long term retention in some experimental tasks and not in others? Experiment 2 failed to find that even object labels were fast mapped yet the evidence for the fast mapping and long-term retention of count nouns is persuasive. Markson and Bloom (1997), Waxman and Booth (2000), Childers and Tomasello (2002), Goodman, McDonough and Brown (1998), Jaswal and Markman (2003), Woodward *et al*., (1994), Booth *et al*., (2008) and Vlach & Sandhofer (2012) all found long term retention of object labels with a minimum of a 24-hour delay between exposure and test. In addition, the data reported in Experiment 1 provide further support for these findings.

The failure to produce long term retention of object labels in Experiment 2 is consistent with some studies in the literature. Horst and Samuelson (2008) and Vlach and Sandhofer (2012) demonstrate how the retention of object labels following a significant delay cannot be assumed and how relatively small changes in methodology can prevent long term retention. However, the fact that Experiment 2 does not demonstrate any retention indicates that there was some kind of procedural step preventing any long term learning. It is therefore unlikely to give much insight into the reasons why facts are fast mapped and retained in some circumstances but not in others.

Experiment 1, on the other hand, demonstrated long term retention of object labels, giving some reassurance that the experimental method can produce some long term learning. Yet there was no retention of fast mapped linguistic facts after a week's delay, in contrast to Experiment 3. It is therefore, of more interest why linguistic facts were not fast mapped in these circumstances. A review and comparison of the methodologies of Experiment 1 and Experiment 3 may prove fruitful in determining the reasons for the variation in findings of the long term retention of facts.

Procedural Differences Between Experiment 1 and Experiment 3

There were a number of methodological differences between Experiment 1 and Experiment 3 that may account for the variation in fact data. Experiment 3 utilised a number of procedural techniques that were likely to help participants fast map and retain the information to which they were introduced. These would be described as memory supports by Vlach and Sandhofer (2012). The procedural techniques that were likely to help and support fast mapping and retention were utilised following the failure to evidence any long term retention in Experiment 2. Experiment 3's procedure included ostensive labelling and the target object was highlighted. In addition, the within participants Time Interval condition meant that each participant in the Week Delay condition was exposed to the novel fact twice in total and had already experienced the test question once before (and had been corrected if they had answered inaccurately in the Immediate Test Session). How these methods differ from those adopted in Experiment 1 is detailed below.

Ostensive v Implicit Exposure

Experiment 1 involved implicit exposure to the new fact – the participants were required to work out the target associated with the novel fact from the experimenter's comments using a procedure similar to a standard referent selection task. In contrast, participants in Experiment 3 were introduced to the novel word or fact via ostensive labelling. Their attention was drawn to the target object by the experimenter picking up and holding the object and they were told explicitly that the target object comes from a place called Koba (Booth, McGregor and Rohlfing, 2008, evidenced that gestural cues such as pointing and touching helped children retain object labels). It seems likely that ostensive labelling, which clarifies the intentions of the speaker and makes the link between the novel fact and the object explicit, would certainly help a child to map the fact to the appropriate target and may well help retention of this novel fact. One could argue that if a child is much more certain about the link between an object and a fact s/he may find it easier to retain. Horst and Samuelson (2008) did not find retention without using ostensive labelling. Waxman and Booth (2000) employed ostensive labelling in their procedure and demonstrated fast mapping and retention of object labels and facts after a significant delay. This experiment replicated Waxman and Booth's (2000) method of ostensive exposure and found similar results.

However, the benefit of ostensive labelling in the retention of fast mapped words and facts is less than clear. It certainly does not seem to always be necessary in order to attain long term retention. Experiment 1 found that novel object labels were retained after one week using an adaptation of a standardised referent selection task where no ostensive labelling took place. Markson and Bloom (1997) established long-term fast mapping of both count nouns and facts and did not utilise ostensive labelling. However, neither was their procedure as implicit as a referent selection procedure; participants were not required to work out which object was associated with the novel object label or novel fact. Their methodology was somewhere in the middle – the experimenter referred to the target object's name or associated fact whilst interacting with it during a measuring task. The child's attention was not specifically drawn to the target object, nor was the child asked to work out which object was the target upon hearing the novel object label or fact.

Jaswal and Markman (2003) investigated the accuracy of word learning following direct and indirect exposure to proper names and common names after a 2-day delay. Jaswal and Markman conclude that most of the data suggest there is little difference between indirect and direct word learning and "this is noteworthy because our indirect word-learning situation lacked all of the overt, behavioral social-pragmatic cues – eye gaze, voice direction, a deictic statement – that we know children are extremely sensitive to" (p.758). The participants used syntactic and semantic cues to learn a new word indirectly and the resulting mapping was as robust as a mapping based on ostensive instruction, when tested immediately (Jaswal & Markman, 2001) or after a delay (Jaswal & Markman, 2003). And the mapping made indirectly after a delay, was not more fragile and open to revision from subsequent inconsistent information than the mapping made directly.

However, Experiment 1 and Jaswal and Markman (2003) only found long-term retention of object labels. Neither of these studies has tested retention of novel facts from a mapping made indirectly. It is possible that indirect mappings of facts are much more difficult. Other indicators that can help children feel confident about the referents for novel count nouns, such as syntactic and semantic cues, may not be available for facts.

Emphasising the Target Object

In addition to ostensive labelling, Experiment 3's procedure emphasised the target object by referring to it as 'really special'. This copied the language used in Waxman and Booth's (2000) study where long-term fast mapping of facts was also established. Intuitively, it would seem that the experimenter's focus on the target would help children to listen to the fact and remember its connection to the target object, familiar or novel. But what of the evidence? Markson and Bloom (1997) did not draw special attention to the target object in this way and still attained retention of fast mapped linguistic facts. In contrast, Vlach and Sandhofer (2012), when looking at the retention of fast mapped object labels, drew special attention to their target object and found that it was not sufficient on its own to aid long term memory of the associated novel object label – the participant also needed to generate the new word to evidence long term retention.

Number of Presentations of the Novel Fact

Experiment 1 presented the novel fact just once before testing one week later, whereas participants in Experiment 3 heard the fact twice - once during the Exposure Session and once during the Immediate Testing Session. Hearing the fact more than just once may have helped the participants in Experiment 3 retain the novel fact after one week. There was more than one exposure to the new fact in the other studies in the literature that also found retention of facts. Participants were introduced to the new fact twice during the training phase in Waxman and Booth (2000) and three times in Markson and Bloom (1997). It is possible that fast mapping and retention of facts is sensitive to the number of exposures and that just one exposure is simply insufficient to produce retention.

Repeat Testing

In Experiment 3, in contrast to Experiment 1, the Time Interval conditions were within participants: the same children were tested in each time delay. This meant that each child was tested on his/her knowledge of the link between the novel object and the novel fact at the end of the exposure session and before they encountered the test session one week later. Waxman and Booth (2000) included a similar step. Although their Immediate and Delay conditions were between participants, the experimenter assessed whether each participant had established a mapping to the target at the end of the training phase, asking `Can you hand me the one that my uncle gave to me?' (Fact condition). This was identical to the question asked during the test session. This very act of testing participants straight away may have assisted retention in two main ways. Testing immediately after exposure may have helped consolidate the children's understanding and knowledge. The test may also have signalled the novel fact as important and/or relevant and encouraged a commitment to memory. Nevertheless it is important to note that, however helpful undergoing the test question previously may be, it does not seem to be absolutely necessary. Markson and Bloom (1997) found long term fact retention without including a repeat of the test question. In addition, several studies have evidenced long term object label retention following minimal exposure without using repeat testing (e.g. Vlach & Sandhofer, 2012; Booth, McGregor & Rohlfing, 2008; Goodman, McDonough & Brown, 1998; Woodward, Markman & Fitzsimmons, 1994).

Mixed v Uniform Object Arrays

Experiment 1 presented an array of objects that were uniformly familiar. Experiment 3, on the other hand, presented an array of objects where some were novel and some were familiar (a mixed array). So, even though only the familiar objects were associated with a fact in the Fact, Familiar Object condition in Experiment 3, the participants were still presented with novel objects as part of the array. Markson and Bloom (1997) and Waxman and Booth (2000) also presented a mixed array. Experiment 3 demonstrated that children will fast map facts to familiar as well as novel objects, but perhaps the difference is more subtle. Maybe it is the mere presence of novel objects that 'primes' children to accept new information about any of the objects in the array and this may be true of object names as well as facts about objects. It is interesting to note that Experiment 2 presented uniform object arrays, either wholly familiar or wholly novel, and no retention was evidenced in any of the conditions.

<u>Other Differences Between Experiments 1 and 3, Common with the Literature</u>

There are some remaining methodological differences between Experiments 1 and 3 that share similarities with experiments reported in the literature.

Naming

During Experiment 1's Exposure Session, each of the familiar objects was labelled. However, in Experiment 3, the exposure session did not involve naming any of the familiar objects. The naming might have somehow interfered with participants' ability to be open to new information about the familiar objects. It might have ‘primed’ participants for object labels or count nouns, distracting them from the relevance or importance of any other information they heard about the objects such as facts. Markson and Bloom (1997) found that facts were fast mapped and retained but did not appear to label any of the familiar objects. Waxman and Booth (2000) did refer to their four familiar objects by name and still found fact retention, but the naming was not intrinsic to the task.

Selection

In Experiment 1, where there was no fact retention, participants were asked to select the target object based upon its name during the Exposure Session. (Note that Experiment 2 also required participants to select objects (based on their colour) and failed to evidence long-term retention). In comparison, participants did not select objects in Experiment 3 - each object was handed to the child. Perhaps, asking participants to select objects based upon their names in Experiment 1 was an absorbing task and prevented the children from learning a new fact about the target object. They could have selected the correct target without listening to or processing the novel fact. This is in contrast to the object label condition, where interpreting the novel object label was key to solving the selection task. Or perhaps selecting objects, based upon their names, ‘primes’ children to accept new object labels but not novel facts, explaining why there were good object label data in Experiment 1 and 3 but not good fact data in Experiment 1. Neither Markson and Bloom (1997) nor Waxman and Booth (2000) required participants to select the referent of their novel fact.

Summary

No single procedural property explains why facts are retained in some circumstances and not others. Each possibility would need to be explored in turn. Perhaps the differences are quite subtle, based upon methodological differences that are hard to identify. Alternatively, fact retention may be produced by a number of different factors that may all play a part: no one factor is key or even necessary. Some factors may have a stronger influence than others but it is the right mix or balance that will enhance retention.

The aim of this analysis has been to elucidate methodological factors that may boost or deter fact retention. There were a large number of procedural differences between Experiments 1 and 3 and any of these may have contributed to the variation in fact retention reported. However, there are some procedural steps used in Experiment 1 that differ from Experiment 3 as well as Markson and Bloom (1997) and Waxman and Booth (2000). All three of these experiments evidenced long term retention of linguistic facts in contrast to Experiment 1. Logically, it would seem that these procedural steps are the most likely to have some causal effect on the long term retention of linguistic facts. These are the experimenter naming the familiar objects in the array and the participant selecting objects from the array.

CHAPTER 5 – EXPERIMENT 4

Do Target Selection and Naming of Familiar Objects During Exposure to a Novel Fact Affect the Fast Mapping and Long-term Retention of Facts?

Introduction

So far the results for the retention of linguistic facts reported in this thesis have been equivocal. All the experiments have introduced children to an array of objects and linked a novel object label or a novel fact with one of these objects during the course of an activity. The child's recognition of the novel word-object link or the novel fact-object link was tested one week later. Experiment 1 suggested that facts were not retained. In contrast, Experiment 3 demonstrated retention of facts in line with Markson and Bloom (1997) and Waxman and Booth (2000). The current experiment tried to establish what may have caused these different results. From analysing the detailed procedures of Experiments 1 and 3, a number of procedural variations were detected – see Chapter 4, Discussion. The two procedural steps that also mark differences between Experiment 1 and the literature were investigated in the current experiment. This experiment addressed whether the retention of linguistic facts in pre-school children is affected by two different factors during the exposure session: (1) the experimenter naming the familiar objects presented to the child, and (2) the child selecting the target object. These factors are explained in detail below.

Naming

Does naming the familiar objects in the array discourage learning a fact about the target object? During the exposure session in the fact condition in Experiment 1, the experimenter named the familiar objects. Participants were presented with an array of five familiar objects and participants were tested on their comprehension of the familiar label. Participants were asked, "Can you point to the teddy? Can you point to the duck? Can you point to the car? Can you point to the pen? Can you point to the sock?" Facts were not retained above chance in Experiment 1. In contrast, none of the objects (familiar or novel) were named in Experiment 3, where retention of facts was evidenced. Instead objects were referred to in the generic form "this one". Participants were asked, "I want to stick all of these things onto my cloth so that it makes a fun picture. Let's start with this one. Where would you put this one? And how about this one?" etc. Naming the familiar objects may have prevented the participants from fast mapping and retaining anything else about them. Of course, facts can be learned about objects that are named, but perhaps the quick, incidental, long-term learning traditionally associated with the fast mapping concept is more restricted.

Why would naming familiar objects deter fast mapping and retention of a fact about an object? Firstly, naming the target object that is then linked with a novel fact may prevent the child from learning anything novel about that particular object from minimal exposure. So, naming every other object in the array may still permit fast mapping and retention of the novel fact, just not naming the target object. It is important to note that within a standard word-learning task, the child learns a new word relating to a novel object. Even if the familiar objects in the array are named during the task, the novel target object itself will never be named except with the novel word to be learned. Therefore, before hearing the novel object label, the child will not be given any other linguistic information about the target object. It may be this very lack of information about the target object that encourages a child to attach and retain a novel label or a novel fact to it. Secondly, the very act of naming the familiar objects during the exposure session may 'prime' children for processing names and make it difficult to learn facts. Naming objects may well help children to learn new object labels by setting up an appropriate context. However, naming objects is not an appropriate context for fact learning and may even deter fact learning. On hearing the new fact children may disregard it as unimportant or irrelevant. Experiment 2 did not name any of the objects that were presented to participants during the Exposure Session. Instead, participants were asked about the colour of each of the objects. No long term retention was evidenced and this may be because the colour naming established an inappropriate context for learning object labels and facts thereby discouraging long term learning.

In Experiment 3, none of the objects were named during the exposure session in the fact conditions, not even the target object. The target object was introduced to each participant in the following way: “This is really special - it's from a place called Koba - where do you want to put this one?” This may have allowed participants to fast map and retain new information about these objects. It is also worth noting that Markson and Bloom (1997) found that fast mapped facts were retained and they did not name any of the objects during the exposure session. Waxman and Booth (2000) did refer to the four familiar objects in their exposure session by name, but the novel fact was only ever applied to one of the novel objects that was not named. Also, Waxman and Booth (2000) introduced the target object (always the orange carpenter's level) at the very beginning of the training session for every participant and then went on to present the remaining novel and familiar objects, referring to the novel objects as ‘this one’ and the familiar objects by name. So Waxman and Booth’s (2000) participants were unlikely to have been ‘primed’ to process only object names as they were introduced to the novel fact before hearing any of the other object labels.

Selection

Does selecting an object interfere with fast mapping and retaining a linguistic fact about it? In Experiment 1, participants were asked to select objects during the Exposure Session. For example, participants were asked, “Can you give me the green duck that comes from koba?” Participants did not have to process the novel fact in order to make the correct selection from the array of objects – hearing the object name would have been enough. Also, participants had already been asked to select the objects based upon their names to evidence that the objects were indeed familiar. This was prior to hearing the crucial request incorporating the novel fact. Participants may have been primed to choose the target object by listening out for its name, thereby ignoring any other information.

But surely referent selection tasks require participants to select the novel object on hearing the novel name and referent selection tasks are a standard paradigm to demonstrate word learning (e.g. Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Wilkinson, Ross, & Diamond, 2003; Halberda, 2003;

Horst & Samuelson, 2008; Horst, Scott & Pollard, 2010). This is a commonly held view in the literature but there are two issues to consider when thinking about referent selection: long term learning and retention of a fact-object link. These referent selection studies have not evidenced long-term retention and a referent selection task is designed to introduce a novel name-object link - it is not easily adapted to introduce a novel fact-object link. These issues will be discussed in turn.

Firstly, referent selection studies rarely test long-term retention. Indeed, none of the studies that have produced convincing evidence of long-term retention have used a standard referent selection task. Markson and Bloom (1997), Waxman and Booth (2000) and Childers and Tomasello (2002) did not introduce their novel object labels (or facts) by requiring participants to make any kind of selection of the target object. Horst and Samuelson (2008, Experiment 1c) could not establish retention of a single novel object label even after just five minutes using a standard referent selection task. Their 2-year-olds could only demonstrate retention of fast mapped object labels once the experimenter named the novel object whilst pointing to it and holding it up. Goodman, McDonough and Brown (1998) demonstrated retention of multiple name-object mappings a day after exposure to the novel name-object links. Goodman *et al*., (1998) did not use a standard referent selection task but did use a similar procedure that required their participants to process the novel object label in order to be able to select the target object correctly. However, at the end of the exposure session, the experimenter reviewed the name-object mappings and made much more explicit connections between the novel objects and their novel labels. It is possible that the retention tested a day later was an outcome of this review rather than the referent selection task itself.

Jaswal and Markman (2003) appear to demonstrate retention of object labels up to two days following exposure to the novel words. Like Goodman *et al*., (1998), they did not use a standard referent selection task, but they did use a similar method to introduce the novel object label - participants had to process the novel name before selecting the target. However, two of the three objects presented at test were the target or an exemplar of the target, so it would seem that chance of a correct choice was 67%. It is therefore not clear from the results that retention at a rate significantly above chance was established. Experiment 1 reported in this thesis is not a standard referent selection task but did require the participants to select the target on the basis of the novel label introduced and appears to be the best evidence that a selection task can be associated with long-term retention of object labels. However, a similar selection task may discourage long term retention of linguistic facts.

Secondly, in referent selection tasks the child chooses the target based upon the novel word they hear, as they use the whole object assumption (Markman, Wasow, & Hansen, 2003), the mutual exclusivity principle (Markman, 1987) or the novel-name, nameless-category (N3C) principle (Golinkoff *et al*.,1994 and Mervis & Bertrand, 1994). But these are principles of word learning and no such principles have been established for the fast mapping and retention of facts. In the fact condition of Experiment 1 of this thesis, participants were presented with familiar objects and heard familiar names for these objects. Unlike the four word conditions, children could not link the novel fact with the target object simply from hearing the novel fact (there is no reason for them to link a novel fact with a particular object). Their accurate choice of the target object would have been guided by the experimenter's use of the object name, not the novel fact. Perhaps, only object labels are retained (on occasion) in such circumstances, because they are relevant and are intrinsic to the task. Experiment 3, reported in this thesis, evidenced good retention of facts, well above chance levels. Participants did not have to select objects in any way during the exposure session – each object was handed one by one to the child. This may allow them to register 'other' information about the object, such as a novel fact. Similarly, Markson and Bloom (1997) and Waxman and Booth (2000) did not require their participants to select the target object on introducing the novel fact and they both found good fact retention data.

The Current Experiment

This study was designed to establish whether two aspects of an experimental procedure, naming and selection, could prevent the fast mapping and retention of linguistic facts. Other procedural differences exist between Experiments 1 and 3 in this thesis that may well explain the variance in their results - fact retention after one week at chance levels versus impressive rates of fact retention after one week, significantly above chance levels. However, naming and selection also correspond to differences between Experiment 1 and the other studies in the literature that have evidenced fast mapping and retention of facts, namely Markson and Bloom (1997) and Waxman and Booth (2000). Neither Markson and Bloom (1997) nor Waxman and Booth (2000) included a selection task in establishing the retention of novel facts. Markson and Bloom (1997) did not name any of their familiar objects. Waxman and Booth (2000) did refer to their familiar objects by name but they only did so after introducing the novel fact-object link.

The current experiment presented participants with five familiar objects and introduced them to a linguistic fact about one of the objects. The children's comprehension of the novel fact-object link was tested one week later. In one condition the experimenter named all the objects and the child was required to select the target object based on its name whilst linked with the novel fact. In the second condition the experimenter named the objects but handed the target object to the participant whilst telling the child the novel fact. In the final condition, the experimenter did not name any of the objects and handed the target object to the child, whilst telling the child the novel fact. If selection and/or naming did affect the fast mapping and long term retention of linguistic facts then rates of retention should differ significantly between conditions.

Method

Participants

Table 5.1: Experiment 4 - Age, gender and numbers of participants

	Naming and Selection (NS)	Naming only (N)	No Naming, No Selection (NoNS)	Total
n	30	30	29	89
mean age (yrs)	4.02	4.08	4.17	4.09
age range (yrs)	3.37-4.66	3.39-4.65	3.43-4.68	3.37-4.68
gender (M,F)	17, 13	14, 16	16, 13	47, 42

98 children (3- and 4-year-olds) took part in this study. 47 were boys and 51 were girls, with a mean age of 4 years and 0 months. Three girls in the NS condition, three girls in the N condition and three girls in the NoNS condition were not available for the Test Session which occurred 6-9 days after the initial introduction, so their data were excluded. Therefore, there were a total of 89 participants: 47 boys and 42 girls. All participants attended a state-run primary school (nursery and reception years) in North London, UK. The number, mean age, age range and gender of all the participants that took part in Experiment 4 are summarised in Table 5.1 above. There are no significant gender or age differences between conditions.

Design

This study used a between participants experimental design. There were three conditions: ‘Naming and Selection’ (NS), ‘Naming only (N), ‘No Naming, No Selection (NoNS). These conditions refer to how the child was exposed to the novel fact. In the NS condition, the experimenter named the familiar objects and the task required the child to select the target object. In the N condition, the experimenter named all the objects, including the target object, but the child did not need to select it; instead the experimenter handed the target object to the child. In the NoNS condition, the experimenter did not refer to the name of the objects, nor did the children select the target object.

The dependent variable was Comprehension Accuracy – picking the item that had been associated with a novel fact from an array of objects (as for Experiments 1, 2 and 3).

Stimuli

The task introduced a novel fact linked with a familiar object in the Exposure Session and tested comprehension of this novel fact one week later in the Test Session. The fast mapping task presented the participant with five familiar objects (the task array). All of the conditions presented the same task array of five familiar objects in both the Exposure Session and the Test Session. The familiar objects were in five familiar basic colours: a blue pen, a red sock, a green duck, a pink teddy and a purple car. The objects were placed upon a plain white cloth. All the objects and their colours used in the fast mapping tasks in this study are depicted below in Figure 5.1.

Figure 5.1: Experiment 4 - Stimuli

From left to right: Blue pen, red sock, green duck, pink teddy and purple car

An important difference between this experiment and the previous experiment, Experiment 3, is that the array of objects presented to the participants comprises familiar objects only. This is for two reasons. Firstly, if the array of objects was mixed, made up of both familiar and novel objects, not all the objects could be named. Nor could participants be expected to select the unnamed novel objects except by referring to some other feature of the novel objects. It was this kind of procedure that may have prevented any retention in Experiment 2 – the focus on colour may have distracted children from processing or learning anything at all. As the focus of the experiment was on naming and selection of objects, it was important to include only those objects that could be named and then selected based upon that name. Secondly, Experiment 3 demonstrated that children can attach novel facts equally well to either familiar or novel objects. This suggests that the familiarity or novelty of an object has no effect on a child's ability to map and retain information.

<u>Procedure</u>

All participants underwent a fast mapping task comprising an exposure session and a testing session. Each participant was introduced to a novel fact "(it) comes from a place called Koba", about one of the five familiar objects in the exposure session (see Figure 5.1.). Each of the five objects was associated with a novel fact in strict rotation. Comprehension of this novel fact was assessed in the testing session one week later.

Exposure Session

Participants were presented with a transparent box containing the five familiar objects depicted in Figure 5.1. above. Participants were asked to get all the objects out the box and were asked to "Look at all these things. How many are there? Do you want to count them?" If the child was hesitant to count the objects the experimenter said, "Let's count them together" and counted the objects, pointing to each of them in turn. This ensured that participants touched and looked at each object, for broadly equivalent amounts of time.

Following this brief introduction to the objects, the experimenter started the main task. The experimenter said, "Look. Here I have a cloth" and laid out a white cloth, placing the five objects in a pile on the side of the cloth. Then the experimenter said, "I want to place all of these things onto my cloth so that it makes a fun picture. Can you show me where to put them so it looks really good? We'll do it one at a time so we don't miss any out."

Naming and Selection Condition (NS)

In the NS condition, the experimenter named each familiar object and the participant was asked to select each object, as part of the experimental task. For example, the experimenter said, “Can you get the pen? Where do you think it should go?” The experimenter waited for the child to take the pen and put it somewhere on the cloth. If the child was unsure of what to do, the experimenter suggested a couple of places the pen could go and demonstrated with a couple of the objects how to make a picture, returning all the objects to the side of the cloth (this was necessary for only two participants across all the conditions). After the child had placed the pen somewhere on the cloth, the experimenter asked, “Can you get the sock? Where's a good place for it?” After the child picked up the sock and placed it on the cloth the experimenter asked, “Can you get the duck? Where would you like to put it?” then “Can you get the teddy? Where should this one go?” and finally “Can you get the car? Where would you like it to go?” waiting for the child to place the object before going on to the next one.

During this task, with the child picking up each object in turn and placing it on the cloth, the experimenter introduced some new information about just one of the objects (the target object). For example, when the target object was the blue pen (for approximately a fifth of participants) the experimenter asked, “Can you get the pen that comes from a place called Koba? Where do you think it should go?” Another fifth of the children heard the novel fact linked with the sock: “Can you get the sock that comes from a place called Koba? Where's a good place for it?” For similar numbers of participants the duck, the teddy and the car was the target, respectively.

Once the child had completed the task and had placed all five objects onto the cloth, the experimenter said, “That's brilliant thank you. I think that looks really great. What do you think? Are you happy with it?” and participants were allowed to change the position of any of the objects if they wanted to (only two did so). The task was specifically designed so that there was no obvious right or wrong answer, in which participants could ascertain the rules and then focus on that aspect of the task, as appeared to happen in

Experiment 2. The participants could lay out the objects as they saw fit. It was important that participants were not distracted by the task requirements from processing any new information they heard about any of the objects.

Naming only Condition (N)

In this condition, the experimenter named each of the familiar objects, but the participants did not select each object as part of the task in the Exposure Session. The experimenter picked up each familiar object in turn and named it before handing it to the child to place on the cloth. After counting the objects and being told that the objects were to be used to make a picture, the experimenter picked up each of the objects in turn and the participant was told: “Let's start with the pen. Where do you think it should go? How about the sock? Where's a good place for it? What about the duck? Where would you like to put it? And how about the teddy? Where should this one go? And here's the car. Where would you like it to go?” For one of these objects, the novel fact “that comes from a place called Koba” was attached to it. For example, for the children where the teddy was the target, the experimenter said “And how about the teddy that comes from a place called Koba? Where should this one go?”

No Naming, No Selection Condition (NoNS)

In the NoNS condition, the experimenter did not name the familiar objects and the participants did not select each object during the experimental task. The experimenter picked up each familiar object in turn and merely handed it to the child to place on the cloth. Each object was referred to in a generic way, such as “this one”. After counting the objects and being told that the objects were to be used to make a picture, the experimenter picked up each of the objects in turn and the participant was told: “Let's start with this one [the pen]. Where do you think it should go? How about this one [the sock]? Where's a good place for it? What about this one [the duck]? Where would you like to put it? And how about this [the teddy]? Where should this one go? And here's this one [the car]. Where would you like it to go?” For one of these objects, the novel fact “that comes from a place called Koba” was attached to it. For example, for the fifth of children where the duck was the target, the experimenter gave the duck to the participant and said “What about this one that comes from a place called Koba? Where would you like to put it?”

Test session

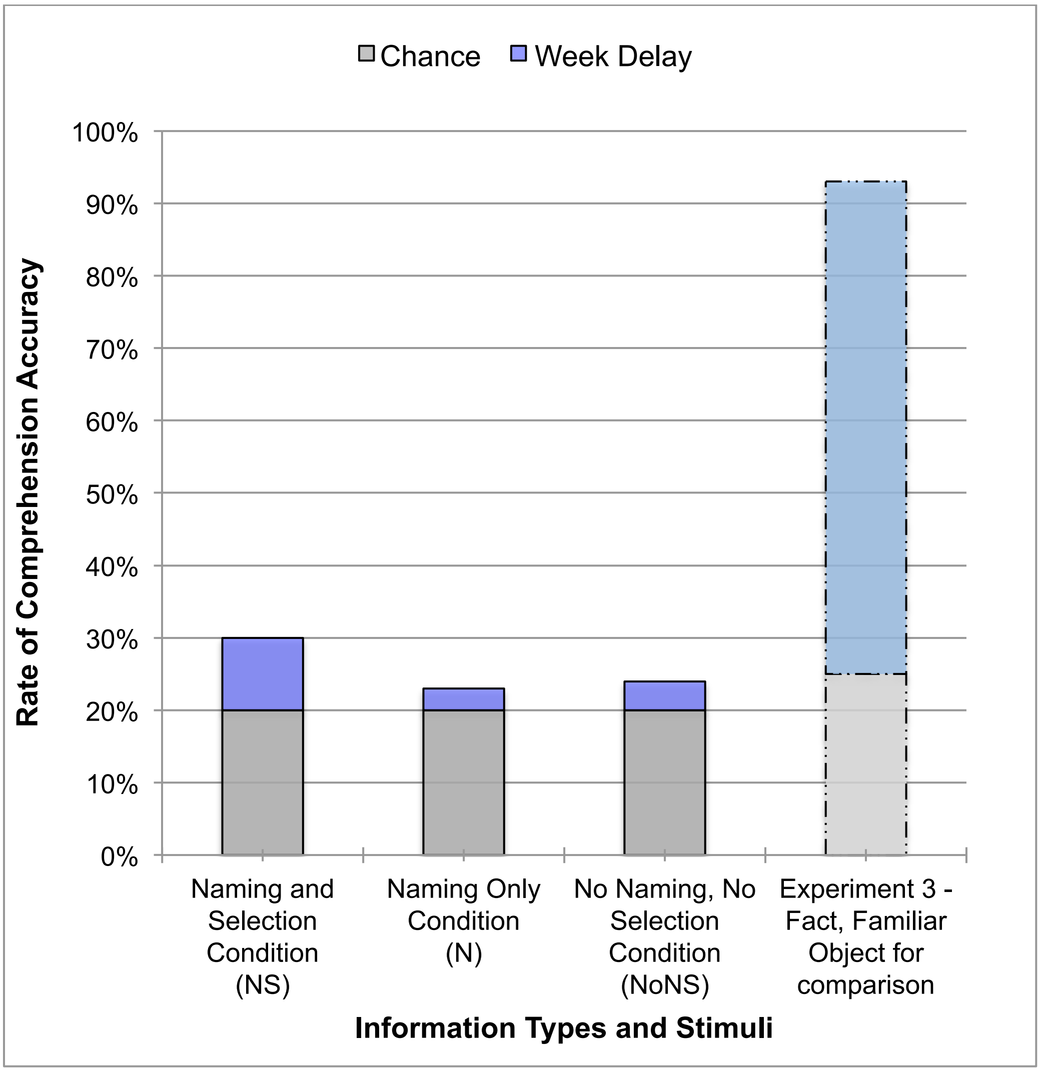
Participants’ comprehension of the novel fact was tested after a delay of one week. The object array of the five familiar objects used in the exposure session was laid out on the cloth before the child was called into the room. When the child was in front of the objects, the experimenter asked, “Can you show me which one is from a place called Koba? Can you point to it?” If they chose the target object that had been introduced with the novel fact during the exposure session their answer was deemed correct. Any other choice was deemed incorrect.

Results

Comprehension accuracy was low - between 23% and 30%. The children could not identify the referent of the novel fact after one week. Binomial tests comparing performance to chance revealed that retention was not significantly different from chance in any of the conditions. As any of the five novel objects in the test array could have been the target, chance was 1 in 5 (20%).

There were no significant differences between conditions. The data are represented in Figure 5.2 below. The profiles of chance and comprehension accuracy in each condition, and the similarity of these profiles across conditions, are clear. There was not a significant association between the experimenter’s naming of familiar objects nor participants’ active selection of the target object and comprehension of the novel fact-object link after one week, $\chi^2(2, N=89)=0.41$, $p=0.813$.

Figure 5.2: Experiment 4 - Participants' Comprehension Answers



Discussion

There was no learning evidenced in the current experiment. It sought to establish whether two methodological factors affect the long-term retention of facts. These two factors affected the exposure session, where the participant was introduced to the novel fact: (1) the experimenter naming the objects in the array and (2) the child actively selecting the target. It was expected that the participants' active selection of objects and the experimenter's naming of the familiar objects, within a fast mapping task, would deter retention of a linguistic fact-object link. It was predicted that retention one week later would only be significantly greater than chance in the third experimental condition, where no naming or selection took place. In addition, it was expected that retention in the 'No Naming, No Selection' Condition would be significantly greater than the rate of retention in the 'Naming and Selection' Condition and the 'Naming Only' Condition.

As expected, facts were not retained significantly above chance levels in the 'Naming and Selection' and the 'Naming Only' Conditions. However, no facts were retained in any of the conditions, significantly above chance. Whether the object was named by the experimenter, selected by the child or simply handed to the child, and referred to in its generic form, had no effect on retention. These results suggest that neither the experimenter naming familiar objects nor the participant's active selection of the target object had any effect on retention.

However, as no facts were retained in any of the conditions it is difficult to make any firm conclusions about the effect of selection or the naming of objects on the long-term retention of facts. Perhaps, a different procedure that would demonstrate at least some long-term fact retention, would be sufficiently sensitive to demonstrate some differences from the effects of selection of objects (either by the participant or by the experimenter) or from the naming of objects in the array. Nonetheless, it would appear at the very least that selection and naming are not strong enough factors on their own to induce the retention of facts.

The failure to retain any facts, reported here, is consistent with the data reported in Experiments 1 and 2 but contradicts Experiment 3's results, where the majority of children retained a novel fact after one week, and the literature, where long-term retention of facts has been evidenced in two separate studies (Markson & Bloom, 1997 and Waxman & Booth, 2000). In Experiment 3 and the studies cited in the literature, participants could identify the object associated with a novel fact from an array of novel and familiar objects at least one week after the initial introduction to the novel fact.

No Long Term Fact Retention

It is important to consider why facts were not retained in this experiment, especially when the task that the participants completed was so similar to the task in Experiment 3. In both experiments, the children placed the objects on a cloth to make a picture. Whilst they were placing one of the objects on the cloth, they were told, “it comes from a place called Koba”. Yet, in Experiment 3 facts were retained at well above chance levels in both the fact conditions. In comparison, the participants tested in this experiment failed to retain the same fact above chance levels. Perhaps these varying results are due to one or more of the possible reasons for differences considered in the discussion section in Experiment 3.

Intuitively, the most likely reason for good retention performance in Experiment 3 is repeat testing. The within-participants design meant that participants were tested immediately as well as one week later. Being asked the identical comprehension question straight after exposure is apt to be an important *aide memoire*, embedding the link between the linguistic fact and the object. In addition, the experimenter stated that the target object was ‘really special’, emphasising its importance. And, Waxman and Booth (2000) incorporated both these procedures and similarly found very high levels of retention of linguistic facts. However, the reasons for not exploring such differences in this study and focusing on naming objects and experimenter versus participant selection still hold true - Markson and Bloom (1997) did not use either of these techniques and found good retention, even a month later. Perhaps, Markson and Bloom’s (1997) data are hard to replicate and it is very difficult to obtain fact retention without repeat testing.

Mixed Array

A consistent difference between all the various methods across Experiments 1-4 and the majority of the literature is the use of a mixed array versus an all-novel or all-familiar array. Woodward, Markman and Fitzsimmons (1994), Markson and Bloom (1997), Waxman and Booth (2000), Childers and Tomasello (2002) and Vlach and Sandhofer (2012) have all found retention of object labels and, when tested, facts. And they have all used a mixed array comprising both novel and familiar objects. Experiment 3 used a mixed array and found fact retention. The current study, along with Experiments 1 and 2, presented an array comprising either familiar objects or novel objects exclusively and retention was no better than chance. Whether the mix of familiar and novel objects in the array affects retention has not been investigated in this thesis as it seems an unlikely prerequisite for fact retention in the long term (note that performance was good in the immediate condition in Experiment 1 where an all-familiar array was used). However, it is possible that a mix of familiar and novel objects provides an implicit contrast that encourages children to attend to new information about any of the objects presented.

Indeed, it may be the case that fast mapped object labels can only be retained in the long term when presented with a mixed array, and perhaps this is the reason why not even object labels were retained in Experiment 2. Most studies in the word learning and fast mapping literature have used a mixed array. For example, a common word-learning paradigm is the referent selection task, which by its very nature involves a mixed array. But the composition of the array itself has never been looked at. Maybe some familiar objects are required to provide context and some novel objects are required to indicate that there is something new to be learnt.

However, it is important to note that Goodman, McDonough and Brown (1998) and Jaswal and Markman (2003) both evidenced retention of object labels after a 24-hour and 48-hour delay, respectively, and their arrays consisted only of novel objects. Yet both these studies involve other methodological steps that are likely to foster long-term retention and may have more than compensated for any problems posed by an array comprised of novel objects exclusively. Goodman *et al.*, (1998) reviewed the name-object links with their participants prior to testing so retention may be a result of this review rather than memory of a clear link between the object label and its referent. In Jaswal and Markman (2003) the test objects presented on the retention trial were the named target, a slightly different exemplar of the target and a completely novel object that the child had not previously seen. Thus, it is not clear whether children's selections of the target during retention were based on the increased familiarity of that object relative to the others or on a long-term representation of the name–object link. In addition, chance performance would have been 67% - either the target or the novel generalization item from the same category would have been a correct answer in response to the test question. It is not clear that participants' retention rates were significantly greater than chance. Finally, even if Goodman *et al*., (1998) and Jaswal and Markman (2003) are assumed to demonstrate long-term retention of object labels, long-term retention of facts has only ever been demonstrated when a mixed array has been used.

Do familiar objects compete for the child's attention?

Since Experiments 1, 2, 3 and 4 were devised and completed, Horst and Samuelson (2008) and Horst, Scott and Pollard (2010) published their studies on fast mapping and retention of object labels with 2-year-olds. In Horst and colleagues' (2008, 2010) first set of studies they found it difficult to find any evidence of retention after just a five-minute break. They were eventually able to demonstrate retention using a standard forced-choice referent selection task, augmented with ostensive naming. Retention was only evidenced when: (1) participants were provided with ostensive presentation of the novel name-novel object link as well; and (2) the number of familiar objects in the referent selection task was limited to two. So the array during the exposure session always comprised some familiar objects but when more than two were present there was no retention.

Horst *et al*., (2010) argue that in a standard forced-choice task, familiar objects compete against each other and against the target object as possible referents for the novel name. Their data suggest that the mutual exclusivity rule predominates during a referent selection task – the principle that if an object already has a name it cannot also be the referent of the novel name. Thus, children eliminate objects as potential referents by going through each of the familiar objects one-by-one. This means that the initial referent selection task requires the child to attend to the known objects - the child could determine the referent of a novel name by attending exclusively to the familiar, competitor objects and encoding nothing about the physical properties of the referent itself. The number of competitors does not affect success at referent selection as children can choose the target by a process of elimination – a real-time process. However, the number of familiar objects may affect retention. The number of competitors in the referent selection task may hinder a child's ability to encode the target name-object mapping during the initial naming instance, as the attention to the novel object is reduced by attention to increasing numbers of familiar objects. This in turn may prevent the child from remembering the name-object mapping. So the referent selection task itself may hinder retention and does so to a lesser or greater degree depending on the number of familiar objects that are presented.

How does Horst and colleagues' work inform the discussion of the data presented here? The conclusions and parallels that can be drawn here are inevitably limited. Horst and Samuelson tested object labels only, whereas the current experiment examined the fast mapping and retention of linguistic facts. Also Horst and colleagues (2008, 2010) tested younger children and they introduced their participants to several object labels whereas Experiments 1-4 exposed the children to just one new word or fact. However, some useful inferences can be drawn. Firstly, perhaps the number of familiar objects presented during the exposure session can, at least in part, explain the retention rates of linguistic facts. Experiments 1, 2 and 4 presented participants with an array comprising only familiar objects and found no retention. Experiment 3, which evidenced retention of facts well above chance, presented children with only four familiar objects as part of an array that comprised novel objects as well. It is possible that it is the overall proportion of familiar to novel objects that is key. Secondly, Horst, Scott and Pollard (2010) suggests that a selection task can affect retention as can the number of familiar objects presented in the array of objects at exposure. Finally, Horst and colleagues (2008, 2010) demonstrate that fast mapping and retention of object labels is limited and that results are more varied than the literature previously suggested.

Summary

The current study and the previous three experiments suggest that fast mapped facts can be retained, but only in some circumstances. The overall picture is much more mixed than would at first appear from the literature. From seemingly similar experimental procedures very different results have arisen. There may be a whole host of factors that contribute to the retention of facts and these may or may not correspond to those required for accurate retention of object labels. Some factors may be essential to attain retention – perhaps a mixed array or some appropriate balance of novel and familiar objects. Other factors may contribute to better retention but not be absolutely necessary on their own: selection, ostensive labelling and testing immediately are possible examples. Other factors, if present, may deter or preclude retention of facts and, crucially, different combinations of these various factors may produce wildly fluctuating results. For example, what would be the outcome of a study that incorporated a factor that reliably produces fact retention with a factor that deters or precludes retention? Establishing exactly what these factors are would require developing a set method that reliably produces fact retention, which would be challenging in itself, and then going on to test each factor one by one to measure its effect. This is beyond the scope of this thesis but would be an interesting avenue for future work.

CHAPTER 6 – EXPERIMENT 5

Are Some Facts Extended Systematically?

Introduction

So far this thesis has investigated the fast mapping and long term retention of linguistic facts and words (principally object labels) and explored how different experimental procedures affect long term retention. This final experiment shifts focus away from long term retention, to the extension of object labels and linguistic facts.

Extension

Knowing when and how to extend a word is an important next step in word learning. When a child learns a word they have to work out the link between the word and its referent and retain that link in memory. However, in order for language to be a useful method of communication, words also need to be generalisable and on learning a word a child needs to know how and when to extend it to other referents. For example, learning a count noun such as ‘horse’ requires the understanding that the word ‘horse’ will also apply to other similar-shaped animates of varying sizes, colours and textures. Knowing the word ‘horse’ also requires that you do not ‘over-extend’ the word to other referents that may have similar features e.g. a cow is an animal, potentially similar in size and colour, with four legs and hair. Young children are known to demonstrate a ‘shape bias’ - a tendency to generalize a novel name for a novel solid object only to other items that are similar in shape (e.g., Landau, Smith & Jones, 1988).

Children extend object labels but not facts

Waxman and Booth (2000) argued that upon learning a novel word a child knows how to extend this word. In particular, children extend novel object labels beyond the individual, systematically, to incorporate other members of the same object category. Children as young as 14 months are able to demonstrate this pattern of extension (Waxman, 1999; Waxman & Markow, 1995). Waxman and Booth (2000) proposed that this is a crucial difference between learning words and facts, suggesting that learning words may still utilise domain specific cognitive abilities, counter to Markson and Bloom's (1997) claims. They introduced their 4-year-olds to a novel object label or a novel linguistic fact, linked with a novel object. Testing comprehension immediately and one week later, they demonstrated that children retained fast mapped object labels and linguistic facts following a significant delay, echoing Markson and Bloom's (1997) data. Following the comprehension test at both time intervals, Waxman and Booth (2000) also tested whether their participants would extend these newly learned object labels and facts using two challenging extension tasks (a more detailed description is provided below). The 4-year-olds systematically extended fast mapped object labels to novel exemplars of the same object category. This evidenced that children appropriately extended object labels even when their exposure to the label and its referent had been minimal. In contrast, children in the fact condition revealed no such systematic extension of the fact to members of the target category in either of the extension tasks. Behrend, Scofield and Kleinknecht (2001) replicated this finding in 2½-year-olds.

Waxman and Booth (2001) argue that the key difference between words and facts is that children know how and when to extend newly learnt words but demonstrate no such knowledge when extending facts. For example, children will extend novel count nouns to other objects from the same category, but know not to extend proper names beyond the individual, and will do so at well below chance levels (Hall, 1999). In contrast, facts such as "my uncle gave this to me" are extended at chance levels. It is this key difference in how children treat newly learnt words and facts that lead Waxman and Booth to argue that at least some aspects of word learning are likely to invoke specially dedicated mechanisms. Or, more precisely, there is insufficient evidence to support Bloom's (2000) claim that word learning only involves general cognitive processes by merely demonstrating one shared component (fast mapping) between word learning and fact learning.

Can some facts be extended like words?

Waxman and Booth (2000) introduced their participants to a fact that has indefinite extension rules, particularly within the context of their experiment. There are strict semantic and grammatical rules surrounding most word types. Proper names for example, refer to an individual, in all situations in which that individual appears, regardless of the conditions in which it is used. The individual needs to be animate or animal-like. In English, proper names such as ‘Tom’ are constrained by the following grammatical rules. They are not normally plurals and they do not follow determiners ('a', 'the' etc.), quantifiers ('several' etc) or adjectives (‘happy' etc) – e.g. it is generally regarded as incorrect to say Toms, a Tom, several Toms, happy Tom. The exception is a term such as 'Big Tom', generally used to differentiate one person named Tom from another. In this way the adjective becomes part of the proper name. These rules help language users to identify a proper name (Hall, 1999). For example, a proper name is only used to relate to a specific individual and therefore does not extend to any other individual.

However, the rules surrounding the extension of linguistic facts are much less clear. “Facts vary in whether they are tied to particular individuals” (Childers & Tomasello, 2003, p.185). Some facts are generalisable to other exemplars of an object category and some facts are not. The rules surrounding the extension of facts are contextual and often rely on the language used in the fact. For example, “dogs have hair like all mammals” is a fact that is clearly extendable to all dogs. However, “Tom likes to play with Lego” is clearly specific to Tom and, even though experience may tell us that other children like to play with Lego too, there is nothing in the fact itself to suggest that it must be applied to anybody else.

Added to this rather more complex situation regarding facts and their extension, children (and adults, possibly) may well interpret facts differently within a standard experimental task. In most normal linguistic contexts, a fact such as “my uncle gave this to me” is not generalisable to other objects that I own. This is based on experiential knowledge that a person tends to own a number of things and it's unlikely that an uncle has given that person more than one or two of those things. However, when presented with a somewhat 'unreal' experimental task, it may be quite a sensible, pragmatic assumption that the experimenter's entire box of objects, most of which are novel, may all have been given to the experimenter by her uncle. This may explain why Waxman and Booth's (2000) participants did not restrict the linguistic fact to the target object, as would have been the case if it was a proper name to which they had been introduced (Hall, 1999). That these rules are changeable and can appear to be unclear even to adults on occasion, suggests they will also be unclear to children.

Waxman and Booth (2000) acknowledge that some facts can be extended beyond the designated individual. They argue that children must discover which facts can be generalized on the basis of category membership. They propose that the extension of a novel fact depends on knowledge about the kind of fact, and the kind of individual to which it has been applied, and that the extension process for novel words is quite different. The extension pattern for words is linked to their grammatical form and these links seem to be available by 2½-3 years of age (Waxman, 1998). The link between count nouns and object categories is evidenced in even younger children (14 months – Waxman, 1999; Waxman & Markow, 1995). Presumably, the reference to the young age that children are able to extend novel words suggests that Waxman and Booth think it is likely that there is some special or dedicated system for word learning – otherwise how would children have knowledge of these extension patterns so early? However, children's exposure to words starts very early, particularly the kinds of words that Waxman and Booth refer to: count nouns, proper nouns and adjectives such as colour or texture – i.e. simple properties with a direct visual link to external objects/materials. Also, the only evidence that Waxman and Booth (2000) provide for the difference between words and facts is an example of a fact that is not extended to the same extent as a count noun by 4-year-olds. If it could be shown that young children can extend a fact systematically, as well as a count noun, this would challenge Waxman and Booth's proposition.

That words and facts differ in their extendibility does demonstrate a difference between words and facts. Words have very strict rules governing their use, most facts do not to the same extent. However, this difference does not demonstrate a disparity in the cognitive processes used to learn words and facts and the nature of their extension. The cognitive processes used to understand and extend words may well be the same as those used for facts. Words and facts are both used to categorise information.

Other evidence for the extension of facts

Behrend, Scofield and Kleinknecht (2001) similarly found that extension of facts was significantly poorer than the extension of novel count nouns. However, like Waxman and Booth (2000) they also introduced children to facts that were unlikely to extend to other objects. All the children in the fact condition in Experiment 1 were told "See this? This fell in the sink yesterday" about the target object. In Experiment 2, all the participants were told one of four facts: "My uncle gave me this koba", “My cat stepped on this agnew”, “This jeter was found in the park” and “The nixon fell in the sink” thereby introducing each child to both a fact and a novel object label. Again all of these facts are very specific and very unlikely in any real situation to apply to more than one specific object.

Diesendruck and Bloom (2003) investigated the shape bias in 3-year-olds. The shape bias describes children’s tendency to name objects based on their shape. Bloom’s (2000) “shape-as-cue” account states that the relationship between count nouns and same-shaped objects exists, not due to a direct association but because children believe that count nouns refer to object kinds. Children pick objects based on their shape as shape is a reliable cue to the kind to which an object belongs. Diesendruck and Bloom (2003) were not researching extension of facts directly but Study 2 presented facts about novel objects and investigated how children would extend these facts. Would they extend them to another object similar in shape or an object similar in colour or an object similar in material? These facts were defined as either category-relevant or category-irrelevant. Category-relevant facts described an “objective” feature of the target object that was relevant to the object’s category membership or kind and, therefore, should be generalisable. In the category-irrelevant condition, the property was irrelevant to the category insofar as it specified a unique feature of the target object.

In the category-relevant condition the experimenter would introduce the child to a novel object and say, for example, “Look at this. It was made at Isradex factories. See, this was made at Isradex factories.” The participant was then given the opportunity to generalise this property to one of three test objects, similar in shape, colour or material. The experimenter asked the child “Which one of these (the test objects) was also made at Isradex factories?” In each condition, this procedure was repeated for four different sets of objects, each with a different fact. An identical procedure was used for the category-irrelevant property condition, but here the fact introduced was not relevant to the object’s category e.g. “My uncle gave this to me” or “I got this for my birthday”.

Diesendruck and Bloom (2003) found that category-relevant facts were applied to objects similar in shape significantly more than category-irrelevant facts, and that both types of facts were generalised to objects of a similar shape more than chance. Diesendruck and Bloom’s findings suggest that some facts are indeed generalisable, and that children will extend newly learned facts to other objects of the same shape as they do with newly learned object labels.

I collected pilot data from some of the participants at the end of Experiment 3, following the test session in the Week Delay condition. Experiment 3 introduced some children to a linguistic fact, “it comes from a place called Koba”, and it was found that they could retain the object-fact link one week later at well above chance levels. “It comes from a place called Koba” is more generalisable than the ‘uncle fact’ used by Waxman and Booth (2000) - it refers to information relevant to how the object is categorised. Participants’ willingness to extend this more generalisable fact was tested. The 24 (of 30) children who correctly chose the target at the comprehension test after one week were presented with a new array of 6 novel objects: 1

exemplar of each of the 4 original novel objects used in the comprehension task – the same shape but in different colours - plus two additional novel objects. 92% of children tested, readily extended “it comes from a place called Koba” to the exemplar of their target object. This compares to 93% of the 25 children who extended a novel count noun (koba) to the target exemplars. So the rates of extension for novel words and novel facts are very similar.

These pilot data support Diesendruck and Bloom’s (2003) findings and suggests that children will extend some facts. However, it did not compare extension of this generalisable fact to a more specific fact. And, like Diesendruck and Bloom (2003), the pilot study only presented children with one exemplar of each of the target objects during the extension test. Further, Diesendruck and Bloom’s (2003) experiment presented children with a forced choice. They had to choose either the shape match, the materials match or the colour match in response to the generalisation question. Similarly, it is likely that participants in my pilot study viewed the task as a forced choice. Even though the question was open (“Can you see a koba?” or “Are any of these from a place called Koba?”), the children probably assumed that they were ‘supposed to’ choose one of the six objects in the extension array. This interpretation is supported by the data. None of the children extended to either no objects or more than one object, unlike the children in Waxman and Booth (2000). A forced choice task is an appropriate test when investigating the shape bias, but is very limited when assessing extension. The participant is not given the opportunity to extend the word or fact to all of or a selection of the objects presented. So, my pilot study and Diesendruck and Bloom (2003) give an indication of how children will behave in a situation where they are asked to extend facts, but it is far from a complete picture.

Waxman and Booth (2000) set a more challenging task to assess extension. They introduced their participants to the target novel object, applying either a novel word to it (“koba”) or a novel fact (“my uncle gave this to me”). The target object was one of 10 training objects (6 novel, 4 familiar) that the children saw and touched during a task that demonstrated an arbitrary action with each of the objects. If the child could accurately identify the target object as the object linked with the novel count noun or novel fact in the comprehension task, they went on to be tested for extension. Waxman and Booth (2000) tested children for comprehension either immediately following the training session or one week later. The extension test always followed straight after a test of comprehension.

During the extension test children were introduced to an extension set of 13 objects. This set comprised the original target object plus two novel exemplars of each of the 6 novel objects from the training set. They underwent two different extension tasks presented in counterbalanced order: the Yes/No task and the Choice task. The Yes/No task showed the participant each of the objects in the extension set and asked “Is this one a koba?” (Word condition) or “Is this one that my uncle gave me?” (Fact condition). So the child needed to make an extension decision about each object presented to them.

The Choice task presented the child with the entire extension set, asking the child “Can you show me one that is a koba?” (Word condition) or “Can you show me one that my uncle gave me?” (Fact condition). Once a choice was made, the object was removed and the participant was asked, “Are there any other ones that are kobas?” (Word condition) or “Are there any other ones that my uncle gave me?” (Fact condition). This was repeated until the child said ‘no’ or until all the objects had been chosen.

In the Yes/No task, Waxman and Booth (2000) found that 100% of children extended the novel count noun, koba, to members of the target category exclusively. The corresponding figure in the Choice task was 92%. In contrast, the children’s extension of the fact was far less systematic across both tasks. An analysis of individual performance supported these findings: the proportion of children extending to the target category exclusively versus another type of extension pattern, varied significantly as a function of word/fact condition. However, it is proposed that, for a ‘generalisable’ fact the extension pattern will be much closer to that of a count noun.

The Current Experiment

This experiment used Waxman and Booth's (2000) extension tasks but included a generalisable fact to compare extension performance between a general fact, a more specific fact and a count noun. The generalisable fact used was "It comes from a place called Modi": clearly a more extendable fact than "my uncle gave this to me". "It comes from a place called Modi" is relevant to the object's category or kind, specifying an objective feature of the object. It refers to information relevant to how the object is categorised. For example, "a boomerang comes from Australia; therefore, other boomerangs come from Australia". Children's willingness to extend a fact like "It comes from a place called Modi" has been demonstrated via pilot testing and it is similar to one of Diesendruck and Bloom's (2003) category-relevant properties, "It was made at Isradex factories", that children extended to another object with a similar shape.

It is predicted that the current experiment would show that children extend "It comes from a place called Modi" as systematically as they extended count nouns to exemplars of the same object category. In addition, it was predicted that the extension of the generalisable fact and the object label (modi) to the target object exemplars would be significantly greater than participants' extension of the fact, 'my uncle gave this to me'. Such findings would challenge Waxman and Booth's (2000) proposal that fact learning uses different cognitive systems to word learning.

Method

Participants

73 preschoolers took part in this study and were tested for comprehension. The 61 participants who answered the comprehension test correctly, by choosing the target, went on to be tested for extension. The number of participants in each condition and their age and gender profile are

summarised in Tables 6.1a and 6.1b. There were no significant differences in age or gender across Information Type conditions.

Table 6.1: Experiment 5 - Age, gender and numbers of participants

Table 6.1a: Exp 5 - Participants at Comprehension

	Object Label	**Fact Specific**	**Fact General**	**Total**
n	24	24	25	73
mean age (yrs)	3.92	3.85	3.8	3.86
age range (yrs)	3.34 - 4.94	3.21 – 4.94	3.20 – 4.52	3.20 – 4.94
gender (M, F)	11, 13	9, 15	7, 18	27, 46

Table 6.1b: Exp 5 - Participants at Extension

	Object Label	**Fact Specific**	**Fact General**	**Total**
n	19	21	21	61
mean age (yrs)	3.93	3.92	3.84	3.9
age range (yrs)	3.34 - 4.94	3.21 – 4.94	3.20 – 4.52	3.20 – 4.94
gender (M, F)	9, 10	9, 12	6, 15	24, 37

Design

This study used a between participants experimental design. Participants were introduced to a novel piece of information associated with a novel object. There was one independent variable – Information Type. Information Type designated the kind of novel information to which the child was exposed. There were three Information Type conditions: Object Labels, Fact Specific and Fact General. All participants were tested immediately after the exposure session. There were two dependent variables: Comprehension Accuracy and Extension Accuracy – picking the target object(s) from an array of objects.

Stimuli and Materials

The task involved an Exposure Session, a test of comprehension and a test of extension.

Exposure Array and Comprehension Test Array

The Exposure Array, presented to participants during the Exposure Session, comprised ten objects - six novel and four familiar (See Figure 6.1 below). Participants' comprehension of the link between the object and the novel object label or fact was tested using the same array. The novel objects were sourced from a large DIY store and will be referred to as a connector, double pipe clip, elbow, pipe collar, hose clip and pipe clip. The four familiar objects were a pink teddy, a red sock, a blue pen and a green duck. During the Exposure Session the objects were placed upon a plain white towel.

Figure 6.1: Experiment 5 – Stimuli, Exposure and Comprehension Test Array

From top left, by row:
Row 1:
pink teddy, red sock, blue pen, green duck.
Row 2:

white connector	(10mm)
blue double pipe clip	(22mm)
copper elbow	(22mm)
chrome pipe collar	(28mm)
green hose clip	(50-70mm)
pink pipe clip	(32mm)

The objects have been arranged in order for the purpose of this photograph. In the experiment their order was random.

Extension Array

The Extension Array (see Figure 6.2) was presented immediately after the comprehension task and assessed how children would extend the newly learned word or fact. The extension array comprised 12 novel objects. There were six pairs of two exemplars of each of the novel objects from the exposure array. These exemplars differed in colour and/or size. The objects have been arranged in order for the purpose of this photograph. In the experiment their order was random

Figure 6.2: Experiment 5 – Stimuli, Extension Array

From top left, by line: 6 pairs

1) Connector -	blue (15mm)	pink (15mm)
2) Double pipe clip -	red (15mm)	pink (22mm)
3) Elbow -	green (28mm)	red (22mm)
4) Pipe collar -	white (22mm)	blue (22mm)
5) Hose clip -	red (18-25mm)	blue (50-70mm)
6) Pipe clip -	black (60mm)	blue (32mm)

In contrast to Waxman and Booth's (2000) procedure, the extension array did not include the original target object. Waxman and Booth (2000) used only one of their novel objects as the target object (the carpenter level) for every participant. It was introduced in an array made up of 4 familiar and an additional 5 novel objects (the training set). The extension array comprised 13 objects: the original target (from the training set) and two novel exemplars of each unfamiliar object category, differing from the original training objects in color, pattern, texture and/or size. Waxman and Booth's (2000) procedure was biased towards the target object since it was the only object category in the extension array to present three rather than two objects and the target was the only object presented during the Extension tests that the participant had encountered before (during Waxman & Booth's training phase) – the other object categories presented exemplars only. This does not affect Waxman and Booth's (2000) key finding: that there is a difference in participants' extension of facts and object labels, since this bias towards the target object was present in both fact and word conditions. However, this bias may explain why children in Waxman and Booth's (2000) fact condition still chose extension objects from the target object category more than any other object category, so has been removed in this experiment.

Vocabulary Test

Participants' vocabulary was tested about one week after the comprehension and extension testing using The British Picture Vocabulary Scale: Third Edition (BPVSIII) scale (Dunn, Dunn & NFER, 2009). There were no significant differences in vocabulary scores across Information Type conditions.

Procedure

The procedure was based on Waxman and Booth's (2000) methodology. All participants in each of the word and fact conditions underwent a fast mapping task comprising an exposure session and a testing session. Each participant was introduced to a novel count noun or novel fact in the exposure session. Their comprehension and extension of this novel word/fact was assessed in the testing session that followed on immediately after the exposure session. The activity and method of introducing the novel word/fact used in Experiment 3 was reused here as this task had produced good comprehension data. The aim was to test participants for extension but it needed to be clear that they had understood the word/fact-object link first.

Exposure Session

Participants were asked to sit down at a table where a white towel was laid out. They were presented with a transparent box containing six novel objects and four familiar objects (See Figure 6.1 above). Participants were asked to get all ten objects out the box and put them on the table. This ensured that participants touched and looked at each object, for roughly equivalent amounts of time.

Following this brief introduction to the objects, the experimenter started the main task. The experimenter said, "Look. Here I have a towel" and moved the ten objects to the side of the towel. Then the experimenter said, "I want to put all of these things onto my towel so that it makes a fun picture. Can you show me where to put them so it looks really good? We'll do it one at a time so we don't miss any out." The experimenter picked up one of the ten objects at random and said, "Let's start with this one." The experimenter waited for the child to take the object and put it somewhere on the towel. If the child was unsure of what to do, the experimenter suggested a couple of places the object could go and demonstrated with some more of the objects how to make a picture. The experimenter then cleared these to the side of the towel and started again with the first object. This was necessary for only one participant across all the conditions.

After the child had placed the object somewhere on the towel, the experimenter praised the participant and picked up another object asking, "Where would you put this one?" The experimenter continued this process with each of the objects asking, "And how about this one?" waiting for the child to place the object before going on to the next one. Objects were chosen at random except that the target object was never first or last. The target object was each of the novel objects in rotation (Connector, Double Pipe Clip, Elbow, Pipe Collar, Hose Clip, Pipe Clip). The participants were encouraged and praised several times during this task.

The experimenter introduced some new information about the target object. In the <u>Object Label</u> condition the experimenter said "This is really special - it's called a **modi** - where do you want to put this one?" In the <u>Fact Specific</u> condition the experimenter said "This is really special – **my uncle gave it to me** - where do you want to put this one?" In the <u>Fact General</u> condition the experimenter said "This is really special - **it's from a place called Modi** - where do you want to put this one?" In all three Information Type conditions, the target object was each of the six novel objects in turn.

Once all the objects had been placed on the towel the experimenter said, "That's brilliant thank you. I think that looks really great. What do you think? Are you happy with it?" and participants were allowed to change the position of any of the objects if they wanted to.

Test sessions

Participants' comprehension and extension of the novel object label and novel fact was tested.

Comprehension: All participants took part in the Comprehension Test session and this followed on directly from the Exposure Session. Depending upon which of the objects was the target and at what point during the task it was randomly selected, the child experienced a gap between exposure to the word/fact-link and comprehension testing of this word/fact-link that ranged from approximately 30 seconds to 2 minutes.

Referring to the array of ten objects the experimenter said to the child, "We're going to put these away." The experimenter then asked one of three questions: "But just before we do, can you show me which one is called a modi?" (Object Label condition) "….can you show me which one my uncle gave to me?" (Fact Specific condition) or "….can you show me which one comes from a place called Modi?" (Fact General condition). Their answer confirmed whether they had retained the word/fact-object link.

The experimenter ended the Comprehension Test by saying, "Can you help me by putting the things away now? They all go back in the box". For participants who did not choose the target object, this was the end of their participation in the experiment. They were thanked for taking part and accompanied back to their classroom. Participants who answered the comprehension test correctly were tested to see how they would extend their newly learned word or fact to objects from target and non-target categories.

Extension: Participants who chose the target object in the Comprehension Test went on to be tested for extension. Once the Exposure and Comprehension Test Array had been tidied away, the experimenter opened the transparent box containing the Extension Array (See Figure 6.2 above) and placed the twelve objects randomly on the table in front of the participant. Participants underwent two challenging extension tests replicating those used by Waxman and Booth (2000). There was a Yes/No task and a Choice task. These tasks were designed to reveal whether and how children would extend the word or fact when faced with a new set of objects, comprising two exemplars of each of the novel objects presented during the Exposure Session. The order that these tasks were presented was counterbalanced.

Yes/No task – The experimenter pointed to each object in turn, in a random order, and asked, “Is this one a modi” (Object Label condition), “Is this one my uncle gave to me?” (Fact Specific condition) or “Is this one from a place called Modi?” (Fact General condition).

Choice task – The experimenter asked, “Can you see anything here that’s called a modi?” (Object Label condition), “Can you see anything here that my uncle gave me?” (Fact Specific condition) or “Can you see anything here that comes from a place called Modi?” (Fact General condition). After the participant’s initial selection, the experimenter removed that object and prompted the child for additional selections. For example, in the Object Label condition, the experimenter said, “Are there any other ones that are modis?” As in Waxman and Booth (2000), the experimenter repeated this choice question until the child did not select any other objects.

Scoring

Waxman and Booth’s (2000) scoring was not replicated here for two main reasons. Firstly, Waxman and Booth (2000) used just one object as their target and defined Object Type as a condition. ‘Yes’ responses or objects chosen scored 1 and ‘No’ responses or objects not chosen scored zero in the two tests. The target object scores were then compared to the non-target object scores. This would have been difficult to replicate here as the target object varied across participants so each object type would score some target and non-target points. Secondly, Waxman and Booth’s (2000) scoring does not differentiate adequately between an accurate extension pattern and an inaccurate extension pattern. For example, by assigning zero to the selection of any objects other than the target, a child that selects the two target objects along with several other objects scores the same as a child who selects just the two target objects and no other. Yet, this latter extension pattern is the correct pattern for an object label, whereas the former pattern suggests the child is choosing objects randomly.

Instead, a different procedure was devised. Since the objective of the experiment was to compare children's extensions of facts with their extensions of object labels, the appropriate extension of object labels was allocated maximum points i.e. selecting the target object exemplars and only target object exemplars. Selecting target objects earned a positive score, selecting a non-target object earned a negative score, whilst non-selection scored zero points across both extension tests. Scores for selecting target objects were weighted, as there was a far larger proportion of non-target (10) to target objects (2) – a ratio of 5:1.

Yes/No - \`Yes' responses received a score of +5 for the target exemplars and -1 for the non-target category objects. \`No' responses received a score of 0. This produced a score ranging from +10 to -10 for each child.

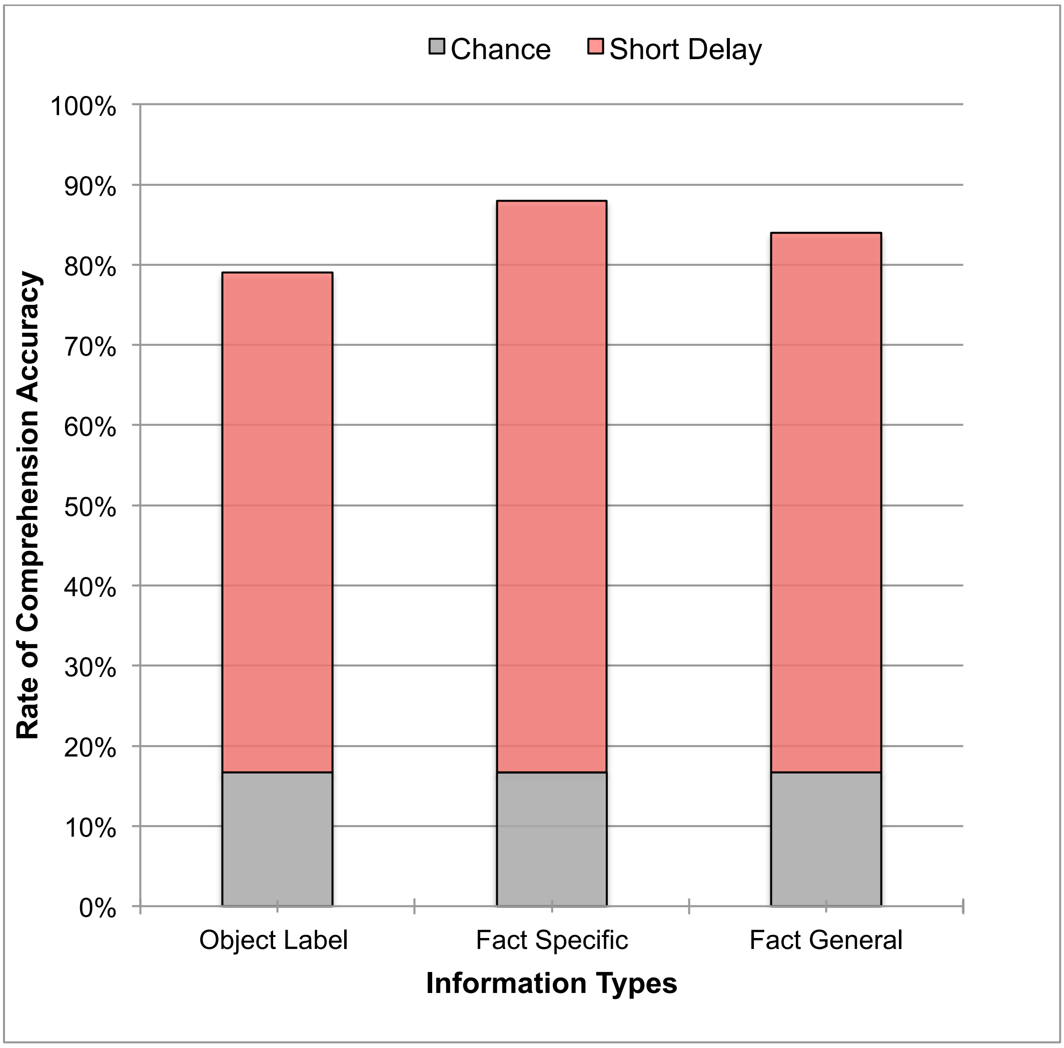
Choice – Selecting objects from the target category received a score of +5, selection of the non-target objects received a score of -1 and objects that were not selected received a score of 0. This produced a score ranging from +10 to -10 for each child.

Results

Comprehension Accuracy

Of the 73 participants, 61 answered the comprehension question correctly by choosing the target object. As expected when tested immediately, a high proportion (79%-88%) of the children could demonstrate their understanding of the mapping between the target object and the novel label or fact (See Figure 6.3 below). There was not a significant difference in comprehension accuracy across conditions, p=0.798 ('s Exact Test) and performance was greater than expected by chance (1 in 6) in all three Information Type conditions.

Figure 6.3: Experiment 5 - Rates of Comprehension Accuracy



Extension Accuracy

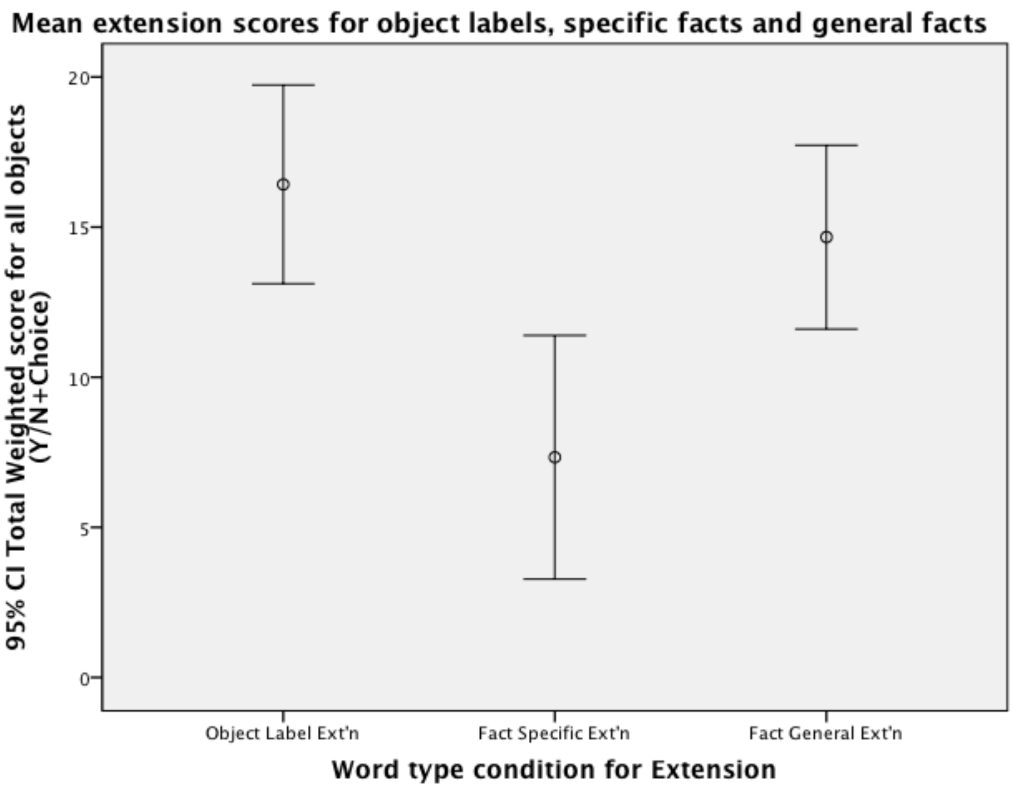
The 61 participants who correctly chose the target in the comprehension test went on to be tested for extension. The results for both tests were analysed separately and the pattern of responses were almost identical: both the overall ANOVA result and the post hoc tests. (These also mirrored the aggregate results – see below). A correlation between the two scores in each Information Type condition produced significant and strong effects (r ranged from 0.47 to 0.59, $p \leq .031$). Given the similarity between the two tests, the aggregate results are presented here rather than duplicating the analysis. The weighted extension scores for each test were summed to provide a total score for each participant, which could range from a minimum of -20 through to a maximum of +20.

The total weighted extension scores are presented in Table 6.2. The children in the Object Label condition and the Fact General condition tended to choose objects from the target category. Given the similarity of scores in the Object Label and Fact General conditions and the difference in the Fact Specific score, it seems that children extended a generalisable fact like an object label rather than a specific fact. Figure 6.4 shows that the confidence intervals of the Object Label and Fact General conditions overlap and neither overlap with the Fact Specific condition.

Table 6.2: Experiment 5 - Extension Accuracy (average weighted scores)

	Object Labels	**Fact Specific**	**Fact General**
Average total weighted score (Y/N+Choice tests)	16.42	7.33	14.67
n	19	21	21

Figure 6.4: Experiment 5 - Extension Scores (Means and 95% Confidence Intervals)



A One-Way ANOVA revealed a significant effect of Information Type on children's extension of novel words and facts,
Welch's F (2,58)=6.94, p=.003. The homogeneity of variances test indicated that equal variances across conditions could not be assumed so Welch's F statistic has been reported to correct for this. Given that equal variances cannot be assumed and there were slight differences in sample sizes, Games-Howell's post hoc multiple comparison tests have been reported. They revealed a significant difference between the Object Label and the Fact Specific conditions (p=0.002) and, crucially, a significant difference between the Fact Specific and the Fact General conditions (p=0.013). There was no significant difference between the Fact General and Object Label conditions (p=0.696).

Extension Response Patterns

Individual children's performance was also examined. There were three primary response patterns. A 'target category only' extension pattern described participants who selected both exemplars of the target category, but no other test objects. An 'extend to all' extension pattern described participants who selected to at least 11 of the 12 test objects. An 'inconsistent' extension pattern described participants who selected objects from the target and non-target categories of objects. [Across the total sample of 122 participants, only two participants selected no test objects and neither of these participants chose no objects in both the Yes/No and the Choice extension tests. So this extension pattern has not been included separately and has been categorised as 'inconsistent'.]

The Object label and Fact General conditions exhibited similar extension patterns – most children (67-79%) extended to the target category and only the target category in both the Yes/No and the Choice tests. In contrast, less than 40% of the children were categorised as 'Target Category Only' in either test of extension in the Fact Specific condition. The remaining children in the Fact Specific condition were split fairly evenly between the

‘Extend to All’ and the ‘Inconsistent’ extension patterns. Participants’ extension patterns for each test are presented in Table 6.3.

Table 6.3: Experiment 5 – Extension Patterns (the number of participants)

Information Type	YES/NO			CHOICE		
	Target Category Only	**Extend to All**	**Incon-sistent**	**Target Category Only**	**Extend to All**	**Incon-sistent**
Object Labels	14	0	5	16	1	2
Fact Specific	4	6	11	8	7	6
Fact General	12	4	5	16	3	2

A 3x3 chi-square test on the Yes/No data demonstrates a significant relationship between the Information Type condition and the Extension Pattern condition. As more than 20% of the cells have a count below 5, Fisher’s Exact Test (FET) has been used: $p=0.003$. The Choice data provide similar results: $p=0.026$ (FET). Both tests allow us to reject the null hypothesis that information type and extension pattern are independent. In other words, whether a child fast maps an object label or a fact affects how that child extends the word or fact to other objects. This supports Waxman and Booth’s (2000) findings.

The aim of this experiment is to establish whether children extend different types of facts in a different way. This requires a more detailed examination of the data. A summary view of the data suggests that, as expected, children in the Fact Specific condition have extended their fact in a different pattern to the children in the Object Label and Fact General conditions. Therefore, I have collapsed Information Type into two conditions: ‘Object Label and Fact General’ combined as one condition and ‘Fact Specific’ as the other condition. In addition, the extension patterns have been collapsed into two categories: ‘Target Category Only’ and ‘Other’, where

‘Other’ consists of ‘Extend to All’ plus ‘Inconsistent’. This 2x2 contingency is presented in Table 6.4.

Table 6.4: Experiment 5 – Collapsed data by Extension Patterns and Information Type (number of participants)

Information Type	**YES/NO**		**CHOICE**	
	Target Category Only	**Other**	**Target Category Only**	**Other**
Object Labels and Fact General Combined	26	14	32	8
Fact Specific	4	17	8	13

Pearson 2x2 chi-square tests on the Yes/No data and the Choice data suggest that there is a significant relationship between the Information Type condition and the Extension Pattern condition: Yes/No data - $\chi^2(1, N=61)=11.63$, $p=0.001$; Choice data - $\chi^2(1, N=61)=10.71$, $p=0.001$. Whether a child learns a specific fact as opposed to a general fact or object label, significantly affects whether they choose extension objects from the target category or different objects. This suggests that children extend object labels and general facts in a significantly different way from specific facts. In contrast, children do not extend general facts in a significantly different way from object labels. A 2x2 chi square comparison of Object labels and Fact General in both the Yes/No test ($\chi^2(1, N=61)=1.20$, $p=0.273$) and the Choice test (FET, $p=0.698$) supports this conclusion.

In addition, post hoc multiple comparisons using 2 x 2 chi square tests to explore differences between the key combination of Information Type categories, Fact Specific and Fact General, corroborated these findings. There was a significant difference between the participants’ extension pattern in the Fact Specific and the Fact General conditions in the Yes/No test, $p=0.011$ (FET) and in the Choice test, $p=0.013$ (FET). The p values of both comparisons fall below the adjusted critical value of 0.025. The critical value has been halved to reflect the fact that each individual group of data in the post hoc multiple comparisons has been used twice. There were also no significant differences between participants' extension pattern in the Fact General and the Object Label conditions in either test (p=0.273, p=0.698).

Finally, there is an additional approach to analysing the data. Reporting the results from the Yes/No and Choice tasks separately demonstrates that both tests produce the same pattern of significant findings - a convincing argument that children do extend specific facts differently from general facts. However, for the categorical data, dealing with the Yes/No and Choice tests data separately can conceal the fact that some children answered inconsistently between the two tasks. The data across both extension tests are not simply a straight sum, as adding categorical data is illogical (e.g. the 'Target Category Only' answer in the Yes/No test cannot be 'added' to the 'Extend to All' answer in the Choice test). Instead, each participant's answers across both tests have been reviewed in total and categorised as either 'Target Category Only' answers or 'Other' and presented in Table 6.5. For example, a child who chose only target category answers in the Yes/No test but answered inconsistently in the Choice test would be treated as an 'Other' response pattern when the answers to both tests are taken together. Only a child who selected one or two target category objects, and no other objects, in both extension tests would be characterised as having a "Target Category Only' extension pattern.

Table 6.5: Experiment 5 - Combined Yes/No and Choice Responses and Collapsed Extension Patterns by Information Type (number of participants)

	Yes/No and Choice	
Information Type	**Target Category Only**	**Other**
Object Labels	14	5
Fact Specific	4	17
Fact General	12	9

These results show that children's answer patterns are more inconsistent in the fact conditions than the object label condition. A 3x2 chi-square test showed that there was a significant difference in participants' extension patterns across the three Information Type conditions, when their answers to the Yes/No and Choice tests were combined, $\chi^2(2, N=61)=12.73$, $p=0.002$. But, does a significant difference between the Fact Specific and Fact General persist even with the combined data? Multiple post hoc comparisons were performed and the critical value was halved to 0.025 as each subset of data was used twice. As predicted, there was no significant difference in extension patterns between the Object Label and Fact General conditions ($\chi^2(1, N=40)=1.20$, $p=0.273$) and there were significant differences in extension patterns between the Object Label and Fact Specific conditions ($\chi^2(1, N=40)=12.00$, $p=0.001$) and the Fact Specific and the Fact General conditions ($\chi^2(1, N=42)=6.46$, $p=0.011$). These results strengthen the interpretation that children extended a generalisable fact like an object label in contrast to a specific fact.

In summary, the various methods of analysing the data (aggregate scores and ANOVA or individual response patterns and chi squares) all give a consistent headline result. Children extend generalisable facts to target category objects predominantly, just like their extension of object labels. In contrast, children's extension of specific facts is significantly more varied between target and non-target category objects.

Discussion

The current experiment compared children's extension of object labels and two different facts. One fact was specific to an individual object ("my uncle gave this to me"), the other fact was more general ("it comes from a place called Koba"). It was found that children's extension of the specific fact to other objects was significantly different from the children's extension of the general fact and object label. Children in the Fact Specific Condition were significantly more likely to extend the specific fact to non-target category objects, in line with Waxman & Booth's (2000) findings. In contrast, children in the Fact General Condition were significantly less likely than those in the Fact Specific Condition to extend the general fact to non-target category objects. Moreover, children in the Fact General Condition had an extension profile similar to those in the Object Label Condition and there was no significant difference between the patterns of extension in these two conditions.

The data were analysed in a variety of ways and all the results were consistent. An ANOVA and post hoc tests of the individual scores for the Yes/No test and the Choice test demonstrated no significant difference between the Object Label and Fact General condition. But there were significant differences between the Fact Specific condition and each of the Object Label and Fact General conditions. It is this difference between the Fact Specific and Fact General conditions and the similarity between the Object Label and Fact General conditions that distinguishes this experiment from Waxman and Booth's (2000). The aggregate scores across both tests of extension produced the same set of findings. Further, when individual participants' answers were categorised into different response patterns and the data were analysed using chi square tests, the same story emerged. And this was true for participants' responses in the Yes/No test and in the Choice test and participants' responses across both tests. The results were consistent across both tests of extension and across both types of data, scores and categorical.

These results, taken together, strongly suggest that children can extend a fact to other same-category objects just like they do with object labels. It would appear that if the fact is generalisable or "category relevant" rather than object-specific or "category irrelevant" children will systematically extend facts to appropriate same-shaped objects. These findings are consistent with Diesendruck and Bloom's (2003) data and demonstrate that young children's readiness to extend generalisable facts stands up to a much more robust test of extension.

Methodological issues

Before discussing wider issues an important methodological point needs to be addressed. The fact introduced to children in the Fact General Condition was “It comes from a place called Modi” which contains a novel non-word. Perhaps children are extending this fact, not because it’s more generalisable and therefore applicable to target-category objects, but because they associate the novel word with the target object and are extending the novel word, rather than the fact, to other similar-shaped objects. However, this interpretation is unlikely for two main reasons.

Firstly, other researchers have shown that children will not extend category-irrelevant facts when they do contain a novel word and, vice versa: children will extend category-relevant facts when they don’t contain a novel word. Behrend, Scofield and Kleinknecht (2001) evidenced that children do not extend specific facts that contain novel words. They introduced their participants to one of four facts in their second experiment. Each fact was specific to the individual and each included a novel object label, for example, “My uncle gave me this koba”. Children chose 3.32 on average of the 4 possible target exemplars when asked the extension question regarding count nouns compared to 1.69 regarding facts. What’s particularly interesting about this procedure is that each participant was hearing exactly the same piece of information, a linguistic fact that contained a novel object label, and they extended the novel object label to target category objects significantly more than they did facts. This strongly suggests that the children linked the fact, not the novel word, to the novel object and extended accordingly. In addition, Diesendruck and Bloom (2003) introduced some of their participants to generalisable facts that did not contain a novel word ('It was made especially to play with cats', 'It comes in a special box' and 'It is used in the kitchen') and the young children readily extended these facts to another object of the same shape. Diesendruck and Bloom (2003) used a simpler extension test than the one used here but they still demonstrated a significant difference. The children introduced to the category-relevant property (general fact) selected the shape match significantly more than those children introduced to the category-irrelevant property (specific fact).

Secondly, the general fact used in the current study introduces a novel proper name, not a novel object label, and Hall (1999) demonstrates that children do not extend proper names. Indeed, they "systematically restrict the extension of proper names to include the designated individual only" and extend to non-target objects significantly less than chance. So, if children in this experiment had linked the novel word rather than the fact with the object, they would have been more likely to extend the fact at significantly less than chance levels – neither to the target or non-target category objects. This was not the case.

So it would appear that children treat the extension of novel generalisable facts and novel object labels that they have fast mapped in a very similar way. This does not necessarily mean that the same mechanism in the brain is used for extension of words and linguistic facts. However, arguing that there are two systems that both determine whether a piece of information is general in nature and, therefore, eligible for extension to other similar objects/features seems a less likely explanation and certainly a more complex one. Even if the rules governing extension patterns for the different types of information vary, it seems more likely that just one cognitive process will control the interpretation of these rules.

Is there one cognitive system for extension?

Waxman and Booth (2000) argue that the mechanism that governs extension of proper names also governs object labels and adjectives, even though the rules for extension for each of these types of words vary. Their objection to the uncle fact seems to be that children do not know whether to extend it or not. However, there seems to be good reason why, within the context of their experiment a child (or adult) might treat the uncle fact as extendable compared to more normal uses of this fact (see Introduction). In addition, it's not obvious why a cognitive system that's utilised for extension, and needs to make decisions about which kinds of information and actions can be appropriately applied to other similar objects/features, cannot also be responsible for the decision where it is not clear whether the piece of information is extendable or not. It is possible that given linguistic facts consist of words, that children develop an adult understanding of how to extend facts at a slower rate than they do words – they have to develop a good understanding of each word until they can process the more subtle variations that can occur when you combine multiple combinations of words together to make a linguistic fact. Again there seems to be no obvious reason why you might conclude, like Waxman and Booth (2000), that these learning processes use different cognitive mechanisms.

Systematic patterns of extension indicate one cognitive system for extension

Categorising the individual response patterns provides some additional insight. It can indicate whether children are thinking systematically about extension or whether they are exhibiting random behaviour. Systematic thinking is evidenced by a participant's answers that can be classified as a logical extension pattern, such as extending to all of the objects. Extending to all of the objects suggests the child has made and implemented a specific decision about how and when to extend the novel name or fact. Even though this decision may differ to the "Target Category Only" extension pattern favoured by participants in the Object Label condition, it still suggests that a systematic approach has been adopted. This is in contrast to an "Inconsistent" response pattern, where the child seems to have chosen objects at random.

The data demonstrate systematic thinking on the part of participants in the Fact conditions, particularly the Fact General condition. If the "Target Category Only" and the "Extend to All" patterns are viewed together, as both can be considered examples of systematic thinking, the similarities between the Fact General and Object Label conditions are even more striking. And this is true in both tests of extension. In the Yes/No test the number of participants in the Object Label condition that exhibit systematic thinking is 14 compared to 5 displaying an Inconsistent response pattern. The corresponding numbers for the Fact General condition are 16 and 5. In the Choice test the number of participants in the Object Label condition that exhibit systematic thinking is 17 compared to 2 displaying an Inconsistent response pattern. The corresponding numbers for the Fact General condition are 19 and 2. The similarities are marked. Even in the Fact Specific condition, the majority of children in the Choice test demonstrated a systematic approach to extension (15 compared to 6) and almost 50% of participants in the Yes/No test.

These data suggest that children are adopting a defined approach to extension rather than acting randomly and that this is true whether they are extending object labels or facts. This indicates that children use the same cognitive mechanism for extending facts as well as object labels, adding weight to the argument that learning words (and facts) employs domain general mechanisms (Bloom, 2000 and Childers and Tomasello, 2003).

Summary

3- and 4-year-old children extended a newly learned generalisable (category-relevant) linguistic fact from an individual novel object to other objects, similar in shape but different in size and/or colour. They did so at a level not significantly different from the high rate of extension of a novel object label to other same-category objects. In contrast, their willingness to extend a specific fact to same-category objects was significantly worse than either the generalisable fact or the object label.

The evidence here lends support to Bloom's theory (2000) and Childers and Tomasello (2003) that word learning is domain general, using a number of different general cognitive processes in a unique way to work out the meaning of a word and retain it in memory. Counter to Waxman and Booth's (2000, 2001) view, extension of words does appear to be part of a wider general mechanism. The current experiment has demonstrated that category-relevant linguistic facts are extended in a similar way to object labels, evidencing that extension applies beyond word learning. Further, Childers and Tomasello (2003) evidenced that extension applies beyond just language when they showed that 2½-year-olds extended novel actions to new objects in the same way that they extended novel words to new objects.

CHAPTER 7

General Discussion

Summary and Integration of Findings

This thesis has investigated long-term learning and extension of words and facts from minimal exposure in 3- and 4-year-old children. The first four experiments concentrated on retention following a significant time delay, testing comprehension of fast mapped words and facts one week after introduction. The final experiment, Experiment 5, shifted focus away from long-term retention and investigated extension of fast mapped object labels and facts.

Experiment 1

Experiment 1 was a large study (n=442) and tested children's retention of a novel word or fact. This experiment compared children's learning of different types of words. Participants were presented with a single incidental exposure to a novel word ('koba') - either an object label, a colour word, a shape word or a texture word - or a new linguistic fact ('it comes from a place called Koba'). Participants were tested for comprehension after a 5-minute delay or after one week. After a short delay, about two-thirds of children could remember the new word or fact, a rate significantly above chance (one-third). However, after a significant delay between exposure and test (one week), comprehension of all feature words and facts was at chance levels (average 37%). Long-term retention significantly better than chance was only evidenced in the object label condition (61%). Object labels were retained significantly better than colour words, shape words, texture words and linguistic facts.

New Findings

There is some evidence that object labels are retained better than other words and linguistic facts. Experiment 1 demonstrated that object labels were retained significantly more than colour, shape and texture words when tested one week after a single, incidental exposure. The large number of participants in each of the conditions (44-46) strengthens this conclusion and these findings are mostly consistent with the literature. Carey and Bartlett (1978) tested children's ability to remember colour words, after a single, incidental exposure one week later. But their data did not provide clear evidence that children could fast map a colour word and remember it a week later at levels significantly greater than chance. Heibeck and Markman (1987) demonstrated high rates of retention for colour words and shape words following minimal exposure, at levels significantly greater than chance. But they tested children's comprehension of these newly learned words just ten minutes after exposure. So their findings are consistent with the short delay data from Experiment 1. Finally, O'Hanlon and Roberson (2006, 2007) evidenced the relative difficulty children experienced in learning a novel colour or novel shape word. They required direct teaching and repetition. These data support the conclusion that children cannot remember feature words following a significant time delay after a single, incidental exposure to the novel feature word. Of course, it is possible that were such words presented to children using aids to memory like those utilised in Experiment 3 (saliency, ostensive naming and repeating the test) that children may have been able to evidence learning. But O'Hanlon and Roberson's (2006, 2007) data would suggest not.

Experiment 1 also demonstrated that object labels were learned better than linguistic facts. This evidence is more tentative. Firstly, it was not replicated in subsequent experiments in this thesis. Further testing produced all-or-nothing results after a week's delay. Either no information was retained (Experiments 2 and 4) or both facts and object labels were retained (Experiment 3). Secondly, this finding that object labels were retained better than facts, contradicts the literature – albeit only two studies that investigated the long-term retention of facts. Markson and Bloom (1997) and Waxman and Booth (2000), both found high rates of accuracy in comprehension tasks set either a week or even a month later. It has, at the very least, been shown that the retention of fast mapped linguistic facts is not a simple process and is certainly not guaranteed.

Exploring the failure to retain facts after a delay

Experiment 1 failed to replicate long term retention of fast mapped linguistic facts demonstrated in the literature (Markson & Bloom, 1997; Waxman & Booth, 2000). My next three experiments attempted to explain this failure to replicate by investigating a number of differences between the experimental procedures evidenced in the literature and the methods used in this thesis. The aim was to highlight factors that might influence the long-term retention of linguistic facts (and potentially object labels). Experiments 2 and 3 compared linguistic facts linked with novel versus familiar objects. Experiment 4 tested whether the experimenter labelling familiar objects or the participant selecting objects affected long term retention. These attempts were largely unsuccessful as none of the experiments found any differences between conditions. Retention rates were low in Experiments 2 and 4 in all conditions. Experiment 3 found impressive rates of retention after one week in all conditions.

Experiments 2 and 3

Experiment 2 investigated whether the novelty of the object to which the new object label or fact was linked affected long-term retention. Markson and Bloom (1997) and Waxman and Booth (2000) had found impressive rates of retention of linguistic facts, significantly above chance, following a considerable time delay. Their facts were linked with novel objects. In contrast, Experiment 1 linked linguistic facts to familiar objects and found low levels of retention of linguistic facts, no different from chance. The familiarity or novelty of the target object could be the reason for these different findings.

Following a colour comprehension task, 124 participants (aged 3 and 4) were introduced to either a new object label or a novel linguistic fact relating to one object in an array of five, signalled by its colour. There was a single incidental exposure to the novel word/fact. In the Object Label condition a novel object label ('koba') was linked with a novel object. In the Fact – Novel Object condition, a new linguistic fact ('it comes from a place called Koba') was linked with a novel object. In the third and final condition

(Fact-Familiar Object), the same linguistic fact was introduced, but this time it was linked with a familiar object. All participants were tested for comprehension of the novel word or fact after one week, choosing an object from the original array of five objects.

There were no significant differences in rates of retention between any of the conditions (29%-36%) and these low rates of retention were no different from chance in the Object Label and Fact, Novel Object conditions. Retention in the Fact, Familiar Object condition at 36% was significantly above chance (20%) but this level of comprehension accuracy after one week was well below the striking retention rates evidenced in Experiment 1 and the literature (Markson & Bloom, 1997; Waxman & Booth, 2000). It is possible that the procedure distracted participants from processing the novel object label or novel fact. The task demanded a response that could be answered by focusing on the colour of the object – the novel name or fact could be completely ignored. Indeed, the experimental procedure may have motivated children to ignore this information. The studies that have evidenced substantial rates of long-term retention (60% or more) have not used tasks that involve a right-wrong framework in this way (Experiment 1; Markson & Bloom, 1997; Waxman & Booth, 2000).

Methodological differences aside, Experiment 2 demonstrates that long-term retention of fast mapped object labels is far from guaranteed. These results support the more recent findings (e.g. Horst & Samuelson, 2008; Horst, Scott & Pollard, 2010; Vlach & Sandhofer, 2012) that retention of object labels after a significant time delay is more difficult than suggested by the earlier literature (Carey & Bartlett, 1978; Woodward, Markman & Fitzsimmons, 1994; Markson & Bloom, 1997; Waxman & Booth, 2000; Jaswal & Markman, 2003; Akhtar, 2005).

Unfortunately, Experiment 2 found very similar comprehension results in the Fact, Novel Object and Fact, Familiar Object conditions, thus failing to address the experimental question. There is no evidence that children find it easier to retain mappings of facts to novel objects rather than familiar objects after a significant time delay.

Experiment 3 tackled the same experimental question as Experiment 2 and investigated whether the novelty of an object would affect the long-term retention of linguistic facts. In order to obtain good comprehension rates after a delay, the procedure was adapted to include aides to memory. In addition, a new task was devised so that children would not be motivated to ignore new information due to answering questions with a clear right-wrong response. The 93 children were asked to place objects on a towel to make a picture whilst they were introduced to a novel object label/fact about one of the objects. The children were not required to choose objects based upon a right-wrong answer. Each child was tested both immediately and after one week. The Immediate Test ensured that children had mapped the word/fact-object link by the time they underwent the Week Test. Experiencing the test question once before would also have helped children to retain the link. In addition, ostensive naming and increasing the salience of the target object were incorporated into the task to promote good long-term retention.

Comprehension accuracy rates were impressive in both time delays and in all three Information Type conditions, averaging 86% retention in the Immediate time delay and 87% retention in the Week time delay. Results were significantly greater than chance (25%) in all conditions. There were no significant differences in performance between any of the conditions.

New Findings

Experiment 3 provides the first strong evidence that facts, linked with familiar objects, can be retained from minimal exposure after a significant time period. The link between a linguistic fact and a familiar object was remembered one week later by a substantial 93% of participants in the Fact, Familiar Object condition. Markson and Bloom (1997) argued that children could link facts with a familiar object but there have been no data to support this argument. To date, linguistic facts have always been linked with a novel object in fast mapping, retention and extension studies (Markson & Bloom, 1997; Markson, 1999; Waxman & Booth, 2000; Behrend, Scofield & Kleinknecht, 2001; Diesendruck & Bloom, 2003). In contrast, Experiment 3 demonstrates that 3- and 4-year-olds can, under some circumstances, retain a link between a linguistic fact and a familiar object, at an impressive rate and significantly above chance, one week after the initial introduction.

Of course, Experiment 3 (and Experiment 2) failed to establish its primary purpose: there were no significant differences between conditions. It was predicted that children would find it easier to remember a fact paired with a novel object based upon the principles of mutual exclusivity (Markman & Wachtel, 1988) and children's attention to novelty (Horst, Samuelson, Kucker & McMurray, 2011). This might explain children's failure to retain facts at above chance levels in Experiment 1. However, there was no evidence that children find it easier to retain mappings of facts to novel objects over familiar objects following a significant time delay. There may be differences in how easily children retain new facts depending upon the novelty/familiarity of the referent. The performance at ceiling in Experiment 3 (and the performance at floor in Experiment 2) masks any such effects, telling us nothing about whether children learn facts better when the referent object is novel.

What other factors may explain the failure to retain facts in the long term in Experiment 1?

Experiment 1 indicated that fast mapped linguistic facts linked with familiar objects could not be retained after a week's delay. In contrast, Experiment 3 evidenced long-term retention of fast mapped facts. A comparison of the procedures used in Experiments 1 and 3 produced a list of possible factors that may have affected retention. Markson and Bloom (1997), Markson (1999) and Jaswal and Markman (2003) evidenced impressive retention rates without incorporating the more obviously helpful procedural characteristics, such as ostensive naming, drawing attention to the target object ('This is really special') and testing children immediately for comprehension as well as a week later (repeat testing). This narrowed the list down to two key factors that were investigated in Experiment 4.

Experiment 4

Two methodological differences between Experiments 1 and 3, that are consistent with the literature, concern the exposure session where the child is being introduced to the novel fact or word. These are the naming of familiar objects by the experimenter and the selection of the stimulus objects by the child. It was possible, therefore, that it was these two factors which enabled retention in Experiment 3 but prevented retention in Experiment 1.

During Experiment 1's Exposure Session, each of the familiar objects was named and this was intrinsic to the task, yet facts were not retained following a one-week delay. In contrast, none of the familiar objects in Experiment 3's array were named, yet facts were retained one week later. Markson and Bloom (1997) and Waxman and Booth (2000) both found that facts were fast mapped and retained. Markson and Bloom (1997) did not label any of the familiar objects. Waxman and Booth (2000) did refer to their familiar objects by name, but the naming was not intrinsic to the task and it occurred after the introduction of the novel fact. The naming of familiar objects in Experiment 1 might have interfered with participants' ability to be open to new information about those objects. It may have 'primed' participants for object labels, distracting them from the relevance or importance of any other information they heard about the objects, such as facts.

In Experiment 1, where there was no fact retention, participants were asked to select the target objects based upon its name during the Exposure Session. No such selection was required of participants in Experiment 3 - each object was handed one by one to the child. Perhaps, asking participants to select objects based upon their names was a sufficiently absorbing task to prevent the children from learning a new fact about any of the objects. In Experiment 1's fact condition, children could have selected the correct target without even listening to or processing the novel fact (like Experiment 2). This is in contrast to the object label condition, where interpreting the novel object label was key to solving the selection task. Alternatively, perhaps selecting objects based upon their names, 'primes' children to accept new object labels but not novel facts. This may explain why there were good object label data in Experiment 1 and 3 but poor fact retention in Experiment 1. Neither Markson and Bloom (1997) nor Waxman and Booth (2000) required participants to select the referent of their novel fact and both evidenced retention.

Experiment 4 was designed to establish whether these detailed aspects of the experimental procedure could affect the long term retention of fast mapped facts. 89 participants were introduced to a novel fact linked with a familiar object during an experimental task similar to that used in Experiment 3, which had evidenced strong retention (objects were placed on a towel). Ostensive labelling, saliency of the target and repeat testing were not embedded in the task, however. In the three different conditions (Naming and Selection, Naming Only and No Naming, No Selection), the task varied by labelling the task objects and/or the participant's selection of the task objects.

The results were disappointing. The rates of retention after a week's time delay were low in every condition (none differed significantly from chance at 20%) and there were no significant differences between conditions. There was no evidence of any learning. Floor effects may have masked any differences in the ease of retention, but there was no evidence that there are any differences in long term retention arising from the participant selecting the object or the experimenter naming familiar objects.

New Findings

The main conclusion arising from these data, especially when the results from Experiments 1 and 2 are taken into account, is that the fast mapping and long term retention of linguistic facts is not nearly as straightforward as Markson and Bloom (1997), Markson (1999) and Waxman and Booth (2000) suggest. Out of the four experiments in this thesis that investigated retention after a week's delay, three failed to show any long term retention of linguistic facts. Only Experiment 3 evidenced convincing retention rates. The pattern of fact retention results evidenced in Experiments 1-4 resonate with those studies in the more recent literature that have struggled to establish long-term retention of object labels (Horst & Samuelson, 2008; Vlach & Sandhofer, 2012). The data here suggest that long term retention of facts does not occur unless there are some memory supports embedded in the experimental task e.g. repeat testing.

Experiment 5

Experiment 5 was the final experiment in this thesis and it investigated a new area: the extension of object labels and linguistic facts to other similar objects. This study was designed to question Waxman and Booth's (2000) assertion that extension constitutes a crucial difference between learning words and learning facts, and that learning words may utilise some domain specific cognitive abilities. Waxman and Booth (2000) based this assertion on their evidence that 4-year-olds did not systematically extend a linguistic fact to similar objects from the same category whereas they did systematically extend object labels. However, Waxman and Booth (2000) only introduced their participants to a category-specific fact ('my uncle gave this to me'), which was much less likely to be extended beyond the individual.

Experiment 5 addressed this question by examining how children would extend a 'category-relevant' fact ‑ one that is generalisable to other objects of the same kind. 70 preschoolers were introduced to a novel object label ('modi') or a novel linguistic fact, linked to a novel object. Children were exposed to a novel object label or one of two types of fact. One fact was likely to be viewed as specific to the introduced target ('my uncle gave it to me'). The other fact was more generalisable ('it's from a place called Modi') and was more likely to be extended to other objects in the same object category as the target. Participants were tested for comprehension shortly after and those who correctly chose the target (n=61) went on to be tested for extension. Their answers from two challenging extension tests were scored out of 20. The closer their answers were to the accurate extension profile for an object label (choosing the two target-category extension objects and no others), the higher their score.

Extension performance in the Object Label and category-relevant Fact General conditions was significantly higher than in the Fact Specific condition: scores were 16.4, 14.7 and 7.3 respectively. There was no significant difference in extension performance between the Object Label and Fact General conditions. These data demonstrate that children can extend generalisable facts from an individual object to other objects in the same category, just as they do for object labels. This extension profile can be contrasted with that for specific facts, where extension decisions were more ad hoc. An analysis of individual response patterns was consistent with these findings: even when children did not extend the generalizable fact exclusively to the target category, they demonstrated a systematic approach to their extension decisions, such as choosing to extend to all the objects.

New Findings

Data from Experiment 5 indicate that young children do extend some facts at a similar rate to object labels. Fact extension seems to depend upon what the children think about how extendable the fact is. This mimics the extension of words. Not all word types are extended: for example, children know not to extend proper names beyond the individual (Waxman & Booth, 2001). And, crucially, children do not know how to extend all word types from the get go. Booth and Waxman (2009) demonstrated that infants extended count nouns to object categories well before they extend colour words to properties. This suggests that children learn how to extend different types of words at different rates and perhaps this is true of facts too. Data from Experiment 5 suggest that children will extend facts from an individual object to other objects in the same category where appropriate. Category-relevant linguistic facts are extended in a similar way to object labels, evidencing that extension applies beyond word learning.

Now that all the experiments have been summarised and new evidence considered, it is time to address the themes and ideas that arise from considering these experiments as a whole.

Themes

Throughout this thesis a number of important themes and concepts have emerged. These include:

1. Variation in experimental methods
2. Does long-term retention follow on from fast mapping?
3. Which factors might influence retention?
4. Domain general or domain specific mechanisms in word learning

These four themes will be discussed in turn and finally some ideas for future work will be presented.

Theme 1: Variation in experimental methods

The studies reported in the literature have implemented quite different experimental procedures. A review of the literature and an exposition of the methods employed have been presented in Chapter 1 and throughout this thesis. It makes a straightforward comparison of results difficult. Even the experiments undertaken within this thesis that investigate fast mapping and retention (Experiments 1, 2, 3 and 4) employ different procedural steps and, again, this complicates the process of comparing their results.

Why do the procedures change throughout the experiments presented here? Surely it would have been much easier to use one basic fast mapping task across all the experiments. This would have aided understanding of the experimental method and allowed comparison between different experiments, especially as the data were collected from similar cohorts of children. However, the first four experiments in this thesis that address retention of fast mapped words and facts were planned and executed before or just after 2008. The literature at this point did not indicate that fast mapping and retention data were sensitive to minor changes in experimental procedure. The suggestion was that fast mapped information would be retained for at least a week (e.g. Markson & Bloom, 1997; Waxman & Booth, 2000). Indeed, Bloom's (2000) definition of fast mapping requires retention of at least one month, not just the map itself. There was not a strong reason to refrain from minor variations in the experimental task.

And it's worth considering how similar Experiments 1-4 are. They all followed a basic paradigm: participants interacted with an array of objects in a task lasting about 5 minutes; a new word or fact was introduced once or twice and was linked with one of the objects; comprehension of this link was tested immediately and/or one week later by asking participants to select the target object from the original array. I did not conclude that retention of fast mapped information was complex and far from a reliable process until I had collected most of the data in Experiment 4. Previously, Experiment 2 was considered an outlier. It was the very variation in experimental method and the surprising fluctuating results through Experiments 1 to 4 that highlighted the effect of procedural change on long-term retention. Horst and Samuelson (2008), and Vlach and Sandhofer (2012) more recently, have drawn similar conclusions.

Even with the benefit of hindsight, trying to establish a fail-safe task so that small variations in procedure could then be tested, is far from straightforward. Markson and Bloom's (1997) task, for example, has proved difficult to replicate (Vlach & Sandhofer, 2012). It would seem sensible to use Experiment 3 as a base since this produced such convincing results across object labels and linguistic facts, regardless of the novelty of the target objects. And these results replicate at least one other study in the literature (Waxman & Booth, 2000). It would then be possible to make small adjustments in each condition to see if any one factor or group of factors affect the retention levels. For example, ostensive naming was a key retention factor in Horst and Samuelson (2008) but may prove unnecessary when repeat testing is employed.

<u>Theme 2: Does long term retention follow on from fast mapping?</u>

Is there any long-term learning that can be achieved from just minimal exposure to a novel word or fact? Given the difficulties demonstrated in the literature and the fluctuating results evidenced here, is retention of fast mapped information a reliable phenomenon as Markson and Bloom (1997) and Waxman and Booth (2000) would have us believe? The process would certainly seem to be less robust than they suggest. A newly formed link between an object and a name, feature word or fact is not always retained for a significant period of time.

Feature words

Feature words are labels for a feature or property of an object such as colour, shape and texture. There is no clear evidence that fast mapped feature words can be retained for anything longer than a few minutes. Experiment 1 showed that colour words, shape words and texture words could not be retained above chance levels when tested after a week despite good comprehension rates after five minutes in the Short Delay condition. Experiment 1 was the first study to compare retention of feature words to object labels and found that object labels were retained significantly above chance after a week's delay in comparison to the chance performance in the colour, shape and texture word conditions. These results are consistent with the findings in the literature. Carey and Bartlett's (1978) data on colour words are equivocal. Heibeck and Markman (1987) found good rates of comprehension for colour words and shape words but the delay between exposure and test was only ten minutes. O'Hanlon and Roberson (2006, 2007) indicate that colour and shape words can only be learned by young children from repetition and rehearsal.

Of course a different experimental procedure that includes the kind of factors discussed below (ostensive labelling, repeat testing, gestural cues etc.) may allow 3- and 4-year-olds to be able to retain novel colour or shape words from minimal exposure. Experiment 1 provided very little 'help' to participants to encourage retention. Only systematic testing would preclude this possibility. But O'Hanlon and Roberson's (2006, 2007) data suggest this is unlikely for either colour words or shape words.

Shape is the most interesting type of feature word in this scenario. It is the condition most similar to object labels – the wording used by the experimenter is identical in both conditions - and there is plenty of evidence to suggest that 3- and 4-year-old children use shape to identify objects, known as the shape bias (e.g. Diesendruck & Bloom, 2003). Yet, object labels are learned in the long term and shape terms are not. Given the formal similarity between object labels and shape words, the difference in long-term retention found in Experiment 1 can best be explained by some reference to a substantive difference between the two word types. Objects are special and object labels are important because they are a way of communicating about and labelling/categorising something special. Shape is only important when it is about objects (shape bias).

Object labels

Experiment 1 suggests that object labels can be fast mapped and retained even under quite challenging circumstances: a single, incidental presentation, followed by a comprehension test one week later. These data echo Markson and Bloom's (1997) results. Experiment 3, like Waxman and Booth (2000), supports this evidence that fast mapped object labels can be retained long-term (albeit by using ostensive presentation, saliency and repeating the test question to promote retention).

Yet Experiment 2 and more recent papers in the literature, indicate a different picture. Retention after a significant delay has proved difficult. Horst and Samuelson (2008) struggled to demonstrate retention after just five minutes when their 2½ year-olds were introduced to just one object label (Experiment 1c). Vlach and Sandhofer (2012) replicated Markson and Bloom's (1997) procedure and could not maintain retention levels without providing children with memory supports (saliency, repetition, word generation).

So the data here reflect the inconsistent set of results reported in the literature. What are we to make of this? Are object labels retained following minimal exposure? The answer appears to be 'sometimes'! Deák and Toney (2013) propose that fast mapping may be simply the tail end of a normal distribution curve of a model of incremental learning. Children will learn most words from a medium number of exposures, a few will be learnt from a minimal number of exposures and a few will be learned very slowly. Fast mapping is not a robust phenomenon but merely a statistical occurrence. This account could explain a variation in rates of retention across different experiments. However, with the data presented in this thesis and elsewhere, this account seems unlikely. Experiment 1 evidenced 27 of 44 children remembering a novel object label after one week from minimal and incidental exposure. Experiment 3 evidenced 27 of 31 children remembering a novel object label after one week from minimal, if not incidental, exposure. Markson and Bloom (1997) demonstrated that over 60 preschoolers could evidence retention of a novel object label at least one week after exposure. That a group of children in different situations are retaining a novel word (or fact) after a week's delay suggests that long-term learning from fast mapping can take place. And the large sample sizes, especially in Experiment 1, provide persuasive evidence.

Facts

Experiment 3 provides evidence that fast mapped linguistic facts are retained in the long-term, consistent with the literature (Markson & Bloom, 1997; Waxman & Booth, 2000; Deák & Toney, 2013). However, Experiments 1, 2 and 4 demonstrate that retention of fast mapped linguistic facts is far from guaranteed. These data taken together intimate, in contrast to the literature, that the retention of fast mapped linguistic facts is variable and, most likely, dependent upon elements of the experimental procedure. This is similar to object labels. Although, the retention of object labels and the failure to retain facts in Experiment 1 provides some preliminary evidence that children may find fast mapped linguistic facts harder to retain than fast mapped object labels.

Incidental exposure

Fast mapping for the purposes of this thesis has been defined as minimal exposure to the name-category link so that some consistency across the experiments here and the literature can be maintained. However, it is worth considering a common definition of fast mapping whilst evaluating long-term retention. For many researchers it is the incidental nature of the exposure to the novel word that is the most important aspect of fast mapping. Incidental exposure is the opposite of ostensive exposure. The participants have not been told directly that the novel object is named with a specific novel word. Instead the child has to work out the referent of the novel word (as in Experiment 1 or in a referent selection task) or hear the experimenter refer to the novel object by name in passing (Markson & Bloom, 1997). Many researchers are interested in this aspect of the mapping as they focus on how children work out the meaning of the novel word and what assumptions they make in order to help them narrow down the possibilities.

Can long-term retention occur when the exposure is not just minimal but incidental too? The data are mixed. Two key studies suggest this is not possible without 'helping' factors. Horst and colleagues (2008, 2010), using a referent selection task, could not evidence retention even after 5 minutes with 2-year-olds without using ostensive naming and repetition of the word. Vlach and Sandhofer (2012) could not replicate Markson and Bloom's (1997) findings and only found similar retention results when they made the target object more salient, repeated the word-object link 6 times and got the participants to produce the novel word themselves. Waxman and Booth (2000) did show long term retention but using ostensive rather than incidental exposure. (Experiments 1-4 suggest that linguistic facts cannot be retained unless they are introduced to children ostensively. Good linguistic fact retention was only evidenced in Experiment 3 where there was ostensive presentation, saliency of the target object and repeat testing).

On the other hand Markson and Bloom's (1997), Markson (1999) and Experiment 1 demonstrate long term retention from minimal and incidental presentation to a novel word-object link. Why would it be possible in some scenarios and not in others? One possibility is the presence of some unknown or hidden factor that researchers have yet to identify in the experimental procedure. For example, the role of praise is unknown in these kinds of experiments. In Experiment 1, participants were praised for choosing the target in the fast mapping task. This may have helped them be more certain that their choice was correct and aid retention. In contrast, Horst and Samuelson (2008) did not praise their participants for accurate choices during the referent selection task. Participants lacking confidence in the accuracy of the word-object link may have been less likely to retain this link.

What causes or motivates retention?

There are a number of factors that could help transform a fast mapped word into long-term learning and these are discussed in the next section. However, the picture is not straightforward. Horst and colleagues (2008, 2011) and Vlach and Sandhofer (2012) both identify factors that they argue affect long-term retention. Yet there is no common ground between the two. Horst and colleagues (2008, 2011) posit that ostensive presentation and minimising the number of distracting familiar objects in the exposure array are key factors for long term learning. Vlach and Sandhofer (2012) demonstrate the importance of saliency, repetition of the word-object link and generation. Experiment 1 does not use any obvious 'help' factors to achieve retention of object labels after a week's delay. Experiment 3 does include aides to memory in the procedure, like Waxman and Booth (2000). These are ostensive presentation (used by Horst & colleagues 2008, 2011), saliency (used by Vlach & Sandhofer 2012) and repeat testing.

Theme 3: Factors that can affect long-term retention

What does the evidence presented in this thesis tell us about the factors that may affect the long-term retention of fast mapped information – what Vlach and Sandhofer (2012) describe as 'aids to memory'? A number of potential factors that seem to affect retention were identified in chapter 1 including ostensive labelling, the number of familiar objects and gestural cues. Do Experiments 1-5 cast any more light on the influence of these factors or suggest other factors may be important?

It is clear that retention does not always succeed fast mapping (Horst & colleagues, 2008; Vlach & Sandhofer, 2012). Experiment 1's fact condition, Experiment 2 and Experiment 4 contribute to these data. Horst and colleagues (2008, 2010) and Vlach and Sandhofer (2012) have also demonstrated that procedural variations can produce or deter retention. What are the different factors that encourage retention of fast mapped object labels? Are they necessary, sufficient or merely contributory? Are there factors that can deter long-term retention?

Ostensive presentation

Horst and colleagues (2008, 2010) suggest ostensive presentation is a key factor in contributing to the long-term retention of novel object labels. When this factor was manipulated (Horst & Samuelson, 2008) retention rates were affected. Ostensive presentation ("Look, this is the cheem") was associated with retention at rates significantly above chance whereas follow-in labelling (confirmation of the child's choice) was not. Waxman and Booth (2000) and Experiment 3 both introduce their novel names-object link ostensively and both show impressive rates of retention after one week.

However, the evidence is mixed. Other procedural factors are present in Waxman and Booth (2000) and Experiment 3 such as repeat testing that may be producing or contributing to the long-term retention. Jaswal and Markman (2003) demonstrate that ostensive and indirect presentation produce equally good rates of retention after a 2-day delay, suggesting that ostensive presentation does not affect retention. In addition, Markson and Bloom (1997), Vlach and Sandhofer (2012) and Experiment 1 both reported rates of retention significantly above chance without using ostensive presentation.

So, it would seem that ostensive presentation contributes to long term retention of fast mapped object labels but is not necessary in order to produce long term retention as many studies have evidenced retention without using ostensive labelling. Neither does it seem to be sufficient to achieve long term retention on its own – Horst, Scott and Pollard (2010) demonstrate that once the number of familiar objects in the exposure array exceed two, retention is no longer evidenced despite the ostensive presentation.

The number of familiar objects

Horst, Scott and Pollard (2010) report that the number of familiar objects presented during the referent selection task (i.e. at exposure) affects retention. They argue that the familiar objects act as distracters, competing for children's attention as they select which object is the referent for the novel name. Experiment 1 provides some tacit support for this theory. Only two of the five objects in the exposure array are familiar. Perhaps that helps explain the good performance in the Week Delay, Object Label condition. But, there was no retention evidenced in Experiment 2 and in this experiment the exposure array consisted of only novel objects in two of the three conditions. In addition, Horst *et al*., (2010) focus on the referent selection task which only ever involves one novel object. It is difficult to understand how their conclusions about familiar objects acting as distracters informs other fast mapping and retention studies. Most of these studies present children with a mixed array of objects that consists of several novel objects. Perhaps, with more novel objects in the array, the familiar objects no longer act as distracters. Or perhaps it is the balance of novel to familiar objects that is important. It is also possible that the number of familiar objects at exposure affects 2-year-olds' ability to retain new words but has less of an effect (conceivably no effect) on older children. For two-year-olds a large proportion of their surroundings would be perceived as novel (without a name). As children age and attain larger vocabularies an increasing amount of the objects that surround them are familiar. This may affect how much they are affected by novelty in word learning. Note that children were able to learn a fact-object link in Experiment 3 when all the stimuli including the target were familiar. If the factors that affect fact retention are similar to the factors that affect object label retention it would appear that the number of familiar objects in the exposure array is unlikely to be of paramount importance with 3- and 4-year-olds.

The number of familiar objects may be a factor that deters retention, but certainly does not seem to block it. Most studies have included many more than two familiar objects and evidenced retention (Markson & Bloom, 1997; Waxman & Booth, 2000; Vlach & Sandhofer, 2012, have all presented 4 familiar objects). It is possible, that when learning an object label (not a fact), presenting a mixed array is key. Looking at the data from Experiments 1, 2 and 3 together, long-term retention of object labels was only evidenced when the array of objects comprised both novel and familiar objects.

Gestural cues

Some of the answers to effective retention may well lie in gestural cues. Booth, McGregor and Rohlfing (2008) introduced 28-31 month children to 3 object labels using a hierarchy of gestural cues. They tested each participant immediately following exposure and 3-5 days later. Although this study with 12 exposures to each novel word does not meet the criterion for a fast mapping experiment, insight into gestural cues is of interest here. Their results demonstrated that gazing alone did not produce retention significantly above their baseline condition (no cues). However, once the experimenter gazed at and pointed to the target object, children's comprehension performance significantly improved. When the experimenter additionally touched and, in the final condition, moved the object, performance continued to improve but not significantly so. Hennon, Chung and Brown's (2000) data are consistent with these results. Their data with 12-month-olds suggest infants can learn with the support of manipulation, but fail with gaze alone.

This suggests that even very young children are highly sensitive to gestural cues and these may be embedded in other fast mapping studies without being highlighted or even described. For example, Markson and Bloom (1997) do not provide sufficient detail of their experiment to elucidate the experimenter's interaction with the object. But when the experimenter said "let's use this koba to measure this" the experimenter may well have looked at and pointed to and/or picked up the object giving the child vital cues as to the referent of the novel word and motivating memory of the novel word by drawing attention to the target object.

Further, gestural cues may be obscured by the terminology that different researchers use. For example, Horst and Samuelson (2008) test “ostensive labelling” and compare it to “follow-in labelling”. Their ostensive labelling condition involved the experimenter holding up and pointing to the target object. Waxman and Booth (2000) and Experiment 3 mark out the target object in a similar way. What is described as ostensive labelling effectively incorporates several gestural cues in addition to the language “This is a ….”. It is of interest to note that when Axelsson, Churchley and Horst (2012) tested ostensive labelling without holding up the object 2-year-olds failed to retain the novel word after 5 minutes.

But, however much these cues, hidden or not, may explain the variation in results across fast mapping and retention studies they do not tell the whole story. Experiment 1 did not include any gazing at, pointing to or touching/manipulation of the target object on the part of the experimenter and retention of object labels after one week was still significantly above chance.

Other Factors

There are many additional factors that have been tested in the literature or embedded in their experimental procedures and many of these were described in Chapter 1 such as familiarisation with the target novel object and generating the novel object label. Two procedural components that have been used in at least one of the experiments presented in this thesis will be discussed here.

i) *Saliency* – I have adopted Vlach and Sandhofer’s (2012) definition of this factor as describing the object as “special”. This procedural step was utilised in Experiment 3 of this thesis. (Note that other researchers define saliency differently. Some use the term to describe any methodological component that emphasises the target object over and above the other objects e.g. Horst & Samuelson, 2008). Although this factor is associated with long-term retention in Experiment 3, Waxman and Booth (2000) and Vlach and Sandhofer (2012) there are other factors also present such as repeat testing or generation that are likely to be more important aids to memory. Certainly Vlach and Sandhofer (2012) found that saliency alone was associated with significant deterioration in retention from immediate testing to testing after one week and one month. In addition, saliency is clearly not necessary to engender long-term retention as there are many experiments reported that do not use this memory aid (e.g. Markson & Bloom, 1997; Experiment 1). So at most saliency may contribute to long-term retention.

ii) *Repeat testing* - an additional factor that does seem to be helpful in assisting long-term retention of object labels is repeat testing. To be clear, this refers to an experimental procedure where the child undergoes the test question and answer session more than once. (Compare this to Woodward, Markman & Fitzsimmons, 1994 where the test question was repeated several times at the start of the test session but participants merely heard the test question as opposed to having to answer it more than once). Excellent rates of retention were reported in Waxman and Booth (2000), Booth, McGregor and Rohlfing (2008), Deák and Toney (2013) and Experiment 3 and all these studies incorporated a repeat of the comprehension test and answer session. Children were tested immediately following exposure to the novel word and up to one week later. Repeat testing is commonly used in teaching contexts to improve learning and is likely to be a strong factor in helping children to retain a word-object link over time. Certainly, there are no studies to date that incorporate repeat testing and go on to fail to demonstrate retention. It is possible that repeat testing would be a sufficient factor to elicit long-term retention. However, even this seemingly strong aid to memory is not necessary for long-term retention of object labels. Markson and Bloom (1997) and Experiment 1 both evidence comprehension of object labels after one week or more without using this technique.

How do factors interact?

There is widespread variation in results across and within studies: factors are associated with long-term retention in some studies and not in others. What can explain such variation? A possibility is that there is some kind of threshold that needs to be exceeded for long-term retention to be attained. This threshold would comprise elements such as attention, child's confidence in the accuracy of the novel word-object link and perception of importance. The factors detailed in the previous section feed into each of these elements. For example, repeat testing might increase children's attention to the target and its referent, increase their confidence in the accuracy of the word-object link and affect their perception of the importance of the novel name-object link. Other factors may reduce the likelihood of retention. For example, inconsistent praise may reduce children's confidence that the name-object link is accurate. All of these factors, positive and negative, may vary in their power and their intensity (potentially connected to the number of elements they affect). Some may be sufficiently strong to produce retention on their own: perhaps, repeat testing is an example. Others may be insufficiently powerful on their own but when combined with other positive factors and the absence of negative factors, they too can produce retention.

The size of the threshold may vary depending upon the length of time the child will remember the word-object link. Presumably, the longer the delay between exposure and test, the higher the threshold needs to be. For example, ostensive presentation (and some gestural cues) may not be a particularly strong influencing factor but when combined with just a five-minute delay it is sufficient to produce retention in Horst and Samuelson's (2008) last experiment. Thresholds' influence and strength may also vary with a child's age.

What about facts?

Finally, what about linguistic facts? Is the long-term retention of facts affected in the same way as the long-term retention of object labels? The evidence for the long-term retention of linguistic facts is as variable as it is for object labels so the principle that there is some kind of threshold for retention seems appropriate. Whether the factors that feed into this threshold are the same as those factors that feed into the threshold for long-term retention of object labels is an entirely different question, however.

It is not clear if the same factors that encourage/hinder retention of object labels also influence the long-term retention of linguistic facts. All the studies in the literature that have tested factors specifically have all introduced participants to object labels. Experiment 1 suggests that children might find remembering facts harder than object labels following minimal exposure. Children may need more helping factors for facts than object labels. However, despite the large sample size in Experiment 1, these data have not been replicated. Whenever facts and object labels have been tested together in subsequent experiments, the results have been all-or-nothing. In Experiment 2 neither object labels nor facts were retained after one week. In Experiment 3 both object labels and facts were retained after one week. This would suggest that similar factors help children to retain facts as well as object labels.

<u>Theme 4: Domain general versus domain specific mechanisms in word learning</u>

A domain general view of word learning posits that humans are endowed with a general set of learning abilities that they bring to bear on any cognitive task, including word learning. Bloom (2000) argued that word learning involves a number of general cognitive skills such as theory of mind, and conceptual biases. Fast mapping is another cognitive mechanism that he argues is essential for, but not restricted to, word learning. "Domain specificity", on the other hand, is the idea that the structure of knowledge is different in important ways across distinct content areas (Hirschfeld & Gelman, 1994). Researchers explain the existence and structure of these content areas in different ways. For example, Cosmides and Tooby, (2006) posit that the mind is made up of a large number of specialized modules that evolved to deal with highly specific problems that arose in human evolutionary history. What do the data in this thesis tell us about the domain generality of the cognitive mechanisms involved in word learning?

Experiment 5

Experiment 5 addressed the question of the domain generality of word learning by comparing 3- and 4-year-olds' extension of a newly learned object label, a specific fact and a general fact. It was found that children readily extended a generalisable novel fact ('it comes from a place called modi') to other examples of an object category, just like they did for object labels. In contrast, when children were introduced to a novel specific fact ('my uncle gave this to me'), as they were in Waxman and Booth's (2000) study, their extension patterns were significantly different.

These data suggest that children will extend facts from an individual object to other objects in the same category where appropriate. Category-relevant linguistic facts are extended in a similar way to object labels, evidencing that extension applies beyond word learning. This counters Waxman and Booth's (2000) claim that extension illustrates a fundamental difference between words and facts. Instead, extension of words does appear to be part of a wider general mechanism. Experiment 5 provides evidence that supports Bloom's theory (2000) and Childers and Tomasello (2003) that word learning is domain general: it uses a number of different general cognitive processes to work out the meaning of a word and retain it in memory.

Other data

Do any of the other data presented in this thesis give any clues to the domain specificity or the domain generality of word learning? Taken together, Experiments 1, 2, 3 and 4 suggest that children do not fast map and retain feature words (colour, shape and texture labels) in the same way as object labels, yet seem to fast map and retain linguistic facts, in at least some circumstances. The variation in retention of different word types combined with the similarity in retention of object labels and linguistic facts suggest that there are general cognitive systems at work here. In addition, the variation in retention across experimental procedures seems to operate for facts as well as object labels. This provides further evidence that the process of learning at least some words (object labels) is very similar to learning processes outside word learning, suggesting a general cognitive mechanism. Some recent studies support this view. Deák and Toney (2013) demonstrate good retention of pictograms after one week, following one exposure and repeat testing, suggesting that nonverbal information can be fast mapped and retained long-term. Moher, Feigenson and Halberda's (2010) findings suggest that preschoolers' rapid learning about faces and voices may be aided by biases that are similar to those that support word learning.

Future Work

Relatively little research into the study of long-term retention of fast mapped information means there is a huge amount of work still to do. For example, what other kinds of learning are prone to be remembered following minimal exposure? Deák & Toney (2013) suggest that children can retain fast mapped pictorial symbols and there is preliminary evidence that actions may be remembered following minimal exposure (Hahn and Gershkoff-Stowe, 2010; Riggs *et al*., 2014). The future work that links most closely to the findings in this thesis are discussed here.

An obvious area for future work that follows on from the previous discussion is to test factors ('aids to memory') that are likely to influence long-term retention. As previously suggested, using the procedure from Experiment 3 would be a good place to start - this method has produced reliable retention results across different studies and by different researchers (Experiment 3; Waxman & Booth, 2000). Small adjustments to the experimental procedure could test the effect of a variety of factors on retention of fast mapped words. The most interesting factor to test would be repeat testing. The data, as well as common sense, suggest that this is likely to be sufficient to produce retention. Another interesting factor to explore would be the effect of praise on children's retention performance. This may prove to be a key influence and often goes unnoticed. A particularly interesting avenue for future research would be to assess the cumulative effect of different factors on long-term retention to try to establish whether there is additional support for a 'threshold of retention'. Of course, any gestural cues that are embedded into the experimental procedure would need to be clearly delineated.

Another area of interest would be to apply Vlach and Sandhofer's (2012) rate of forgetting principle to shorter time scales such as 1 hour, 3 hours, 24 hours and 48 hours. This may illuminate at what point children start to forget newly learned object labels and suggest preliminary ideas for how to improve word learning. It may be useful to consider this research in light of effects of sleep on vocabulary acquisition. For example, Henderson, Weighall, Brown and Gaskell (2012) verify that following exposure to nonword competitors, children's ability to recognize and recall nonwords improved only after sleep. This suggests that word learning may actually improve following an overnight delay.

Summary

From an overview of all the evidence presented in this thesis and a summary of the literature, the testing of fast mapping, and particularly its connection with long-term retention, is a complex area. Experimental methods vary and the fluctuation in long-term retention data suggests that children's memory for words is affected by these fluctuations.

Long-term retention from fast mapping appears to be a variable process. Even when it does occur, this type of learning does not equate to full word learning. It is important to emphasise the kind of learning tested here: recognition of a link between a novel word and its referent object in a standard comprehension task. The child is very unlikely to be able to reproduce this novel word after such minimal exposure and it is even more unlikely that the word would become part of the child's working vocabulary.

However, it is easy to diminish how impressive this kind of learning is. Retention may not be as reliable as Markson and Bloom (1997) suggested but children are still demonstrating a remarkable memory for novel information linked with an object. They have been introduced to this novel information just once or twice within the same time event. Even if they have been ‘helped’ to remember this novel information at the point of exposure, being able to recognise this link after a week or more is impressive, especially in light of how much your average 3- or 4-year-old forgets! This kind of fast learning would certainly help children accumulate a large vocabulary.

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