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MECHANISMS OF WORD LEARNING IN CHILDREN: 
INSIGHTS FROM FAST MAPPING

by

Lori Robin Markson

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A Dissertation Submitted to the Faculty of the 
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1999
As members of the Final Examination Committee, we certify that we have read the dissertation prepared by Lori Robin Markson entitled *Mechanisms of Word Learning in Children: Insights from Fast Mapping* and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy.

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Michael Curtis King (1966-1998),

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS ........................................................................................................ 9
ABSTRACT ............................................................................................................................ 11
1. THE PROBLEM OF WORD LEARNING ............................................................................. 12
   Introduction .................................................................................................................... 12
   Vocabulary development in childhood ........................................................................... 14
   Infants' ability to segment spoken words ..................................................................... 17
   Children's capacity to infer word meaning ................................................................. 20
   Children's capacity for fast mapping ........................................................................... 24
   The underpinnings of children's word learning abilities ............................................. 31
   Overview of the rest of the dissertation ....................................................................... 35
2. THE GENERALITY OF FAST MAPPING ........................................................................... 36
   Introduction .................................................................................................................... 36
   Study 1: Fast mapping of words and non-words ......................................................... 39
   Method ........................................................................................................................... 39
      Participants ............................................................................................................... 39
      Materials .................................................................................................................. 39
      Procedure .................................................................................................................. 40
   Results ........................................................................................................................... 46
      Overall findings ....................................................................................................... 47
      Word condition ......................................................................................................... 49
      Fact (linguistic) condition ........................................................................................ 52
      Fact (perceptual) condition .................................................................................... 56
   Discussion ...................................................................................................................... 58
3. THE COMPLEXITY OF FAST MAPPING ......................................................................... 63
   Introduction .................................................................................................................... 63
   Study 2: Task complexity in learning and remembering words
      versus facts .............................................................................................................. 64
TABLE OF CONTENTS - Continued

Method .................................................................................................................. 64
Participant ............................................................................................................. 64
Materials ................................................................................................................. 65
Procedure .............................................................................................................. 65
Results .................................................................................................................... 66
Discussion ............................................................................................................ 70

4. THE PRECISION OF FAST MAPPING .................................................................. 72
Introduction ......................................................................................................... 72
Study 3: Memory for specific informational content in fast Mapping ................. 74
Method ................................................................................................................... 74
Participants .......................................................................................................... 74
Materials ................................................................................................................. 74
Procedure .............................................................................................................. 75
Results .................................................................................................................... 76
Discussion ............................................................................................................ 80

5. THE DEVELOPMENT OF FAST MAPPING ....................................................... 83
Introduction ......................................................................................................... 83
Study 3: Two-year-olds' fast mapping of words and non-words ......................... 84
Method ................................................................................................................... 84
Participants .......................................................................................................... 84
Materials ................................................................................................................. 85
Design .................................................................................................................... 86
Procedure .............................................................................................................. 86
Results .................................................................................................................... 89
Discussion ............................................................................................................ 93

6. GENERAL DISCUSSION .................................................................................... 95
LIST OF ILLUSTRATIONS

Figure 2.1: Mean percentage of comprehension test trials on which subjects selected the target object, collapsed across the word and act conditions, when tested immediately, after one-week, or after one-month. ........................................................................................................................................ 48

Figure 2.2: Mean percentage of comprehension test trials on which 3- and 4-year-olds and adults selected the target object in the word (koba) condition when tested immediately, after one-week, or after one-month. ........................................................................................................................................ 51

Figure 2.3: Mean percentage of comprehension test trials on which 3- and 4-year-olds and adults selected the target object in the linguistic fact (uncle) condition when tested immediately, after one-week, or after one-month. ........................................................................................................................................ 54

Figure 2.4: Mean percentage of comprehension test trials on which 3- and 4-year-olds and adults selected the target object in the perceptual fact (sticker) condition when tested immediately, after one-week, or after one-month. ........................................................................................................................................ 57

Figure 3.1: Mean percentage of comprehension test trials on which children and adults chose the target object in the fact + novel form condition (from Koba), compared to the fact (uncle) and word (koba) conditions of Study 1. ........................................................................................................................................ 68

Figure 4.1: Mean percentage of comprehension test trials on which children and adults selected the target object in the distracter word and distracter fact conditions compared to the original word and fact conditions of Study 1. ........................................................................................................................................ 78

Figure 5.1: Mean percentage of comprehension test trials on which 2-year-olds selected the target object on word and fact trials when tested immediately or after a one-week delay. ........................................................................................................................................ 91
LIST OF ILLUSTRATIONS – Continued

Figure 5.2: Mean percentage of comprehension test trials on which 2-year-olds selected the target object in the distracter word and distracter fact conditions compared to the original word and fact conditions.................92
ABSTRACT

Children can learn aspects of the meaning of a new word on the basis of only a few incidental exposures and can retain this knowledge for a long time. The process of rapidly learning and remembering new words has come to be known as fast mapping. It is often maintained that fast mapping is the result of a dedicated language mechanism, but it is possible that this same capacity might apply in domains other than language learning.

The present studies explore the nature of fast mapping, with the goal of revealing more about the mechanism underlying word learning in children. One possibility is that the capacity for word learning is mediated by a specialized language mechanism. A second view posits that all of language acquisition depends on more general cognitive processes. Alternatively, the acquisition of words and grammar may involve different mechanisms.

To test these alternative proposals, children and adults were taught a new object name and an arbitrary fact about a novel object, and were tested for their retention immediately or after a delay. The findings revealed that fast mapping is not limited to word learning, suggesting that the capacity to learn and retain new words is the result of learning and memory abilities that are not specific to language. Three further studies then explored the specificity and development of the capacity for fast mapping. The implications of these findings for theories of word learning are discussed.
Chapter 1

THE PROBLEM OF WORD LEARNING

Introduction

A fundamental question in the study of the mind is how children learn the meanings of words. To a naïve observer the act of learning a word might look fairly straightforward. A pancake is flipped onto a child's plate, he is handed a fork and told, "...eat your pancake, Max", and a new word is learned over breakfast. But scholars intimate with the problem of word learning know that children must overcome a number of obstacles before a word can be learned.

First, the child must isolate the word from the stream of speech in which it is spoken. Thus, in the example above, the novel form *pancake* must be segmented from the rest of the phrase. Second, the child must determine that the form *pancake* refers to the thing that recently fell onto his plate, and not the fork he was given to eat the pancake with, the syrup that was poured onto the pancake, just those parts of the pancake that are covered in syrup, the act of the pancake hitting the plate, and so on. Since all of these interpretations (and an infinite number of others) are equally plausible, how can the child know which entity the new word describes? In order to solve this problem of referential indeterminacy the child must somehow pick out
which concept a new word maps onto from an infinite number of logical possibilities (Quine, 1960). Third, once the proper translation of the new word has been inferred, an arbitrary mapping between the form and its meaning must be established, and this mapping must be remembered for a long time. Each of the steps described above is an essential component of integrating a new word into a child's lexicon.

Despite these hurdles, children learn the words of their language, and they do so with a swiftness and ease that allows one to pardon the naïve observer for overlooking the complexities of this task in the first place. Studies of vocabulary acquisition estimate that children know thousands of words before formal education even begins, suggesting that they must be learning many words a day throughout the preschool years (Anglin, 1993; Miller, 1977). Given these striking statistics, Carey speculated that:

"The only way to begin to account for the child's wizardry as a word learner, given the sheer weight of how much there is to be learned, is to grant that the child brings a great deal to the 'original word game.'" (Carey, 1978; p.265)

Carey went on to conduct a classic study of word learning, which discovered that children can learn aspects of the meaning of a word after hearing it only once or twice, and still show some understanding of its meaning when tested five weeks later (Carey & Bartlett, 1978). This suggests that children actively
try to map at least some meaning onto every new word they hear – a process referred to as “fast mapping” (Carey, 1978).

This dissertation concerns the nature of fast mapping. It first discusses how children rapidly learn and remember the arbitrary pairing between a form and meaning. It then explores the generality, development, and precision of the fast mapping abilities of children and adults. It concludes with speculation about possible mechanisms that might underlie this capacity, and provides some insight into mechanisms of word learning more generally.

In the remainder of this chapter, I review some of the relevant literature on word learning. I begin with a discussion of vocabulary development, which highlights the fact that the average child has accumulated a large vocabulary by the age of six. I then provide some background on the three basic problems children encounter in the course of word learning. The chapter concludes by posing a number of unanswered questions concerning children's rapid word learning abilities, and speculating about the underpinnings of this capacity.

**Vocabulary development in childhood**

The average six-year-old child can understand somewhere in the neighborhood of 8,000 to 10,000 words (Anglin, 1993; Carey & Bartlett, 1978). Children begin learning words around the time of their first birthday, and are
typically pre-literate until five or six years of age when they begin elementary school, at least in American culture. This means that the estimated thousands of words children know by the age of six were acquired through ambient speech. Once children begin to read they have access to an even wider array of vocabulary entries (Nagy & Anderson, 1984). It should not be too surprising, then, that the average high school graduate is estimated to know well over 50,000 words (Anglin, 1993; Lorge & Chall, 1963)\(^1\).

Since children begin learning words around twelve months of age, in order to achieve the numbers described above, they must learn somewhere in the range of five to ten new words a day between their first and sixth birthdays. Names for things are arbitrary; there is nothing intuitive about why we refer to wooden sticks filled with lead as *pencils*, but paper sticks that start fires as *matches*. Thus, learning a single new word requires memorizing an arbitrary relationship between a form and its meaning. In general, learning and remembering arbitrary associations is an arduous task requiring a fair amount of concentration. Consider how difficult it is to memorize random facts (e.g., mountain altitudes, foreign currency exchange, etc.), and you will have an idea of what is involved in learning a new word. Yet children appear to learn words quite naturally, almost without effort.

\(^1\)Vocabulary size in school children and adults is measured by selecting a random location in a large dictionary, such as the fifth entry from the top of the last column on every tenth right-hand page, and checking how many words a person knows at least one meaning for. This number is corrected for guessing, and the proportion correct is multiplied by the size of the dictionary.
It would be misleading to give the impression that infants, preschoolers, and elementary school aged children are equivalent word learners. The statistics described previously suggest that children must be learning five to ten new words a day. In reality, however, the pace of word learning is not evenly distributed across development. Given what we know about children’s lexical acquisition skills, it is more likely that one-year-olds are learning closer to one word a day (or a mere fraction of a word), two-year-olds are perhaps learning two or three new words a day, and so on (Fenson et al., 1994). Older children, who are attending school and have started reading independently are likely to compensate for the younger children by learning more than ten words a day.

Regardless of how vocabulary acquisition is characterized, one thing is certain: the sheer number of words children know by the end of the preschool years makes the child’s capacity for word learning an impressive one. This becomes particularly apparent if one dissects the process of word learning into components and considers the specific abilities needed for each step. The next three sections discuss three basic steps involved in learning a single new word: parsing the speech stream, inferring the concept to which a word refers, and learning and remembering the mapping between a word and meaning.

The resulting number is an estimate of the person’s vocabulary. This can be done across a random sample of people to determine a group’s average vocabulary size.
Infants' ability to segment spoken words

When we read, the words on a page are demarcated by blank spaces, relieving the reader of the burden of having to individuate one word from the next. In contrast, verbal discourse leaves this task to the listener. Word boundaries are not clearly marked by pauses or other consistent acoustic cues (Aslin, Woodward, LaMendola, & Bever, 1996). Because young children are not yet literate, all of the words they know must have been acquired through ambient speech. Therefore, in order to learn a new word, a child must first be able to disentangle it from the sentential context in which it was presented. Adults may do a number of things to reduce the burden of comprehending fluid speech for children. For example, parents may speak to young children in a slow, high-pitched manner with more elongated contours and repetitions, a style of speaking referred to as “motherese” or “child-directed speech” (Snow, 1972). Infants prefer to listen to this type of speech which tends to exaggerate prosodic features, an effect which has been found across a number of languages (Fernald, 1985; Fernald et al., 1989). Adults may also highlight new words by stressing them, or placing them at the end a sentence (“Look at the apple.”). But, even in these cases where parental assistance might ease the task of segmentation, children must still be able to parse the speech stream and isolate individual words before they can be learned.

There is an abundant literature on children's early phonological skills demonstrating infants' capacity to segment and recognize words in fluent
speech. In the first year of life, infants become increasingly sensitive to potential cues to word boundaries, and it is apparent that their word segmentation skills develop considerably between six to twelve months of age. Previous studies discovered that some of the specific cues infants are sensitive to include prosodic and distributional information that is available to the listener (Jusczyk, 1997; Saffran, Aslin, & Newport, 1996).

Infants' ability to recognize words in fluent speech was directly tested in a number of recent studies (Jusczyk & Aslin, 1995). Two words were repeatedly presented in isolation, until infants were familiar with the two words. Following this familiarization period, infants were presented with sentences that either did or did not contain the target words. The amount of time infants spent listening to the two types of sentences was recorded. In a different condition, infants were familiarized to the two words embedded in fluent speech passages, and then tested on them presented in isolation. Across both conditions, 7-1/2-month-olds listened significantly longer to the presentation containing the two familiar words, but 6-month-olds showed no preference for the familiar words over unfamiliar words. These findings demonstrate that by 7-1/2 months of age, infants are capable of segmenting and recognizing words in fluent speech, and are thus ready to move on to the next phase of word learning.

It is important to note that what the infants in the studies described above were doing is recognizing a word as familiar, not understanding its
meaning. Understanding this difference is quite relevant in studies of word learning, where recognizing a word as familiar could easily be misconstrued as understanding the meaning of a word. For example, 4-1/2-month-old infants can recognize the sound pattern of their own name, although it is unlikely that they understand what it means (Mandel, Jusczyk, & Pisoni, 1995). In other words, such findings do not suggest that infants understand that their names refer to themselves, but simply that infants prefer to listen to repetitions of their own name over other infants’ names. The ability to recognize one’s own name might develop before the ability to recognize other words as a result of familiarity with one’s own name, the salient stress patterns of names, or the fact that names are frequently used in isolation. The finding that infants can recognize sound patterns without understanding what they mean serves as a reminder that proper experimental controls are necessary in language comprehension studies to avoid mistaking children’s recognition of a word as familiar for knowledge of a word’s meaning.

The studies described up to this point concerned infants’ ability to remember speech information shortly after they heard it. Less is known about infants’ long-term memory abilities for specific characteristics of words. A recent study tested the ability of eight-month-olds to recognize the sound pattern of spoken words after a two-week delay (Jucszyk & Hohne, 1997). The infants in this study were repeatedly exposed to words embedded in stories over a two-week period. Two weeks after the last training session infants
were presented with lists of words containing either the familiar story words or unfamiliar words. Infants showed a strong listening preference for the lists of familiar words, suggesting that long-term memory for spoken words is attainable by eight months of age. Memory for the sound pattern of words is important for word learning since a critical component of learning a new word is remembering the relationship between a phonological form and the thing to which it refers. The fact that infants can recognize spoken words as familiar suggests that the initial steps toward solving the problem of word learning are taken in the first year of life.

Taken together, these findings suggest that by their first birthday, infants have the phonological capacities necessary to segment spoken words from fluent speech. They have overcome the first barrier to word learning.

**Children’s capacity to infer word meaning**

Word learning has been described as a classic problem of induction. The problem children are faced with is that there exist an infinite number of logically possible meanings for any new word. This is laid out most elegantly in the classic “Gavagai” puzzle posed by Quine (1960). Imagine a situation in which a linguist, who knows nothing of the language spoken in a foreign land, witnesses a native announce “Gavagai” as a rabbit runs past. Quine argues that there is no way the linguist can know with certainty that “Gavagai” refers to *rabbit*, and not rabbit-tail, brown rabbit running, rabbit-
hood, or any of an infinity of other logical possibilities. Children face a similar problem when confronted with a new word. As a result, determining the referent of a new word appears to be an intractable task, particularly for the young child. The question that continues to puzzle scholars is how children solve the problem of referential determinacy so inherent in word learning.

How do children learn words so quickly and effortlessly given the ambiguity of the context in which things are named? The predominant view of how children solve this induction problem has been the constraints account (Golinkoff, Mervis, & Hirsh-Pasek, 1994; Markman, 1989; Waxman, 1990). Such theories posit that children have internal lexical constraints that bias them to favor certain inferences over others when determining the meaning of a new word. Constraints aid children in the inferential process by drastically reducing the number of possible meanings a child must consider for any given word.

According to various constraint theories, if a child is shown an object and told to "Look at the blicket," children are more likely to assume that blicket denotes the whole-object rather than a part or property of the object. This response bias is interpreted by Golinkoff and her colleagues as an adherence to a principle of object scope, and by Markman as a whole object constraint. Similarly, in the above situation, children tend to assume that blicket is a name for other objects similar in kind to the original object, what
Golinkoff refers to as a principle of categorical scope, and Markman as a taxonomic constraint. Lastly, children will assume that blicket refers to an object for which they do not know a name, rather than to an object for which they already have a name. This response is thought to result from Golinkoff et al.'s novel-name nameless-category principle, or Markman's mutual exclusivity bias (Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Markman, 1990; Markman & Wachtel, 1988; Mervis & Bertrand, 1994; Waxman & Kosowsky, 1990).

Another means by which children could solve the problem of referential indeterminacy in word learning is through their knowledge of pragmatics and theory of mind. Children appear to be sensitive to social and pragmatic information available in the naming context that cues them in to the meaning of a new word. Some potential pragmatic cues that might help children infer the meaning of a new word include eye gaze direction, affective behavior, and discourse novelty. Children's sensitivity to such cues is dependent on their ability to infer the intentions of others.

One pragmatic cue children can use in word learning is direction of a speaker's eye gaze. Children know that the direction of a speaker's eye gaze is a reliable cue to the referent of a speaker’s utterance (Baldwin, 1991). In one study, 18- to 19-month-olds were handed an object to play with while a second object was placed inside an opaque bucket. While the child was distracted with the toy in her hand, the experimenter stared into the bucket and said,
"It's a toma." Despite the discrepancy between the child and experimenter's focus of attention, the infants mapped the new name to the object in the bucket. This finding suggests that infants checked the experimenter's direction of gaze, and used this cue to infer that the label toma was intended to refer to the object in the bucket, and not the one in the child's hand.

Children also interpret emotional expressions, such as frowning, as cues to the communicative intent of a speaker (Tomasello & Barton, 1994). In one study, an experimenter announced, "Let's find the toma," and then one toy after another was picked up and placed in a bucket while she frowned. When one of the objects was picked up, however, the experimenter smiled and said, "Ah!" Two-year-olds mapped the new name onto this last object, suggesting that they used the emotional cues provided by the experimenter to infer which object she was intending to refer to. Children can also learn verbs in this way, on the basis of whether actions occurred intentionally or accidentally.

Finally, young children understand that speakers tend to name things which are new to the discourse context (Akhtar, Carpenter, & Tomasello, 1996). In this study, two-year-olds played with three novel objects with a parent and the experimenter. While the parent was momentarily absent, a new object was added to the collection. The parent returned and exclaimed, "There's a toma!" Children mapped the new label onto the new object, suggesting that two-year-olds understand that speakers tend to comment on
things that are new to the discourse context. In this situation the child inferred that their parent was intending to refer to the most recent object.

These findings highlight children's early capacity to use pragmatic cues to infer the meaning of a new word. Without the ability to use pragmatic cues or lexical constraints, the naming context would be too ambiguous for children to make accurate inferences about word meaning. Children's reliance on pragmatic cues to infer word meaning could potentially work in conjunction with the proposed lexical constraints, or the two could operate independently. It is likely that an ability to infer the intentions of others might be essential to word learning (Bloom, in press).

Taken together, the present findings suggest that by 18-months of age children have two potential resources available to help them infer the meaning of a new word. They have overcome the second barrier to word learning.

**Children's capacity for fast mapping**

A word is an abstract entity that represents the arbitrary relationship between a form and a concept. Thus, every act of word learning involves the acquisition and retention of an arbitrary pairing. As mentioned earlier, children know a lot of words — on the order of 10,000 — by their sixth birthday. These facts suggests that children must be adept word learners, capable of quickly acquiring and permanently storing these arbitrary pairings in their
lexicons. The third challenge that children must overcome to learn a new word is that of establishing and remembering an arbitrary association between a form and meaning. How do children do this when the relationship between words and their meanings is arbitrary and they must remember so many of them?

Carey and Bartlett (1978) were the first to empirically explore children’s ability to quickly learn a new word and remember it over time. In the classic study, three- and four-year-old children were casually introduced to a new color word, "chromium", to designate the color olive green (Carey & Bartlett, 1978). The new word was introduced by the children’s teacher within the context of an unrelated classroom activity, with the distinct purpose of avoiding any indication that they were supposed to be learning something new. For instance, during snack preparation the teacher might privately say to a child, “Bring me the chromium cup, not the red one, the chromium one.” The new word was always contrasted with a different, familiar word from the same lexical domain. This highlighted that chromium was a color term and provided the children with a contextual cue for identifying its intended referent. In this situation, most of the children were able to infer that the new word referred to the unknown color.

When tested for comprehension of the new word one week later, most of the children remembered that chromium referred to the color olive green. Even after five weeks, many children still retained some knowledge of the
new word (e.g., that chromium was a color term), if not the specific color to which it referred. This initial experiment, coupled with a series of subsequent more tightly controlled studies, led the authors to conclude that children can grasp aspects of the meaning of a new word after a single brief exposure and remember this knowledge for a long period of time.

The authors introduced the term "fast mapping" to describe the initial phase of word learning in which children rapidly and efficiently incorporate a new word into their lexicon. Children are attuned to notice new words and quickly recruit them into the appropriate semantic category. After the initial "fast mapping" comes a slower process in which children work out the full meaning of a new word and come to appreciate subtle distinctions among individual words, particularly those within the same category. This second process of word learning, that of sorting out the precise meanings of words in a semantic domain, is more protracted, sometimes never reaching completion.

One limitation of the original study is that it only tested children's capacity for fast mapping in a single lexical domain, that of color. Because of this it was unclear whether fast mapping could be generalized to the acquisition of words in other domains. Heibeck and Markman (1987, Experiment 1) conducted a more systematic examination of fast mapping by testing children's ability to learn words in three lexical domains: color, shape, and texture. They also included two-year-olds, in addition to three- and four-
year-olds, to test whether younger children are capable of rapidly learning new words after limited exposure. One critical measure which differed from the original study was that the delay period between exposure to the new word and testing was reduced from a one-week-delay to about 10 minutes after the new word was introduced.

The primary question these studies sought to answer was whether children as young as two years of age could learn the meaning of a new word from another domain, besides color, after limited exposure. The findings revealed that children could quickly learn a new color, shape, or texture word suggesting that fast mapping generalizes across multiple semantic domains, and is not restricted to the acquisition of color terms. Children were able to learn words from all three domains, but they were best at learning shape terms, second best with color terms, followed by texture words. In addition to the older children, two-year-olds were also able to quickly learn the new words, suggesting that fast mapping is available early in the preschool years.

A second study addressed the importance of explicit linguistic contrast for fast mapping. In Carey and Bartlett’s (1978) experiment, and Heibeck and Markman’s (1987) Experiment 1, children always heard a new word contrasted with a familiar word from the same lexical domain. Do children require explicit linguistic contrast to determine the lexical domain a new word belongs to? Or is this sort of redundant linguistic information extraneous to the task of word learning? To address this, children were presented with a
new word that was not contrasted with a familiar word from the same lexical domain. For instance, in the color condition, instead of hearing "Bring me the chartreuse one, not the red one", children in the implicit linguistic contrast condition heard "Bring me the chartreuse one, not the other one." Children learned the same amount of information about a new word regardless of whether it was taught to them through implicit or explicit linguistic contrast. These findings led the authors to conclude that when the nonlinguistic context in which a word is heard provides sufficient information, children gain no advantage from hearing an unknown word contrasted with a familiar word from the same category. However, when the nonlinguistic context is less compelling, explicit linguistic contrast has been found to help three- and four-year olds acquire new material words, but it did not help children learn new color terms (Au & Markman, 1987).

These studies suggest that children can quickly learn the meaning of a new word after minimal exposure to the word and its meaning, a finding that holds across a number of lexical domains. Children's ability to rapidly learn a new word is now well-documented in the acquisition of nouns, verbs, and adjectives (Dollaghan, 1985; Golinkoff et al., 1996; Zamuner et al., 1999). The finding that children can quickly acquire words across a variety of semantic domains is crucial to account for the impressive vocabulary of six-year-olds. But building a vocabulary mandates that children remember the words they learn. Aside from the original fast mapping study by Carey and Bartlett (1978)
which only tested for the acquisition of color terms, it is not apparent whether children can quickly learn a new word after limited experience and remember it for a long period of time. Both of these features—quick, incidental learning and long-term retention—are essential for fast mapping. Surprisingly, there are very few experiments which replicate the second critical component of the original fast mapping study, that of the long delay between exposure to the new word and testing for comprehension of its meaning. The long delay is critical because it mimics what is required for vocabulary growth in the natural world.

Two studies have tested children's ability to rapidly learn a name for a novel object and remember this mapping for 24-hours. In one study, 13- and 18-month-olds were found to comprehend a new label for an object after hearing it nine times over the course of a few minutes, even when testing occurred after a 24-hour delay (Woodward, Markman, & Fitzsimmons, 1994). These findings highlight the remarkable fast mapping capacities of infants. However, the training phase of this study was quite explicit, with children being shown a single object and repeatedly hearing its name. As a result, the incidental nature of the learning context was lost.

The second study exposed children to words for objects in a more natural, incidental context. In this study, two-year-olds were taught names for novel instances of familiar categories and were required to infer meaning from the semantic context in which the word occurred (Goodman,
McDonough, & Brown, 1998). For example, a child might be taught the new word for a picture of an animal they had never seen before being fed and told "Mommy feeds the ferret." Two-year-olds were good at learning the new words, and remembered them when tested after a 24-hour delay. These findings show that two-year-olds are capable of fast mapping words that are presented in rich semantic contexts. However, new words do not always come so neatly packed in informative sentences, specifically tailored to the needs of the child. Thus, it remains unclear whether fast mapping can occur in less supportive contexts, that more closely resemble natural word learning situations.

The last study provides the strongest evidence to date for fast mapping in preschoolers. While the strength of the two studies described above is that they found comprehension of newly learned words after a 24-hour delay, this is also the source of a weakness. To build a vocabulary, the words children learn must be permanently stored in the lexicon and not fade away with the passing of time. Thus, it is important to ascertain whether children can remember words following more extensive delays, such as a week or even a month. Virtually no studies have examined the child's ability to learn words from a less-restricted lexical domain (e.g. names for objects), on the basis of limited experience and retain this information for a long period of time (e.g., up to a month later). Precisely how and when children overcome the third barrier to word learning is not yet known.
The underpinnings of children's word learning abilities

How do children learn and remember words as efficiently as they do? Is there a special mechanism underlying children's capacity for fast mapping? One possible account of fast mapping is that it results from a dedicated language mechanism, as has been proposed for other aspects of language acquisition. Some support for a biological specialization for language comes from studies which find a firm maturational time-course as well as critical periods for the development of certain aspects of language, such as syntax and phonology (Curtiss, 1989; Newport, 1990).

What differences might exist between children's and adults' fast mapping abilities? This developmental issue is practically untouched in the research on word learning. With the exception of categorization studies interested in how children extend labels to novel artifacts, and word learning studies with patient populations such as aphasics and research on second language acquisition, there is little work addressing the word learning abilities of adults (Grossman & Carey, 1987, Kelemen & Bloom, 1994). It might be intuitive to think that adults would be better at learning words than children, since they have larger vocabularies and hence more experience acquiring words. In addition, adults are generally more skilled at cognitive and intellectual activities. But, as alluded to earlier, it is possible that there exists a critical period in development for word learning, similar to that
which has been proposed for syntax. If this were the case, children might be superior to adults at learning new words.

A compelling argument for a biological specialization for language has to do with issues concerning the impoverished input available to language learners. The fact that word learning is accomplished so readily by young children has led researchers to posit a mechanism dedicated to solving this problem. The idea that a specific part of the brain is dedicated to solving a particular task is not new, especially in the study of language acquisition. For instance, that children acquire grammatical knowledge through limited and impoverished experience and without negative evidence has led linguists to posit internal mechanisms (Chomsky, 1986; Gold, 1967; Marcus, 1993).

The poverty of the stimulus argument is typically restricted to grammatical development, but Chomsky himself alludes to the notion of the word learner facing the same dilemma:

"The pervasive property of "poverty of stimulus" is striking even in the case of simple lexical items. Their semantic properties are highly articulated and intricate and known in detail that vastly transcends any relevant experience, and is largely independent of variations of experience and of specific neural structures over a broad range." (Chomsky, 1993; p.24)

More specific to word learning is the proposal of child-based constraints described earlier (Markman, 1990). However, it must be noted that proponents of theories positing lexical constraints vary with regard to
whether the biases children have about word meanings are innate or learned, although they agree (at least implicitly) that these constraints are specific to the problem of word learning (Markman, 1992; Smith et al., 1997; Waxman, 1994).

It is possible that word learning and grammar may involve different mechanisms (Pinker, 1991). Research with neurologically impaired patient populations supports the idea of a neural dissociation between the memory systems responsible for lexical information and grammatical rules (Ullman et al., 1996). Additional evidence for a dissociation of syntactic and lexical processes stems from event-related brain potential (ERP) studies showing that lexical information is processed differently from grammatical information in both children and adults. Furthermore, ERP studies with deaf and bilingual populations reveal different critical periods for lexical and grammatical knowledge (Neville, Mills, & Lawson, 1992; Weber-Fox & Neville, 1996). Finally, a language acquisition study with twins revealed a dissociation between vocabulary and grammar for heritability. The results found that environmental input may not be as necessary for grammatical development as vocabulary acquisition, and conversely that heritability might not be as important for word learning as it is for the acquisition of grammar, suggesting that these two aspects of language might be learned differently (Ganger, 1998). Together, the findings suggest that children's ability to learn new words is not
dependent on the same system responsible for the development of syntactic knowledge.

In contrast, there is ample evidence supporting the opposite position, that a single domain-general mechanism underlies grammatical and lexical development (Bates et al., 1988; Bates & Goodman, 1997). Studies examining language development in normal and atypical children have found that the emergence of grammar is correlated with vocabulary size. These findings support the idea that early lexical and grammatical development are governed by the same mechanism. Simulations of language learning in connectionist models provide additional support for this unified approach to the mechanisms underlying language acquisition (Elman, 1993; Elman et al., 1996).

However, any theory of language acquisition must not only be able to explain how children learn words, but also how they acquire the sophisticated syntactic knowledge that every normal child displays in the first few years of life (Chomsky, 1988; Pinker, 1994). Proponents of domain-general views of language acquisition do try to account for vocabulary development and some aspects of grammatical development, appealing to connectionist architectures to demonstrate how this could be accomplished (Elman et al., 1996; Karmiloff-Smith, 1992). But these accounts cannot adequately explain how the initial representations needed for subsequent learning get into the system in the first place (Bloom & Wynn, 1994; Fodor, 1981). This suggests that the system —
whether it be a young child or a connectionist network – must start out with at least some domain-specific representations (Marcus, 1998).

Overview of the rest of the dissertation

Three outstanding questions about fast mapping will be addressed in the chapters that follow. First, is fast mapping specific to the domain of language, or does this ability apply more generally? Second, are there developmental differences in the capacity for fast mapping? Third, how precisely is the knowledge acquired through fast mapping remembered? Answering these questions requires empirical studies that explore the fast mapping abilities of children and adults. The next four chapters present studies to address these unanswered questions about fast mapping, with the hope of gaining a better understanding of the nature of fast mapping and the mechanisms of word learning in children. The final chapter draws some conclusions and describes the direction of future research.
Chapter 2

THE GENERALITY OF FAST MAPPING

Introduction

Chapter 1 introduced the concept of fast mapping as the initial process of word learning in which children can quickly map an unfamiliar form to its referent and begin to incorporate the new word into their lexicon (Carey, 1978). The forthcoming set of studies is a more detailed investigation of this process. For the present purpose, fast mapping should be thought of as describing the capacity to quickly learn an arbitrary pairing after limited experience and remember this association for a long period of time. It should be noted that this definition of fast mapping is not restricted to the relationship between a form and meaning (e.g., a word), but rather could be applied more broadly.

The previous chapter reviewed the literature on children's impressive capacity to quickly learn a new word and remember it over time. Three explanations were proposed to account for the rapidity and durability of word learning observed in children. One possibility is that the capacity for word learning is sub-served by a specialized language mechanism. Such a mechanism has been posited to underlie other aspects of language acquisition, such as syntax, making it reasonable to suspect that word learning
might also be governed by the same language-specific mechanism (Chomsky, 1988). In contrast, a second view posits that all language acquisition depends solely on more general cognitive processes (Bates et al., 1988). Proponents of this view claim that word learning and the development of syntax are interdependent, with both processes being driven by the same domain-general mechanisms. Lastly, a third possibility is that the acquisition of words and grammar involve different mechanisms (Pinker, 1991). If word learning and grammatical development are supported by separate mechanisms, it is possible that the acquisition of grammar depends on a mechanism specifically dedicated to language, while the acquisition of words might depend on more general cognitive processes.

The present chapter explores the nature of fast mapping, with the goal of revealing more about the mechanism responsible for word learning in children. This is accomplished by (1) investigating whether differences exist between children and adults for fast mapping, (2) examining whether this process is specific to words, and (3) providing a more complete description of children’s capacity to learn and remember arbitrary information about objects.

In Study 1, three- and four-year-old children, and adults, participated in a measuring activity, during which they were exposed to a number of novel and familiar objects. Subjects were incidentally told a name for one of the novel objects and a fact about a different novel object. After a pre-specified
delay period, subjects were tested for comprehension of the new word and fact.

Three- and four-year-olds were tested to match the age of children tested in the original fast mapping study of Carey and Bartlett (1978), and because this is the age of children typically tested in studies of word learning. Adults were included to test for developmental differences in word learning.

The acquisition of words was compared with the learning of other kinds of knowledge to uncover whether fast mapping is specific to language. The two different types of facts were tested with the objective of uncovering a clearer picture of how broadly fast mapping applies. The two fact conditions were originally conducted as two separate experiments. Due to the similar design and unified theoretical focus of the studies, they have been combined and are reported as a single study with type of fact as a between-subjects condition.

One question that will be addressed in Study 1 concerns whether fast mapping occurs with equal force for non-words, such as arbitrary facts. If children are as successful at learning and remembering a new fact about an object as they are at learning the name of an object, it will suggest that fast mapping is not special to word learning. In contrast, if children perform worse with facts, it will suggest that fast mapping is linked to lexical acquisition.
A second question concerns developmental differences for the fast mapping of both words and facts. If adults and children have comparable abilities it would suggest that there is not a “critical period” for word learning as has been suggested for other aspects of language acquisition (e.g., syntax). Such a finding would support the hypothesis that word learning is mediated by a different mechanism from other aspects of language acquisition which do find differences between children and adults.

Study 1: Fast mapping of words and non-words

Method

Participants

Forty-eight 3-year-olds (mean age = 3.7; age range = 3.0-3.11), 47 4-year-olds (mean age = 4.5; age range = 4.0-4.11), and 48 undergraduate students at the University of Arizona participated in Study 1. Children were tested in a quiet room at their preschool and adults were tested in the Language and Cognition Lab. Parental consent was obtained for all children.

Materials

Stimuli. Subjects were presented with ten objects, six novel and four familiar. All subjects were exposed to the same ten objects, but the objects for
which they were taught a new label and fact varied across subjects. The novel objects were roughly equal in size and were selected based on the criterion that subjects would be unable to name them. The set of novel objects included a white plastic rectangle consisting of ten bars connected by two longer bars, a gray plastic grid, a wooden stick with a black sponge-tip, multi-colored trumpet-shaped pasta, a gray plastic grid, blue plastic tubes with a ridged surface, and a brown rubber disc indented with small circles on one side. The familiar objects included pennies, a pencil, a ruler, and some string.

**Novel label and novel facts.** Each subject was taught a novel label — *koba* — for one of the six novel objects. The label was selected for its novelty and simple phonological form. Each subject was also taught a novel fact for a different novel object than the one they were taught a label for. Subjects were also told a linguistic fact — *that it been given to the experimenter by her uncle*, or observed a perceptual fact — *the placement of a sticker onto the object*, about one of the six novel objects. The two facts were selected according to the criteria that they be arbitrary, in that they could apply equally well to any of the objects, and that they would be easily understood by the children.

**Procedure**

Children were told the task was a measuring game, and adults were told it was a game designed to teach children how to measure. This pretense was important to prevent subjects from realizing that they were being taught
anything new; to them the study involved measuring, not learning names and facts about objects. There were two parts to the study, a training phase and a test phase. In the course of the training phase all subjects were casually introduced to a new word for one of the novel objects, and a new fact about a different novel object. Every subject received an identical word trial, and one of two possible fact trials: (1) a linguistic fact trial, or (2) a perceptual fact trial.

The test phase was conducted after one of three possible delays: immediately, one-week, or one-month after the training session. One third of the subjects from each of the three age groups participated in each delay condition. One child moved away prior to the test session, resulting in one less 4-year-old in the one-month delay condition for word and perceptual fact trials.

Every subject participated in both the word and fact conditions, with one trial of each condition. The order in which subjects experienced word versus fact information was balanced with respect to age group and delay condition. The novel object which the new word and fact referred to was counterbalanced within condition (type of fact) by age and delay. All counterbalancing was done separately for each between-subject fact group. The two comprehension questions followed one practice trial of each type of test question (e.g., “Can you show me a penny?” or “Can you show me something used for writing?”).

Training phase. The experimenter presented subjects with various novel and familiar objects and instructed them on what to do with the
objects. All activities were presented in the same order across all subjects; what varied was which two (out of six) activities involved the introduction of a new word and new fact. There were six measuring activities, each involving one or two of the different kinds of novel and familiar objects: (1) measure the length of child’s foot and experimenter’s foot with string (adults compared length of their own foot and arm); (2) line blue plastic tubes up against two rulers and count how many long each ruler was; (3) compare circumference of wrist and ankle using string and trumpet pasta; (4) measure/compare length of white plastic rectangle and sponge-tipped stick with ruler; (5) measure height or circumference of brown plastic disc using pennies; (6) use ruler to measure gray plastic grid and pencil. Four of the novel objects were yoked into pairs of two; each of the two pairs served as the target objects half of the time, and served as distracter items the other half of the time. The two pairs of target objects were (1) the blue tubes and sponge-tipped stick, and (2) the trumpet pasta and white plastic rectangle. Within each pair, subjects were told a new word for each object half of the time, and a new fact for each object half of the time. In this way, each of the four objects served as the target in both the word condition and the fact condition an equal number of times. The gray grid and brown plastic disc always served as distracter items. In addition, because the measuring activities were always presented in the same order, the new word was presented first half of the
time, and the new fact was presented first half of the time, with respect to age
group and delay condition.

For half of the subjects, the new word koba was used in the singular to
describe a single object; for the other half it was used to describe multiple
identical objects of that kind. Because of this subjects were told either “Let’s
use the koba...” or “Let’s use the kobas...” depending on whether there was
one or many objects present. Subjects who were taught a singular word
learned a fact about multiple objects of the same kind, whereas subjects who
were taught a plural word for multiple objects of the same kind were taught a
fact about a single object. Similarly, subjects were told, “Let’s use the thing(s)
my uncle gave to me...” for one of the objects on fact trial, depending on
whether there were one or many objects present. Of the target items, the blue
tubes and pasta trumpets were objects of which there were many of the same
kind, and the sponge-tipped stick and while plastic rectangle were one of a
kind objects.

*Training phase: Word trial.* The experimenter went through the entire
sequence of events described above. During the designated activity, subjects
were casually introduced to the new word *koba*, used to refer to the novel
object. For example, in activity 2 described above, subjects heard: “Let’s use
the *kobas* to find out which is longer. Line up the *kobas* so we can count
them. We can put the *kobas* away now.” Every subject heard the new word
three times in an incidental context. The experimenter made certain that
subjects were attentive to the task before naming the object. During the non-target activities, an equal amount of attention was paid to the novel objects, but no label was provided (e.g., “Let’s use these to find out which is longer...we can put them away now.”). The word condition was presented first half of the time.

*Training phase: Linguistic fact trial.* The training procedure for the fact condition was identical to that of the word condition, except subjects heard a new fact, conveyed through language, about one of the novel objects. More specifically, subjects heard: “Let’s use *these things that my uncle gave to me* to find out which is longer. We can line up *the things my uncle gave to me* and then count them. We can put *the things my uncle gave to me* away now.” The fact condition was presented first half of the time.

*Training phase: Perceptual fact trial.* The training procedure for the word condition was identical to that of the word and linguistic fact condition, except subjects were shown a new fact, conveyed through perception, about one of the novel objects. More specifically, subjects heard, “Watch where this goes. This goes here [as the sticker is placed onto one of the novel objects]. See, this is where this goes.”

*Test phase.* The test phase examined the consistency with which children and adults selected an object in response to questioning by the experimenter. One-third of the subjects from each age group were tested immediately after the training, one-third after a one-week delay (6-8 days),
and one-third were tested after a one-month delay (28-30 days). Because the novel object for which subjects were told words and facts varied across subjects, the experimenter was blind with regard to which of the novel objects were the targets during the comprehension test. All subjects were first given two practice trials for familiar objects, one involving a word (e.g., "Can you show me a penny?"), and one involving a fact (e.g., "Can you show me the one that you can write with?"). The purpose of the practice trials was to provide children with some easy warm-up questions, and ascertain that they understood the task. Practice trials were followed by two experimental trials on which subjects were tested for comprehension of the new word and the new fact that they had been introduced to during the training phase. The order in which subjects were asked the word and fact questions corresponded to the order in which they were first presented with the information during the training phase. Subjects who heard the word first were asked the word comprehension question first, while subjects who had been introduced to the fact first, were asked the fact comprehension question first. In this way, the order of presentation of word and fact comprehension questions was counterbalanced across subjects by age and delay.

Test phase: Word trial. Subjects were presented with the original set of ten items they had interacted with during the training phase and asked to recall which item was the koba. Specifically, subjects were asked, "Can you
show me a koba? Is there a koba here?" Subjects were given as much time as needed to respond, and were not provided with any feedback.

*Test phase: Linguistic fact trial.* The fact test was identical to that of the word test, with the exception that subjects were asked to recall which object the fact applied to. Subjects were presented with an array of the ten items from training and asked to recall which item had been given to the experimenter by her uncle. Specifically, subjects were asked, "Can you show me the one my uncle gave to me? Is there something that my uncle gave to me here?" Subjects were given as much time as needed to respond, and children were praised for their responses, regardless of their accuracy.

*Test phase: Perceptual fact trial.* The word comprehension test was identical to that of word test and the linguistic fact test. In the perceptual fact condition, subjects were handed a small sticker and instructed to put it where it should go. Subjects were presented with an array of the ten items from training and specifically asked to, "Show me where this goes. Can you put this where it goes?" Subjects were given as much time as needed to respond, and children were praised for their answers, regardless of their accuracy.

**Results**

The data for each subject were coded as correct or incorrect for the two types of test questions, word and fact. Responses were coded as correct or incorrect by checking whether the object selected at test time was the object
the subject had been given that same piece of information about during the training phase. A response was coded as correct if the item selected at test time was the object the subject had been given a new word or fact for in the corresponding condition of the training phase. Likewise, a response was coded as incorrect if the item selected at test time was a different object than the one the subject had been given a new word or fact for in the corresponding condition of the training phase. Every subject provided a response to both the word and fact test questions.

**Overall findings**

A three-way repeated measures ANOVA with Information type (word vs. fact) as a within-subjects variable, and Age (3-year-olds vs. 4-year-olds vs. adults) and Delay (immediate vs. week vs. month) as between-subjects variables uncovered a significant main effect of delay, $F(2,134) = 3.36, p < 0.04$.

As illustrated in Figure 2.1, the main effect of delay was due to a significant decrease in the mean number of correct responses, as length of the delay interval between training and testing increased. Subjects made significantly more correct responses when tested immediately compared to after a one-month delay (77% vs. 60%; $t(93) = 2.45, p < 0.02$), and marginally significant more when tested after one-week compared to one-month (73% vs. 60%; $t(93) = 1.83, p = 0.07$). Performance was comparable when subjects were tested after one-week compared to immediately (73% vs. 77%; $p > 0.05$).
Figure 2.1: Mean percentage of comprehension test trials on which subjects selected the target object, collapsed across the word and fact conditions, when tested immediately, after one-week, or after one-month.

A second three-way ANOVA with Fact Type (linguistic vs. perceptual), Age (3-year-olds vs. 4-year-olds vs. adults) and Delay (immediate vs. week vs. month) as between-subjects variables uncovered a significant main effect of fact type, $F(1, 125) = 12.81$, $p < 0.001$, and a significant main effect of delay, $F(2,125) = 5.97$, $p < 0.003$. Subsequent t-tests revealed that subjects made significantly more correct responses in the linguistic fact condition compared to the perceptual fact condition ($82\%$ vs. $56\%$; $t(141) = 3.43$, $p < 0.001$).
These preliminary findings were examined more closely by breaking the remainder of the analyses down by the specific type of information (word, linguistic fact, or perceptual fact) and comparing differences in performance at each delay by age group.

**Word condition**

Recall that the first question of interest was simply whether children and adults would be able to quickly learn a new object name, and retain the mapping between the word and its referent for a long period of time. To address this, the number of correct responses to the test question for the word condition was calculated for subjects of each age group across each of the three delay conditions. Chance was conservatively calculated as 1/6 (17%) across all three conditions since there were six novel objects to choose from in the test array.¹

T-tests revealed that children and adults were successful at learning the novel object to which the label *koba* referred (see Figure 2.2 below). In the immediate condition, three-year-olds selected the correct object 56% of the time, four year-olds chose correctly 63% of the time, and adults did so 94% of the time. Although there were ten objects in the test array, four of those objects were familiar to subjects, making it unlikely that they would be selected as the referent of the new word. Markman and Wachtel (1988) have shown that children tend to assume that novel words are more likely to correspond to novel, nameless objects than to familiar ones, because they already have a name associated with them. In addition, Diesendruck and Markson (1999) found this same effect to hold true for novel facts. Based on these findings, even if subjects forgot which object the new

¹ Although there were ten objects in the test array, four of those objects were familiar to subjects, making it unlikely that they would be selected as the referent of the new word. Markman and Wachtel (1988) have shown that children tend to assume that novel words are more likely to correspond to novel, nameless objects than to familiar ones, because they already have a name associated with them. In addition, Diesendruck and Markson (1999) found this same effect to hold true for novel facts. Based on these findings, even if subjects forgot which object the new
the time. Subjects in all three age groups tested selected the correct referent of
the new word koba significantly more than would be expected by chance
performance [3-year-olds: t(15) = 3.06, p < 0.008; 4-year-olds: t(15) = 3.64, p <
0.002; adults: t(15) = 12.28, p < 0.001].

Furthermore, when tested after a delay of one-week, three-year-olds
selected the correct object 69% of the time, four-year-olds did so 75% of the
time, and adults 81% of the time. Children and adults were again significantly
better than chance at selecting the referent of the new word when tested after
a one week delay [3-year-olds: t(15) = 4.32, p < 0.001; 4-year-olds: t(15) = 5.19, p <
0.001; adults: t(15) = 6.38, p < 0.001].

Following a delay of one month three-year-olds still selected the correct
object 56% of the time, four-year-olds 73% of the time, and adults 69% of the
time. Performance across all ages was significantly higher than would be
expected by chance [3-year-olds: t(15) = 3.06, p < 0.008; 4-year-olds: t(14) = 4.77, p
< 0.001; adults: t(15) = 4.32, p < 0.001].

The percentage of correct responses made by subjects in each age group
for each test delay is shown in Figure 2.2. Importantly, performance did not
significantly deteriorate over time for any age group (all p values > 0.05).

\[\text{word referred to, they might restrict their guess to the six novel objects. For this reason, chance was conservatively calculated as } 1/6 \text{ in both conditions.}\]
The findings show that children and adults can quickly learn an object name and remember it for a long time — up to a month later — after minimal experience with the new name and its referent. A second question of interest was whether children and adults differ in their ability to quickly learn an object name and remember it over time. To address this question, children and adults' performance was compared in each of the three delay conditions.
Adults were significantly better than children of both ages when tested immediately: adults versus three-year-olds, $\chi^2(1) = 6.0, p < 0.05$; adults versus four-year-olds, $\chi^2(1) = 4.6, p < 0.05$. But, there were no age differences at the longer delay intervals, suggesting that children and adults possess comparable fast mapping abilities. This lack of any difference in performance between children and adults after a delay supports the hypothesis that there is not a critical period for word learning. While there was a significant difference when subjects were tested immediately, this was due to an advantage on the part of the adults, not the children, which is the exact opposite of what would be predicted under a critical period assumption.

Fact (linguistic) condition

The third question of interest concerns the domain-specificity of fast mapping. That is, is fast mapping a process that is specific to the acquisition of new words, or does it also work for other kinds of knowledge acquisition? To address this, the number of correct responses to the linguistic fact test question was calculated for subjects of each age group for each of the three delay conditions. This number was compared both to chance and to subjects' performance in the word condition.

Children and adults were also successful at learning which object had been given to the experimenter by her uncle, as illustrated in Figure 2.3 below. In fact, subjects were just as good at learning this arbitrary piece of
information as they were at learning a new word. In the immediate
condition, three-year-olds selected the correct object 88% of the time, four-
year-olds did so 100% of the time, and adults 75% of the time. T-tests revealed
that subjects in all three age groups selected the correct referent of the
arbitrary fact significantly more than would be expected by chance [3-year-olds:
t(7) = 5.64, p < 0.001; adults: t(7) = 3.54, p < 0.01].

Furthermore, just as in the word condition, subjects of all ages
remembered the referent of the new fact significantly more than would be
expected by chance, when tested after a delay of one week. Three-year-olds
selected the correct object 88% of the time, four-year-olds did so 100% of the
time, and adults 75% of the time. T-tests revealed that performance was
significantly greater than would be expected by chance for all ages [3-year-olds:
t(7) = 5.64, p < 0.001; adults: t(7) = 3.54, p < 0.01].

Even after a one-month delay, three-year-olds still selected the correct
object 63% of the time, four-year-olds did so 88% of the time, and adults 63%
of the time, which was higher than would be expected by chance for all ages
[3-year-olds: t(7) = 2.49, p < 0.05; 4-year-olds: t(7) 5.64, p < 0.001; adults: t(7) =
2.49, p < 0.05]. The percentage of correct responses made by subjects in each
age group for each test delay is shown in Figure 2.3. In addition, there was not
a significant decline in performance over time for any of the age groups (all p
values > 0.05).
Figure 2.3: Mean percentage of comprehension test trials on which 3- and 4-year-olds and adults selected the target object in the linguistic fact (uncle) condition when tested immediately, after one-week, or after one-month (chance = 17% and is represented by the line).

The findings show that children and adults can quickly learn an arbitrary fact about an object and remember it for a long time – up to a month later -- after a relatively brief encounter with the fact and its referent. In sum, all three age groups again performed significantly better than chance in all delay conditions, and there was not a significant decline in performance over time by any of the age groups. It is important to note that this pattern of results mirrors the findings of the word condition.
There was one significant difference in performance across the two conditions, however. When the three- and four-year-olds were combined into a single group they did significantly better in the fact condition than in the word condition, when the test session immediately followed the training phase, \( \chi^2(1) = 6.1, p < 0.05 \). This difference suggests that children were actually better at learning the new fact compared to the new word.

It is not clear why children were better at learning the new fact than the new word. One possibility is that learning an unfamiliar phonological form (e.g., a novel word) poses a greater challenge to children than learning a sequence composed entirely of familiar sound patterns, while adults are unaffected by this distinction. This issue is pursued further in the next chapter. Regardless of what is responsible for this discrepancy, children are clearly capable of learning information other than words after a quick, incidental exposure and retaining this information for a long time.

The present findings suggest that fast mapping is not specific to words, and motivate a fourth question concerning the scope of fast mapping. The perceptual fact condition addresses this issue by examining subjects’ fast mapping abilities for a third type of knowledge – an arbitrary fact conveyed through perception.
Fact (perceptual) condition

The fourth question of interest concerns the generality of fast mapping. Is fast mapping an entirely general learning and memory process, or are there limitations? To address this, the number of correct responses to the perceptual fact test question was calculated for subjects in each age group for the three delay conditions. This number was compared both to chance and to subjects' performance in the word and linguistic fact conditions.

Children and adults were successful at learning a new fact conveyed through perception, if testing immediately followed the training session. When asked to find the object on which a sticker should be placed, three-year-olds selected the correct referent 63% of the time, four-year-olds did so 75% of the time, and adults were at 100% accuracy, suggesting that children and adults could learn this kind of information. Performance was significantly better than chance for all ages in this immediate test condition [3-year-olds: t(7) = 2.49, p < 0.05; 4-year-olds: t(7) = 3.54, p < 0.01].

However, as illustrated in Figure 2.4, recall diminished as the delay between training and testing increased. When tested on their memory for which object had a sticker placed on it after a one-week delay, three-year-olds selected the correct object 63% of the time, four-year-olds did so 50% of the time, and adults did so 50% of the time. This meant that only the very youngest children were performing above chance, while the two older groups
did not differ significantly from chance [3-year-olds: t(7) = 2.49, p < 0.05; 4-year-olds and adults: both p values > 0.05].

![Figure 2.4: Mean percentage of comprehension test trials on which 3- and 4-year-olds and adults selected the target object in the perceptual fact (sticker) condition when tested immediately, after one-week, or after one-month (chance = 17% and is represented by the line).](image)

Performance continued to deteriorate as delay time increased. After a delay of one month, the three-year-olds were selecting the correct object referent of the novel fact only 25% of the time, with four-year-olds doing so only 29% of the time, both of which do not differ significantly from chance [both p values > 0.05]. After a one-month delay, adults chose the correct object
only 50% of the time, identical to their performance after a one-week delay, which did not differ significantly from chance (p > 0.05).

Adults' performance was significantly better when tested immediately than when tested after a week or a month [both analyses: t(14) = 2.65, p < 0.02]. The children's performance was significantly worse after a one-week delay [t(30) = 2.63, p < 0.02] and after a one-month delay [t(29) = 2.97, p < 0.006], than it was in the previous linguistic fact condition. Even the adults were doing significantly worse than chance after both one-week and one-month delays. Most notably, children's performance drastically deteriorated over time, making their performance significantly worse after a one-month delay than when tested immediately [t(29) = 2.5, p < 0.02].

These findings suggest that while the ability to rapidly learn and remember an arbitrary association about an object is not specific to words, it is unlikely to be an entirely general process. While some arbitrary facts about objects might be more easily learned and remembered over time, this is not an across the board phenomenon. It seems that some kinds of knowledge are prone to be more readily acquired and remembered over time than others.

Discussion

Children have an impressive capacity for learning and remembering words. The findings demonstrate that children can learn an object name after minimal exposure, and remember the new word when tested up to one
month later. The findings of Study 1, however, suggest that this capacity is not unique to words. In the present study, three- and four-year-olds, and adults, showed comparable learning and memory for an arbitrary fact they were told about an object and a name for an object. Children and adults were equally good at remembering which object was called *koba*, as they were at remembering which object *was given to the experimenter by her uncle*. In contrast, subjects of all ages were markedly worse at remembering an arbitrary fact that they were shown to be associated with an object. While children and adults could *learn* which object had a sticker affixed to it (as demonstrated by successful retention when tested shortly after exposure to the information), all ages were at chance when tested for retention of this information a month later. Interestingly, across all three conditions, the performance of children and adults was comparable.

Some important conclusions can be drawn from the findings of Study 1. First, the capacity for fast mapping does not appear to change markedly with development, at least for the categories of information and time intervals tested here. The results from all three conditions support this conclusion, as no difference was found between children and adults in their ability to learn and remember a new word, linguistic fact, or perceptual fact. This contrasts with other aspects of language acquisition, such as syntax and phonology, which do show evidence of differential patterns of acquisition at various points in development (Newport, 1990; Curtiss, 1989).
Second, fast mapping is not special to words. The results of the word and linguistic fact conditions support this conclusion. The finding that children and adults seem to have a capacity for fast mapping both words and other non-linguistic knowledge suggests that the learning and memory processes responsible for the two might be related. This supports the assertion that word learning does not depend on a domain-specific language mechanism.

The results of the perceptual fact condition, however, suggest that fast mapping is not an entirely general process. Recall that children and adults were unable to remember which object had a sticker affixed to it after one month. Thus, not all knowledge can be acquired and retained through fast mapping. However, subjects did demonstrate evidence of learning the sticker information in the immediate test condition. Therefore, it is possible that the acquisition of this type of knowledge relies on the same process responsible for learning in the other two conditions, but the mechanisms of memory differ. This problem of potential differences between learning and memory is a serious concern because it affects how the process of fast mapping is best characterized. As defined here, the critical features of fast mapping are that it supports the quick learning and durable memory of arbitrary pairings. Are both of these features essential? If the answer is yes, then the sticker condition clearly does not meet the requisite criteria for fast mapping, since this information was forgotten over the course of one month.
This distinction between learning and memory processes in fast mapping is an important one. Consider asking the identical question about word learning in general: If a word is learned and understood in its context one moment, but then long forgotten, was the word truly learned? We discuss fast mapping, and word learning more generally, in terms of "learning", but memory does seem to be essential. If a word is not remembered beyond an initial encounter it cannot be incorporated into the lexicon and accessed for future use. While there might be a memory trace, at least enough to recognize the word as familiar, this is not sufficient to claim that the word has been learned. As mentioned earlier, infants' ability to recognize a word as familiar does not necessitate that the meaning of the word has been learned. It thus appears that to say that fast mapping has occurred, the knowledge must be both learned (after limited exposure) and remembered (for a long time). In answer to the question posed above, both of these features are indispensable. As a result, the original assertion stands – subject did not show fast mapping for the location of a sticker, suggesting that this process is not entirely general.

If fast mapping is not supported by a language-specific mechanism, what might underlie this rapid learning and memory ability for words and other kinds of arbitrary associations? One possibility is that there are two separate mechanisms responsible for the findings described above. That is, there could be one mechanism underlying the acquisition of words and a
separate one governing the acquisition of non-linguistic arbitrary associations. It does seem improvident however, to posit two distinct mechanisms to account for these seemingly related cognitive functions. Why would having two separate mechanisms for learning arbitrary associations be necessary when one is likely sufficient? A more parsimonious explanation would therefore be that a single mechanism underlies the learning of arbitrary pairs across multiple domains. Some insight into the mechanisms that might underlie the kind of fast mapping abilities observed in the present study is fundamental to this thesis. The issue of possible underlying mechanisms will be given more thorough consideration in the general discussion.
THE COMPLEXITY OF FAST MAPPING

Introduction

Study 1 found that children and adults could remember a fact they were told about an object as well as they could remember a new name they were told for an object. What explanations might there be to account for this similarity between children's and adult's memory for words and arbitrary facts? The explanation favored in the last chapter is that subjects were relying on a common mechanism, that which underlies fast mapping, to perform both tasks. An alternative possibility is that different mechanisms are responsible for children's performance on the two tasks, with fast mapping applying only to the word learning task. In the latter case, we would expect better performance on the word learning task, unless the task demands of learning a new word versus learning a new fact are not equal.

Despite efforts to make the two tasks as close to identical as possible, it is possible that the word learning task imposed a greater cognitive burden on subjects by requiring the encoding and storage of a novel phonological form (e.g., the novel sound pattern of *koba*). In contrast, all of the words used in the fact learning task were familiar to subjects, relieving them of this burden on the fact task. It is therefore still conceivable that children and adults are
better at fast mapping words compared to facts, but that this advantage was obscured by differences in the task demands across the two conditions. It is possible that if both the word learning and the fact learning task required the acquisition and retention of a novel phonological form, children and adults show poorer performance on the fact learning task. This hypothesis was tested in Study 2. Children and adults were taught an arbitrary fact about an object that contains a novel phonological form, and then tested for memory of this new information one month later.

Study 2: Task complexity in learning and remembering words versus facts

Method

Participants

Fifteen 3-year-olds (mean age = 3.7; age range = 3.3-3.9), 15 4-year-olds (mean age = 4.3; age range = 4.0-4.8), and 15 undergraduate students at the University of Arizona participated in Study 2. Children were tested in a quiet room at their preschool and adults were tested in the Language and Cognition Lab. Parental consent was obtained in advance for all children.
Materials

The stimulus items and the novel label were identical to those used in the previous study. The only modification was that subjects were introduced to a different kind of fact about one of the novel objects than the one used in the first study. The fact was conveyed through language to maintain as much similarity as possible across the two fact conditions. The central difference in this fact condition was that the fact contained a novel phonological representation - *koba* (the same string used as the novel word in Study 1). More specifically, subjects were told that one of the objects -- *came from a place called Koba*. As in the previous study, the fact was presented with reference to one of the novel objects in an incidental context.

Procedure

The procedure is identical to that of Study 1 with a few exceptions. First, subjects in this study only participated in one condition, so were only taught one new piece of information about one novel object. As a result, there was only one training trial and one test trial per subject. In an incidental context, subjects were taught a new fact that contained a novel phonological representation, however they were not also taught a new word. Second, all subjects were tested after a one-month delay.

*Training phase.* The fact condition was identical to the fact condition of Study 1 with the exception of the content of the fact subjects heard. More
specifically, while participating in one of the measuring activities, subjects heard the following with reference to the target object, "Let's use the one that came from Koba....we can measure the one from Koba...put the one that came from a place called Koba away now."

Test phase. Subjects were tested for memory of the new fact after a delay of one month. The comprehension test was identical to that of the fact condition of the first study with the exception that there was only one practice trial and one test trial, and the comprehension question subjects were asked differed slightly because of the nature of the fact. Subjects were presented with an array of the ten items from training and specifically asked, "Can you show me the one that is from Koba? Is there one here that came from a place called Koba?". Subjects were given as much time as needed to respond and children were praised for their responses, regardless of their accuracy.

Results

Responses were coded as correct or incorrect by checking whether the object selected at test time was the object for which the subject had been told the new fact. A response was coded as correct if the item selected at test time was the object the subject had been told the new fact for in the training phase. Likewise, a response was coded as incorrect if the item selected at test time was a different object than the one the subject had been given a new word or fact for in the training phase. The number of correct responses was calculated
separately for each of the three age groups. Every subject provided a response to the test question. As in the previous study, chance was conservatively calculated as 17% since 6 of the 10 objects in the test array were novel.

The motivation for Study 2 was to test whether children and adults would successfully learn and remember a fact containing a novel phonological form, a task more equal in complexity to learning a new word. Children and adults were successful at learning and remembering this more complicated fact. The three-year-olds selected the correct object 87% of the time, four-year-olds did so 67% of the time, and adults 60% of the time. Replicating the findings of the original word and fact conditions, all age groups remembered which object came from a place called Koba significantly more than would be expected by chance when tested after a delay of one month [3-year-olds: t(14) = 7.67, p < 0.001; 4-year-olds: t(14) = 3.84, p < 0.001; adults: t(14) = 3.28, p < 0.005]. The fact that fast mapping still occurred when subjects had to learn and remember a fact that contained a novel word alleviates any concerns that task complexity was responsible for subjects’ success in the fact condition of Study 1.

Because there was no significant difference in performance between the three- and four-year-olds (p > 0.05), the two ages of children were collapsed into one group for all subsequent analyses. The 3- and 4-year-olds together were successful 77% of the time [t(29) = 7.6, p < 0.001]. Importantly, there was no difference between children and adults in the ability to learn and
remember the more complicated fact, with adults selecting the correct object 60% of the time ($p > 0.05$).

There were no significant differences between children and adults' ability to recall which object *came from a place called Koba* and their performance in either the word or fact conditions of Study 1 (see Figure 3.1).

![Graph](image)

**Figure 3.1**: Mean percentage of comprehension test trials on which children and adults chose the target object in the fact + novel form condition (from Koba), compared to the fact (uncle) and word (koba) conditions of Study 1.
Children and adults were comparable at selecting the correct referent of the new, more complicated fact and the word from Study 1. In the present study, children and adults selected the correct object 77% and 60% of the time, respectively, compared to 65% and 69% of the time in the previous word condition. Likewise there were no differences in subjects' ability to remember the new fact and the linguistic fact from Study 1. Children in the previous linguistic fact condition selected the correct object 75% of the time, and adults were at 63% (all p values > 0.05). The lack of any difference between children and adults' performance across the three conditions is illustrated in Figure 3.1.

Since no differences were found in subjects' performance in the word and linguistic fact conditions of Study 1, a final analysis collapsed across these two information types and compared them to subjects' performance in the current study. In this combined knowledge condition, which was more similar in sample size to the present study, no significant differences were found. When combined across information type in Study 1, children were accurate 70% of the time, and adults 66% of the time, which obviously does not differ from their performance in the present fact condition (77% and 60%, respectively; all p values, > 0.05).
Discussion

Given the results of Study 2, we can now return to the conclusions previously drawn based on the findings of Study 1. Together, the data from both studies suggests that children and adults can quickly learn and remember different types of arbitrary information about objects. In the present study, our subjects had no difficulty learning a new fact that contained a novel phonological form, despite the increased complexity of this task.

The results of Study 2 provide two avenues of support for the original conclusion that fast mapping is not limited to word learning. First, it shows that the earlier finding generalizes to another kind of fact, and is thus not limited to the single type of fact employed in the first study. Second, it suggests that children and adults succeeded at learning the new fact in the previous study because they are good at this sort of learning, and not merely because it was a cognitively simpler task than learning a new word. In the present study a more complicated fact was employed, and subjects of both ages showed comparable rates of success at learning and remembering the new fact after a one month delay. Furthermore, there were no differences between children and adults on this more complicated fact learning task.

The present findings corroborate those of the original study, suggesting that fast mapping is not specific to the acquisition of words, but rather is a more general process, also supporting the acquisition of at least the two kinds of facts used in the present studies. However, while fast mapping may extend
outside the domain of language, it is not an entirely general process, as
demonstrated by the failure of children, and the limited success of adults, to
learn and remember which object was the referent of a sticker in Study 1. The
issue of the scope of fast mapping, that is, the kinds of information that can be
acquired in this way, will be addressed in the general discussion.
Chapter 4

THE PRECISION OF FAST MAPPING

Introduction

The previous two chapters demonstrated the capacity of children and adults to quickly learn and remember a name for an object and an arbitrary fact about an object. Of interest in these studies is whether the ability to make these sorts of fast mappings is restricted to words. A somewhat different question concerns precisely what is learned via fast mapping? The multiple choice recognition test provides the most sensitive measure for tapping subjects' knowledge in these studies, but this method fails to reveal the precise content of that knowledge. Given the nature of the test procedure used in these studies, there is no way to discern whether children and adults remembered the specific word or fact learned via fast mapping.

Children and adults might have learned and remembered the specific word or fact they had been taught for an object during the training session. Alternatively, it is possible that subjects in these studies simply learned a general mapping between the object and the word or fact, such as which object had a word or fact associated with it, without remembering any details of the particular word or fact. Similarly, subjects could have learned something more specific, but still not entirely precise. For example, perhaps what
subjects remembered was that one of the objects had a peculiar name attached to it, was a gift from someone, or came from an unknown place.

It is fairly straightforward to understand how subjects could succeed at this task without recalling the precise information from the training session. Consider a child who is told that the name of a particular novel thing is *dax*. Now imagine that a week or so later the child is amidst a bunch of things, including the *dax*, and is asked to retrieve the *dax*. Now assume that the child has forgotten the precise phonological features of the word he had been taught a week ago. It is conceivable that he would still choose the correct object as the referent of *dax* simply because he remembered which thing he had previously heard a name for, despite the fact that he could no longer recall the exact sound pattern of that name. An analogous scenario can be imagined to account for how a child might mistake the semantic content of a new fact.

Do children and adults remember the precise information that they are exposed to during training, or do they merely possess a vague recollection of some sort of mapping? Study 3 more accurately examines the precise content of what is learned during fast mapping. This is achieved by examining how subjects respond when presented with distracter words and facts in the test session. The distracter items consisted of new words and facts which differed slightly from the words and facts used in the training session. The distracter
word differed slightly in sound from the original word, and the distracter fact differed slightly in meaning from the original fact.

**Study 3: Memory for specific informational content in fast mapping**

**Method**

**Participants**

Thirty-two 3- and 4-year-olds (mean age = 3.11; age range = 3.1–5.0), and 32 undergraduate students at the University of Arizona participated in Study 3. Children were tested in a quiet room at their preschool and adults were tested in the Language and Cognition Lab. Parental consent was obtained in advance for all children.

**Materials**

The stimulus items were identical to those used in the previous two studies. The novel word and novel fact taught to subjects in the training session were identical to those used in Study 1. As in the previous study, the target word and fact were each presented with reference to one of the novel objects introduced during the training session. The only modification was that during the test session, either a distracter word or a distracter fact replaced
the original word or fact. The novel distracter word *modi* was used in place of the original word *koba*. The novel distracter fact *my sister gave this to me* was used in place of the original fact *my uncle gave this to me*.

**Procedure**

The training phase of the study was identical to that of Study 1. All subjects were taught that one of the novel objects was called *koba*, and a different one of the novel objects was *given to the experimenter by her uncle*. However, the testing phase differed from Study 1 in a number of important ways. All subjects were tested after a one-month delay. In the test session, half of the subjects in each age group were in the distracter word condition and half were in the distracter fact condition. Those subjects in the distracter word condition were asked to find the referent of the distracter word *modi* ("Is there a *modi* here? Can you show me a *modi*?"); instead of the original word *koba*. Subjects in the distracter fact condition were asked to find the referent of the distracter fact of being given to the experimenter by her *sister* ("Is there something here that *my sister gave to me*? Can you show me the one *my sister gave to me*?"); instead of the original fact of being given to the experimenter by her *uncle*. Each question was repeated until an object was selected as the referent of the word or fact under question.
Results

Responses were coded as correct or incorrect by checking whether the object selected at test time was the object for which the subject had been told the new word or fact. A response was coded as correct if the item selected at test time was not the target object, that is, the object provided with a new word or fact in the training phase. A response was coded as incorrect if the item selected at test time was the target object, that is, the object provided with a new word or fact in the training phase. For example, if a child was taught that Object A is called koba during training, and when asked to find the modi at test time selected Object A, his response would be considered incorrect, but if he selected any other object his response would be considered correct. The number of correct and incorrect responses was calculated separately for the two age groups. A handful of children and adults were initially reluctant to select an object in response to the distracter question, but all eventually did so after gentle prompting by the experimenter.

The motivation behind Study 3 was to uncover precisely what information subjects actually learn and remember in these studies. The main question of interest was whether subjects would be “tricked” by distracter words and facts that were substituted for the original training items when tested on them one month later. If subjects confused the distracter for the original word or fact, it would suggest that an imprecise mapping was formed during training, or that memory for this information was weakened or
became less precise over time. The performance of children and adults in the distracter word and distracter fact conditions of the present study were compared with their performance in the one-month delay original word and original fact conditions of Study 1.

An analysis of variance with age and condition (distracter word, distracter fact, original word, original fact) as between-subject variables found a main effect of condition \(F(3,127) = 15.30, p < .001\), but no age effect. Subsequent t-tests revealed that the target object was selected significantly more often when subjects were asked to find the object using the original word or fact compared to the distracter word or fact. The difference between children and adults' performance in the original and distracter conditions is illustrated in Figure 4.1.
Figure 4.1: Mean percentage of comprehension test trials on which children and adults selected the target object in the distracter word and distracter fact conditions compared to the original word and fact conditions of Study 1.

Children chose the target object 65% of the time in the original word condition, but only 19% of the time when asked to find the referent of the distracter word \( [t(45) = 3.23, p < 0.002] \), and they chose the target object 75% of the time in the original fact condition, but only 13% of the time when asked to find the referent of the distracter fact \( [t(30) = 4.44, p < 0.001] \). Likewise, the adults chose the target object 69% of the time in the original word condition,
but only 19% of the time when asked to find the referent of the distracter word \[t(30) = 3.20, p < 0.003\], and they chose the target object 63% of the time in the original fact condition, but only 13% of the time when asked to find the referent of the distracter fact \[t(22) = 2.84, p < 0.009\].

Further analyses found that children and adults made correct responses (by not choosing the target object) when asked to select the referent of a new distracter word or fact for which they had not previously been told a name or fact. Here, the percentage of time that subjects selected the target object did not differ significantly from chance (all \(p\) values > 0.05). Chance was again considered to be 17% on both word and fact trials, since the array of 10 objects contained 6 objects novel to subjects. Recall from above that the children chose the target object as the referent of the distracter word *modi* only 19% of the time, and selected the target object as the referent of the distracter fact of *given to the experimenter by her sister* only 13% of the time. The results were identical for the adults across both the word (19%) and fact (13%) conditions, thus there were no differences between the two age groups. Recall that the opposite pattern was observed in Study 1 when subjects were questioned about the referent of the original word or fact. Children and adults remembered the correct referent of the new word or fact after a 1-month delay significantly more than would be expected by chance (all \(p\) values < .05).
Discussion

The results of Study 3 showed that children and adults in the present fast mapping studies learn and remember precise details about the content of the words and facts they are taught for objects. Children and adults did not mistake distracter words and facts for the original ones they had been taught during training one month before. This is especially impressive given that testing occurred one month after subjects were exposed to the original word and fact. The findings suggest that fast mapping is a fairly precise process, at least for the type of information tested in these studies.

It is important to note that subjects did select the target object in the distracter condition some percentage of the time. It might be expected that if subjects were only choosing the target object at chance levels that this was due to them remembering that the target object mapped onto the original word or fact and could therefore not be the referent of the distracter word or fact. However, while subjects did succeed on these tasks in the previous studies, some proportion of subjects in the prior tasks did not select the target object, suggesting that they did not learn or remember the mapping. Similarly, it is likely that some subjects in these distracter tasks did not remember the mapping they were taught during training. This could explain why the target object was selected at all in the distracter condition of the present study.

Production tests would introduce a more sensitive means of assessing the precision of lexical or factual information people retain when forming
associations to real-world referents. Such tasks could tease apart any subtle differences that might exist between children and adults which are obscured by less sensitive measures. For example, perhaps adults are capable of storing more fine-grained phonological details of lexical entries than children. Fast mapping studies with language-impaired children find that the biggest problem with learning new words is remembering the distinctions between specific phonological attributes (Dollaghan, 1987; Gathercole, 1993). As mentioned in Chapter 1, it is unlikely that phonological deficiencies pose a barrier to word learning after eight months of age, (Jucszyk, 1997). However, the ability to make more fine-grained phonetic distinctions coupled with learning new word meanings does appear to improve between 8- and 14-months of age, and children do sometimes demonstrate perceptual confusion for spoken words in the preschool years (Gerken et al., 1995; Stager & Werker, 1997).

One question raised by the findings of the present study is whether younger children form and remember as detailed information as older children and adults. Carey (1978) suggested that fast mapping describes the quick initial learning children do, but that learning the full meaning of a word or concept can be a long process. As noted earlier, the pace of word learning is not consistent across development, and it is possible that the quality of word learning varies across development as well. It would be interesting to explore the fast mapping abilities of children closer to the start
of word learning. Two-year-olds might have less sophisticated fast mapping abilities than older children and adults. If this were the case, two-year-olds might not demonstrate fast mapping outside the domain of language, or the specific content of their mappings might be less precise than that of older children and adults. Studying fast mapping in younger children might provide further insight into the mechanism underlying this ability. For this reason, the next chapter explores the fast mapping abilities of two-year-olds.
Chapter 5

THE DEVELOPMENT OF FAST MAPPING

Introduction

The previous three studies demonstrated that fast mapping is not specific to word learning in 3- and 4-year-olds and adults. Children and adults were successful at fast mapping both words and arbitrary facts about novel objects. In addition, fast mapping did not appear to change with development. These findings lend support to the notion that word learning is governed by a different mechanism than that which underlies other aspects of language acquisition. If a single mechanism does underlie the rapid acquisition of words and facts, the ability to fast map facts should be present as early as the ability to rapidly learn words.

Two-year-olds are capable of participating in the methodology used in the previous studies, but are still word learning rookies, making them a good candidate population for addressing the question of how early in life the ability to quickly learn and remember non-word arbitrary pairings is available to children. A number of researchers have started to look at the word learning abilities of two-year-olds, and even 1-year-olds (Schafer & Plunkett, 1998; Werker, Cohen, Lloyd, Casasola, & Stager, 1998; Woodward et al., 1994). But none of these studies have examined whether this capacity extends
outside the domain of language. The next study is an attempt to do so, by examining the generality and precision of rapid learning in two-year-olds.

The present study is a modified replication of two of the original studies. The new study has been simplified to make it appropriate for use with two-year-olds. The simplification process consisted of using four objects (instead of ten), all of which are novel to children, and testing their comprehension of the new word and fact either immediately after training or after a one-week delay (instead of after a one-month delay). In addition, a distracter condition similar to that used with the older children and adults was included to assess the precision with which two-year-olds can form and remember word-object mappings and fact-object mappings.

Study 4: Two-year-olds' fast mapping of words and non-words

Method

Participants

Fifty-six 2-year-olds (mean age = 2.6; age range = 1.9-3.0) participated in Study 4. The children were tested in a quiet room at their preschool. Parental consent was obtained in advance for all children.
Materials

*Stimuli.* Each child was exposed to four novel toys. All children saw the same four toys, but the ones they were taught a new word and a new fact for varied across children. Criteria for selection of the novel toys were that they be novel and attractive to children, comparable in salience, and visually distinct from one another. The set of four novel toys included a wooden doorknob hanger covered with odd-shaped colored pieces of foam, a wooden honey stick partially covered with colorful pipe cleaners, a thick green styrofoam circle with eight white plastic sticks protruding from it, and a white styrofoam ring with purple lanyard wound around part of it and a wooden stick with a wooden spinning circle on one end stuck through the center of the ring.

*Novel word and fact.* One novel word was used in the study: *blicket.* The word was selected for its novelty and simple phonological form. One novel fact was also used in the study: *this is broken.* This fact was selected because it was found to be a piece of information easily understood by two-year-olds in a pilot test. Each of the four novel toys had a concealed "broken" aspect to it, which was not noticeable until the experimenter pointed out this flaw to the child. For instance, the doorknob hanger was slightly cracked underneath one of the foam pieces, and one of the pipe cleaners on the honey stick was partially unglued and capable of unraveling. In the distracter conditions, a distracter word (*modi*) and distracter fact (*the one my brother*
gave me) were used during the test phase in place of the original word and fact.

Design

The study was similar to the first three studies, with some modifications designed to make it simpler and more interesting to younger children. Each child participated in one of two conditions: original or distracter. Children who participated in the original condition were taught a new word and a new fact during training, and tested on their memory for both types of knowledge in the test session (identical to Study 1). Half of the children in the original condition were tested immediately after training, and half were tested after a one-week delay. Children who participated in the distracter condition were also taught a new word and a new fact during training, but were tested on either a distracter word or a distracter fact in the test session (identical to Study 3). All children in the distracter condition were tested after a one-week delay. The pairing of each word and fact with the four novel objects was counterbalanced across all subjects by condition (original, distracter), delay, and order of presentation of the word and fact.

Procedure

Training phase. After a brief introduction period in which the child was introduced to Ernie, a puppet of the character from Sesame Street, the
experimenter brought out a bright blue bag from which she removed four novel toys. The child was informed that these were some of Ernie’s toys, and that Ernie liked to share his toys with his friends. Children were presented with the toys and encouraged to play with them freely, with the experimenter making sure that all of the toys were paid equal attention by the child. During the play period, each child was told the new name, blicket, for one of the novel toys ("Look at the blicket. This is a blicket."). Each child was also taught that one of the toys was broken, by the experimenter demonstrating precisely how it was broken and saying, "See, this one is broken. We have to be careful because this one is broken." Equal attention was given to the other two (distracter) toys (e.g., "Look at this one. Isn't this one neat?!"). After about five minutes, the experimenter announced that it was time to clean-up, and asked the child if s/he could please help Ernie put his toys away. The bag was placed far enough away from the child that s/he needed to walk over to it in order to put toys inside. The experimenter then proceeded to ask the child to place each toy into the bag, one at a time. Two of the toys were referred to without any qualifying information, "Could you please put this one away for me. Please put this one in the bag." One of the toys was referred to by name, "Could you please put the blicket away for me. Please put the blicket in the bag." And one of the toys was referred to by the fact that it was broken, "Could you please put the broken one away for me. Please put the broken one in the bag." Children were always thanked for their assistance after they
successfully placed a toy in the bag. Children were exposed to the novel label and novel fact four times throughout the course of the training phase.

**Test phase: Original.** The test phase examined the consistency with which children and adults selected a particular object. Children were tested for recall of the new word and fact either immediately after the training phase or after a one-week delay (6 to 8 days). Each child in the immediate test delay condition first participated in an intervening task for about five minutes before being asked the test questions. The intervening task consisted of the child choosing stickers and decorating the bag containing the toys used in the study. After the intervening task, or upon return after a one-week delay, children were presented with the array of four toys they had been exposed to during training. The order in which the two test questions were asked was counterbalanced across subjects, so that half of the children were asked the fact question first, and half were asked the word question first. Each child was shown the array of objects and asked (1) "Is there a blicket here? Can you show me the blicket", and (2) "Is there something here that is broken? Can you show me the broken one?" Children were given as much time as they needed to respond, and were praised for their answers, regardless of accuracy. In addition, the experimenter was blind to which of the objects the children had been told a novel word and fact for, since each of the four objects was assigned each type of information a quarter of the time.
**Test phase: Distractors.** The test phase for the distracter condition was similar to the original, except that the test questions contained words and facts that differed from those the child had been taught during training. Recall that the distracter condition was run between subjects, so that each child was taught both a word and fact during training, but only asked a distracter question about either the word or fact at test time. Children were asked the original test question as a control measure for the item about which they were not asked the distracter question. More specifically, for the word question, children were asked, "Is there a modi here? Can you show me the modi?"

For the fact condition children were asked, "Is there something here that my brother gave to me? Can you show me the one that my brother gave to me?"

Following the distracter word question, children were asked the original fact question ("Can you show me the broken one?") and following the distracter fact question children were asked the original word question ("Can you show me the blicket?"). The distracter question was always asked first, followed by the original question about the other object.

**Results**

The data for each child were coded as correct or incorrect for the two types of test questions, word and fact. In the original condition, responses were coded as correct or incorrect by checking whether the object selected at test time was the object the subject had been given that same piece of
information about during the training phase. The number of correct responses was calculated separately for the word and fact trials. Every subject provided a response to both the word and fact test questions, hence there were two data points per subject. In the distracter condition, responses were again coded as correct or incorrect on the basis of whether the selected object was the target object. Here, a response was coded as correct if the item selected at test time was not the target object – that is, the subject had been told the new word or fact for in the training phase. A response was coded as incorrect if the item selected at test time was the target object which the subject had been told a new word or fact for in the training phase.”

Two-year-olds’ were successful at fast mapping across all conditions and test delays, as illustrated in Figure 5.1. In the original condition, two-year-olds selected the correct referent of the word taught during training 81% of the time in the immediate condition, and 81% of the time when testing followed a one-week delay. The correct referent of the arbitrary fact taught during training was selected 88% of the time in the immediate condition, and 75% of the time when the test session took place after a one-week delay. Because there were only four objects, all of which were novel to the children, chance was calculated as 25% in all conditions. Performance in all conditions was significantly better than would be expected by chance (all p values < 0.001), and there were no effects of delay or information type (all p values > 0.05).
Figure 5.1: Mean percentage of comprehension test trials on which 2-year-olds selected the target object on word and fact trials when tested immediately or after a one-week delay (chance = 25%).

Is the content of two-year-olds’ mappings as precise as that of the older children and adults, or do they tend to store less specific information during fast mapping? In the distracter studies, even after a one-week delay, children remembered the precise word or fact they had been taught about one of the novel objects during training. Two-year-olds chose the object that they were told was the referent of the original word, when asked to find the referent of
the distracter word, only 17% of the time. Likewise, they chose the object that they were told was the referent of the original fact, when asked to find the referent of the distracter fact, only 17% of the time. Children’s performance in both of the distracter conditions was at chance, and differed significantly from their performance selecting the referents of the original word [t(11) = 8.00, p < 0.001] and fact [t(11) = 5.19, p < 0.001].

Figure 5.2: Mean percentage of comprehension test trials on which 2-year-olds selected the target object in the distracter word and distracter fact conditions compared to the original word and fact conditions.
Discussion

The present findings demonstrate that the fast mapping abilities of two-year-olds are comparable to those of older children and adults. Identical to older children and adults, two-year-old children learn fairly precise information about the objects they interact with, whether this information falls within the domain of language or outside it. While these studies were simplified for the purpose of enabling the younger children to get through them, children were as good as older children and adults at learning and remembering which of four novel objects was a blicket, and which of four novel objects was inconspicuously broken. The fact that two-year-olds were equally good at learning a new fact about an object and learning a word, suggests that this rapid learning process applies more generally from very early in development.

Furthermore, children did not mistake a distracter word or fact for the one originally taught to them during the training session one week before. Their performance on these tasks is especially impressive given that testing was conducted after a one-week delay. It is noteworthy that there was not a significant decline in children’s performance over time, suggesting that similar to the older children and adults, when they do make a fast mapping, this information is retained for a long period of time.

The distracter items used for the two-year-olds were slightly more discriminable than those used in the previous study with older preschoolers
and adults. The phonological features of the distracter and original words in the present study differed more than they did in the previous distracter study. Likewise, the two facts used in the present study were from different categories (this is broken versus the one my brother gave to me), whereas in the previous study they were from the same category (my uncle gave this to me versus my sister gave this to me). It remains an open question whether two-year-olds need these larger differences between distracters and the original training items in order to make the discriminations that they did.

Two-year-olds were exceptionally successful in these studies, which raises the question of when children develop fast mapping abilities. Do children have the ability to rapidly learn arbitrary information about objects at the very start of word learning, or does this ability develop as a result of word learning? Another important question is whether the ability to fast map non-lexical information develops at the same time as the ability to rapidly learn new word-object associations. By looking at these abilities in children even younger than two years of age, we can gain a clearer picture of the emergence and development of fast mapping abilities, which in turn might provide insight into the mechanism underlying children's capacity for word learning. This endeavor cannot be tackled in this thesis, but opens the door to future program of research. Some ideas pertaining to the development of fast mapping abilities in very young children will be developed more fully in the general discussion.
Chapter 6

GENERAL DISCUSSION

Summary and conclusions

To recap briefly, the present studies examined the fast mapping abilities of children and adults by teaching 2-, 3-, and 4-year-old children and adults names and facts for novel objects in an incidental context, and subsequently testing them for learning and memory of this knowledge.

Study 1 showed that 3- and 4-year-old children and adults could learn a name for an object (koba) and a fact about an object conveyed through language (that it had been given to the experimenter by her uncle) after a brief, incidental exposure, and remember this information when tested after up to one month later. Children and adults could also learn a fact conveyed through perception (the placement of a sticker onto one of the novel objects), as demonstrated by performance on a comprehension test immediately after exposure to the new information. However, subjects of all ages performed poorly when tested for memory of this information after a week or month had passed. Furthermore, performance was comparable for subjects of all ages across the three types of learning tasks.

Study 2 demonstrated that the high success rate of the 3- and 4-year-olds and adults on the fact task of Study 1 did not result from it placing less
cognitive demands on subjects compared to the word learning task. Recall that in the word learning task of Study 1 subjects were required to learn and store a novel phonological form, which is a completely unfamiliar sound pattern. In contrast, the fact learning task was composed entirely of familiar words. Study 2 tested whether this discrepancy might underlie subjects' comparable success across the two tasks, by assessing learning and memory for a fact about an object which contained a novel phonological form (that it came from a place called koba). Children and adults did just as well in this more complex fact condition as they did in the previous word and fact conditions, even when tested after a month delay. This suggests that the findings of Study 1 were not a result of the fact learning task being less complicated than the word learning task. In addition, this study provides another example of fast mapping applying outside the language domain.

The findings of Study 3 revealed that the content of the words and facts learned by subjects in these studies is fairly accurate. Three- and 4-year-olds and adults remembered the precise word and fact the experimenter had told them in the training session, and not simply which object had been the referent of this information. Rather, subjects in these studies seemed to be learning the word (koba) or fact (that it was given to the experimenter by her uncle) with a high degree of precision. Neither children nor adults mistook imposter words (modi) or facts (the one my sister gave to me) for those they had originally been exposed to during the training session one month before.
These findings suggest that the knowledge acquired by preschoolers and adults through fast mapping is precise and remembered for a long period of time.

The results of Study 4 demonstrated that 2-year-olds have fast mapping abilities equivalent to those of the older children and adults. Two-year-olds were successful at rapidly learning a name for an object and a fact about an object conveyed through language (that it was inconspicuously broken), and showed memory for this new information when tested after a one week delay. Furthermore, Study 4 found that 2-year-olds were learning and remembering the specific word (blicket) or fact (that it is broken) taught during training. Even this younger age group was not misled into mistaking imposter words (modi) and facts (the one my brother gave to me) for the original word or fact they had been taught for an object one week before the test session.

The finding that two- through four-year-old children and adults exhibit comparable abilities for the rapid learning and retention of new words and arbitrary facts after minimal exposure allows us to draw four conclusions about the nature and development of fast mapping. First, the human capacity for fast mapping is not specific to the domain of language. Second, this ability to rapidly learn and remember information does not change across development, at least not between two and four years of age and adulthood. Third, fast mapping is not an entirely general process. In other words, fast
mapping does not apply across the board to all learning contexts, as shown by the poor performance of subjects on the sticker task. Lastly, the mappings acquired via fast mapping are precise and remain stable over time. These conclusions have implications for theories of word learning and the mechanism underlying this ability. The sections that follow speak to these issues.

Domain specificity and word learning

The term fast mapping has traditionally been used to describe children's ability to learn a new word after a single brief exposure. The present studies suggest that the human capacity for fast mapping is not specific to words. The finding that fast mapping applies outside the lexical domain poses a challenge for current theories of word learning which posit that children have internal constraints or special mechanisms that facilitate lexical acquisition. While these accounts differ on the details of the underlying mechanisms and their origins, they do agree that they are specific to the acquisition of words. It has been acknowledged that the proposed lexical constraints may not be specific to word learning, or even language acquisition (Clark, 1990; Gathercole, 1989; Markman, 1992). But, studies supporting the notion of constraints have exclusively targeted word learning (Markman, 1989). In a sense, by restricting the exploration to words, it presupposes the specificity of the mechanisms.
The lexical specificity of the mutual exclusivity bias and N3C (novel-name nameless-category) principle was recently put to the test. The mutual exclusivity bias asserts that children are constrained to apply one label to any object. Similarly, the N3C principle states that new names apply to novel categories. Both of these constraints predict that in the presence of a familiar and an unfamiliar object, children would infer that a new word refers to the unfamiliar object. Children do in fact show precisely this behavior — when asked to find the referent of a new word in the situation described above, children choose the unfamiliar object (Markman & Wachtel, 1988; Golinkoff et al., 1994). However, this response bias has also been found to occur in situations that do not involve naming, but rather the learning of arbitrary facts about objects (Diesendruck & Markson, 1999). The fact that children generalize this behavior outside the lexical domain suggests that the mutual exclusivity and N3C constraints are not specific to the acquisition of words.

Mutual exclusivity is not the only lexical constraint that is confronted with this challenge. Drawing from multiple sources of converging evidence, Bloom (in press) presents a compelling argument that the whole object constraint — the tendency of children to infer that names refer to whole objects, rather than their parts or substance — is not specific to word learning. It remains a question open to empirical investigation whether other constraints proposed to account for children's word learning abilities also apply more generally.
Continuity across development

The studies reported here uncovered no developmental differences for fast mapping. This finding is relevant to the question of whether word learning should be viewed as continuous or discontinuous across development. The continuity hypothesis suggests that the principles underlying our knowledge of language and the mechanisms responsible for the language acquisition do not change with development (Pinker, 1984). In this way, language processes are dependent on a stable set of basic capacities that do not change as development proceeds. In contrast, if development is best characterized as discontinuous, children and adults have fundamentally different conceptual resources available to them for the problem of word learning, and should show a different pattern of acquisition (Piaget, 1954).

The fact that the present studies found no differences between children and adults suggests that word learning capacities are unchanging across development, in accord with the continuity hypothesis. However, it is possible that different processes are responsible for the performance of children and adults in these tasks. For example, it is possible that adults were utilizing the semantic context in which the information was presented, while children were ignoring contextual information and relying on attention to a particular aspect of the naming context. This question could be addressed by manipulating those variables that might be tapped into by children and adults in these tasks and looking for differences in children and adults.
Dissociation of lexical and grammatical information

There is abundant evidence supporting the dissociation of lexical and grammatical information in the brain. Behavioral and electrophysiological studies have demonstrated that grammatical and lexical information are processed differently (Bradley & Garrett, 1983; Van Petten & Kutas, 1991). One way to study this is to record event-related potentials to open and closed class words, which are presumed to represent lexical and grammatical information respectively. Additional studies measuring responses to words that were semantically versus syntactically appropriate also uncovered differences in brain activity for these two aspects of language (Ainsworth-Darnell, Shulman, & Boland, 1998; Munte, Hans-Jochen, & Mangun., 1993).

Further support for the dissociation of lexical and grammatical functions in the brain comes from electrophysiological studies with congenitally deaf subjects, bilingual speakers, and normal language users (Neville et al., 1992; Weber-Fox & Neville, 1996). The results revealed qualitatively different event-related potentials for syntactic knowledge across the different populations, but these differences do not emerge for lexical knowledge. Based on the findings, the authors suggest that maturational changes constrain the development of the neural systems responsible for language, and that different aspects of language go through different sensitive periods in development.
The above findings supporting different sensitive periods in lexical and syntactic development complement the results of the present studies which found no differences between children and adults in the ability to quickly learn a new word. These findings suggest that word learning is different from other aspects of language acquisition which do find differences in learning at different points in development. The acquisition of syntax, for example, comes more easily to children than adults, suggesting the existence of a critical period in development for this aspect of language (Newport, 1991; Patkowski, 1980).

The notion of a modular contrast between grammar and the lexicon does not go unchallenged. Evidence from studies on language processing, language development, and language disorders provide support for the interdependence of lexical and grammatical information in the brain (Bates & Goodman, 1997). The authors posit that the type of studies described above are compatible with an interactive theory, claiming that such results can be explained away by frequency and priming effects. Of most relevance here are studies on grammatical and lexical development in the first 2-1/2 years of life that find that the emergence of grammar is highly dependent on vocabulary size. Additional studies with early talkers and children with Williams syndrome argue against a dissociation between the development of grammar and vocabulary (Thal & Bates, 1996; Thal, Bates, & Bellugi, 1989). This challenge is not easily dismissed, and the conclusions drawn from this work
must be reconciled with those of the present studies and other work in support of separate mechanisms for lexical and grammatical aspects of language.

Mechanisms of word learning

The three main findings of the present studies speak to the issue of the mechanisms that might underlie word learning in children. The first question concerns the domain-specificity of fast mapping, and it was found that fast mapping was not restricted to the domain of words. Children and adults were successful at fast mapping both words and non-words, suggesting that the cognitive processes underlying these two domains might be related. The second question concerns developmental differences in fast mapping, and it was found that development did not affect fast mapping abilities in these studies. The fact that there were no differences between children and adults highlights that word learning differs from other aspects of language, such as the acquisition of syntax, which do show developmental differences. The third question concerns how precisely information is learned through fast mapping, and it was found that these mappings are fairly precise. That the specific content of the mappings for both words and facts was retained suggests that subjects truly learned both of these types of knowledge, and were not relying on less specific information to pick out the correct referent of the word or fact. Together, these findings suggest that fast mapping is not specific
to words, and more generally, that the underpinnings of word learning may differ from those of other aspects of language acquisition.

Fast mapping has typically been described as a process that enables children to quickly learn and remember new words. Thus, the finding that fast mapping applies with equal force to facts, makes it unnecessary to posit a special mechanism for the acquisition of words. Such a mechanism would be redundant. The argument surrounding the redundancy of mechanisms is that there is no reason to posit a more specific mechanism when a phenomenon can be sufficiently explained by more general processes. It is conceivable that there are two mechanisms responsible for the results of the present studies, one for the learning of words and another for the learning of facts. But this is a rather unparsimonious way to explain the data when the learning of facts mirrors the learning of words, thus implying a single mechanism. The finding that fast mapping is not restricted to word learning is consistent with evidence from different sources (described above) which suggests that the ability to learn and remember words is mediated by processes of human learning and memory that are not special to the domain of language.

The claim that word learning is different from other aspects of language acquisition is a controversial one, and undoubtedly will not go unchallenged. It could be claimed that the present findings reveal nothing about how words are learned, but merely show that words and arbitrary facts
are remembered in a similar way. Put differently, it might be argued that only the results of the immediate condition reveal anything about fast mapping and mechanisms of word learning, and the delay conditions speak only to the issue of memory. The data argue against this explanation, however.

The idea that similar performance on the word and fact learning task can be explained purely by appealing to memory mechanisms does not pose a challenge the claim that word learning is not special. This argument has to do with the importance of both learning and memory processes in fast mapping. It was previously established that fast mapping involves both quick, incidental learning and long-term memory. Both of these features are necessary to make the claim that fast mapping has occurred. We might discuss the concept of fast mapping, and word learning more generally, in terms of "learning", but memory is also essential to this process. If a word is not remembered beyond an initial encounter it cannot be incorporated into the lexicon and accessed for future use. To make the claim that a fast mapping has been formed, the contents of the mapping must be rapidly learned in an incidental context and remembered for a long time. Both of these criteria are necessary, and must therefore be considered together.

Given this, the data show evidence of fast mapping in the word and linguistic fact conditions, but not in the perceptual fact condition. This conclusion is warranted by the significant decrease in subjects’ ability to remember which fact a sticker was associated with over time. However, if
one looks closely at the data, it shows that subjects' recall was quite high in the immediate condition, suggesting that subjects were able to learn the fact about the sticker, they simply did not remember it. As a result of this failure to retain the relevant information, fast mapping cannot be said to have occurred.

It is possible that imposing a longer delay, perhaps a year, would tease apart differences between memory for words and facts. This possibility is mere speculation and cannot dismiss the claim that both the learning and memory processes underlying performance in the word and fact conditions are identical across the two domains (word and linguistic fact). In addition, the findings of Study 3, the distracter condition, which showed that the precision of the contents learned during fast mapping did not deteriorate over time, strengthen the conclusion that both learning and memory are implicated in fast mapping. As a result, the idea of a common mechanism for the fast mapping of words and arbitrary facts stands.

This finding of the perceptual fact condition, that children and adults were quite poor at fast mapping the placement of a sticker on a novel object suggests that fast mapping is not an entirely general process. In other words, fast mapping does not apply across the board to all learning contexts. This issue pertains to the scope of fast mapping. An interesting proposal in the memory literature is that the probability of retrieving a particular memory should track the probability that it is necessary (Anderson & Milson, 1989).
Perhaps the reason the perceptual fact was not remembered following the delay is that the location of a sticker was not perceived by subjects as especially important. In contrast, names for things tend to be useful for communication, while the uncle information could have other merit in that it was relevant to object identity or provided social information. Another explanation for the poor recall in the perceptual fact condition could be that fast mapping applies only to information that is conveyed through language. This is unlikely given that the sticker condition did involve some verbal interaction, even though the relevant information was conveyed through the visual modality. But it does raise an interesting question that could be empirically tested. The issue of scope will be pursued further in the discussion of future research directions.

This dissertation set out to study the process of fast mapping, and from this to gain insight into the mechanisms of word learning used by children. The finding that fast mapping is not a domain-specific process restricted to the acquisition of words, led to the conclusion that word learning is not special. This dissociation between word learning and other aspects of language acquisition, such as the learning of syntax, corroborates the findings of other diverse programs of research. Two possible mechanisms are suggested by the findings of the present study. The first is that fast mapping, and word learning more generally, result from more general processes of human learning and memory. A second possibility is that word learning, and fact
learning, are the result of a special capacity for learning and remembering certain kinds of arbitrary associations that have a common underlying significance. Such a mechanism could have its origin in more general cognitive abilities, or be specialized from the start. This question is left open.

**Future directions**

The results and conclusions of the current studies generate a number of questions concerning the nature and development of fast mapping. These questions are motivated by theoretical considerations and thus could have implications for theories of word learning and our understanding of the mechanisms underlying fast mapping.

The first two questions are fairly straightforward, and could easily be addressed through simple methodological alterations of the present studies. First, how precise is the content of the mappings formed through fast mapping? This was the question addressed in the distracter studies presented in Chapter 4. As mentioned earlier, production tests would provide a more sensitive measure of what is learned in these studies, and could potentially uncover differences across development or domain of knowledge. Second, how many arbitrary pairings is it possible for children and adults to form in a single test session? In the present studies, subjects were expected to learn only one or two associations, but in a natural context we might be exposed to a greater amount of information at any given time. For this reason, it would be
interesting to learn whether children and adults could form multiple mappings after relatively limited exposure, or whether there are limits to the quantity of arbitrary pairings that can be learned at any given time. Studies in which subjects are taught several pieces of information in a single session would likely provide us with an answer to this question.

There are also a number of interesting questions concerning the scope, emergence, and nature of fast mapping.

The first question concerns the scope of fast mapping. In other words, what kinds of knowledge can and cannot be acquired in this way? Clearly, not every piece of information encountered in the world is equally privileged for being learned in this way. This is supported by the results of the sticker condition in Study 1 in which children and adults' were poor at remembering an arbitrary fact conveyed through perception after a delay. One way to get at this issue would be to systematically explore the kinds of information that can and cannot be acquired through fast mapping. This is an ambitious undertaking, but holds the promise of offering a more complete explanation of some of the questions raised by the present studies.

In preliminary studies we have begun to address the question of scope described above. The first study examines whether children and adults are better at learning information about an object that is imperceptible (e.g., it is hidden from view) compared to perceptible (e.g. visible) information. In this study, subjects are told one piece of information for each of three novel
objects. Specifically, subjects are told the name of one object (e.g., koba), the color of the inside of another object (e.g., green), and the outside color (e.g., blue) of a third object. The hypothesis is that information which is not readily available (e.g., the name or internal color of an object) might be remembered better than information that can be immediately perceived upon contact with the object (e.g., the external color of an object). To date, a memory advantage has been found for the imperceptible over the perceptible information in three-year-olds and adults tested after a one-week delay. These findings suggest that information that is not readily available through perception is more likely to be learned via fast mapping.

Given that a pressing concern raised by the present findings is the role of language in fast mapping, an obvious next step would be to examine whether information conveyed through language is learned and remembered better than information conveyed through non-verbal means.

A second question concerns when the capacity for fast mapping emerges. When is evidence of a capacity of this ability first observed in infants or toddlers, and how does it develop over the first two years of life? Chapter 5 presented evidence of this ability in children as young as two years of age. The logical progression is to try to replicate these findings with younger children, and eventually pre-linguistic infants.

Due to the recent flurry of interest in the word learning abilities of children in the first two years of life, more reliable methods for assessing
word learning in infants and toddlers have recently been developed to accommodate this demand (Schafer & Plunkett, 1998; Werker et al., 1998; Woodward, et al., 1994). Increasingly sophisticated measures for testing infants' knowledge of objects are also available (Baldwin, Markman, & Melartin, 1993, Mandler & McDonough, 1993; Oakes, Madole, & Cohen, 1991). These methods can be adapted for use in studies testing infants' rapid learning and memory abilities for arbitrary properties of objects and other knowledge.

A number of studies have shown that very young children can form word-object mappings after limited exposure, as long as they are provided with appropriately supportive experimental contexts (Goodman et al., 1998; Schafer & Plunkett, 1998; Werker et al., 1998; Woodward et al., 1994). Two of these studies even demonstrated retention of word-object mappings after a 24-hour delay in 13-, 18-, and 24-month-olds (Goodman et al., 1998; Woodward et al., 1994). Memory for word meanings has not been assessed for delays longer than 24-hours in infants under two years of age. The long-term retention of word meanings and other knowledge is an important issue to pursue.

Relevant to the issue of when fast mapping is available to children is whether or not this ability extends outside the domain of language. Studies investigating the rapid learning abilities of infants and toddlers for both
words and properties of objects will increase our knowledge of the emergence and developmental course of fast mapping.

The final question concerns the nature of fast mapping. If fast mapping is not a domain-specific ability that children possess to assist with the rapid acquisition of new word meanings, then what is it? Is fast mapping a uniquely human ability, perhaps tied to the human capacity for language? Or is it a more general ability, unrelated to language? Studies exploring the fast mapping capacities of pre-linguistic infants, and perhaps even non-human primates, could get at these questions. As it stands, most of our current knowledge of fast mapping comes from studies with children who are well into lexical acquisition. But if fast mapping is not special to words, it is possible that it results from a more general learning and memory capacity that children have to aid them in learning information about objects (e.g., properties of objects). This possibility is supported by impressive research programs that have begun to uncover the surprisingly sophisticated physical reasoning abilities of infants (Spelke, Breinlinger, Macomber, & Jacobson, 1994; Wynn, 1992).

By investigating the relationship between the emergence of fast mapping, early word learning, and the acquisition of object properties in infancy, we can begin to address questions concerning the nature of the mechanism underlying this ability. Studies with pre-linguistic infants will reveal whether fast mapping is available to children prior to the onset of
word learning. Comparative studies with non-human species offer a way of assessing whether fast mapping abilities are specific to language learners. Future research holds the promise of moving us closer to understanding whether children's accomplishments in the domain of word learning stem from a mechanism dedicated to language, or from a broader mechanism useful for learning and retaining arbitrary associations across multiple domains.

Concluding remarks

One striking feature of word learning is children's remarkable ability to quickly learn aspects of the meaning of a new word on the basis of only a few incidental exposures and retain this knowledge for a long time. The present studies suggest that this capacity is not special to word learning and opens the door to future research on the rapid learning abilities of children and infants.
APPENDIX A

Human Subjects Approval

10 February 1995

Lori Markson, M.A.
c/o Paul Bloom, Ph.D.
Department of Psychology
Psychology Building, Room 507
Main Campus

RE: RAPID ACQUISITION OF MEANING

Dear Ms. Markson:

We have received documents concerning your above referenced project. Regulations published by the U.S. Department of Health and Human Services (45 CFR Part 46.101(b)(2)) exempt this type of research from review by our Committee.

Please be advised that clearance from academic and/or other official authorities from site(s) where proposed research is to be conducted must be obtained prior to performance of this study. Evidence of this must be submitted to the Human Subjects Committee.

Thank you for informing us of your work. If you have any questions concerning the above, please contact this office.

Sincerely,

William F. Danny, M.D.
Chairman
Human Subjects Committee

cc: Department/College Review Committee
30 August 1995
Lori Markson, M.A.
c/o Paul Bloom, Ph.D.
Department of Psychology
Psychology Building, Room 507
Main Campus

RE: HSC A95.104 RAPID ACQUISITION OF MEANING

Dear Ms. Markson:

We received your 25 August 1995 letter and revised parental consent form for
the above referenced project. Use of a combined parental consent form is
requested (to include HSC A95.99, "Constraints on Word Learning"). Note:
project status has been changed to expedite vs. exempt. The procedures to be
followed in this study pose no more than minimal risk to participating
subjects. Regulations issued by the U.S. Department of Health and Human
Services (45 CFR Part 46.110(b)] authorize approval of this type project
through the expedited review procedures, with the condition(s) that subjects'
anonymity be maintained. Although full Committee review is not required, a
brief summary of the project procedures is submitted to the Committee for
their endorsement and/or comment, if any, after administrative approval is
granted. This project (and change as indicated above) is approved effective
30 August 1995 for a period of one year.

The Human Subjects Committee (Institutional Review Board) of the University
of Arizona has a current assurance of compliance, number M-1233, which is on
file with the Department of Health and Human Services and covers this
activity.

Approval is granted with the understanding that no further changes or
additions will be made either to the procedures followed or to the consent
form(s) used (copies of which we have on file) without the knowledge and
approval of the Human Subjects Committee and your College or Departmental
Review Committee. Any research related physical or psychological harm to any
subject must also be reported to each committee.

A university policy requires that all signed subject consent forms be kept in
a permanent file in an area designated for that purpose by the Department
Head or comparable authority. This will assure their accessibility in the
event that university officials require the information and the principal
investigator is unavailable for some reason.

Sincerely yours,

William F Denny, M.D.
Chairman
Human Subjects Committee

WFD:js

cc: Departmental/College Review Committee
REFERENCES


Curtiss, S. (1989). In M. Bornstein & J. Bruner (Eds.), Interaction in Human Development (pp.105-137). Hillsdale, NJ: LEA.


