SEMANTIC ATTRIBUTES AND AURAL ENCODING: A STUDY OF YOUNG CHILDREN

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Mary Alt

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and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of ~~Doctor~~ of Philosophy

[signature] 9/27/02
Date

[signature] 9/27/02
Date

Theodore J. Glattke 9/27/02
Date

[signature] 9/27/02
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[signature] 9/27/02
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DEDICATION

This work is dedicated to Arthur Wolff and Grayson Alt, without whom it would not have been possible.

TABLE OF CONTENTS

CHAPTER 1 10
Introduction 10
What's in a name? Levels of word knowledge 10
How do typically developing children learn words? 11
Learning labels 13
Word extension 16
Phonological/Phonotactic frequency 18
Phonology as a predictor of vocabulary acquisition 22
The case for phonological sensitivity/awareness 24

CHAPTER 2 26
Word learning in children with specific language impairment 26
Different contexts 26
Factors that influence word learning 30
Beyond naming 33
The Current Study 34

CHAPTER 3 43
Methods 43
Participants 43
Materials and procedures 47
Semantic Attributes Task 47
Phonological Sensitivity 51
Phonological Memory 52
General Procedures 53

CHAPTER 4 55
Results 55
Fast-mapping semantic attributes: NL vs. SLI 55
Fast-mapping lexical labels: NL vs. SLI 56
Fast-mapping semantic features: auditory input vs. silence 57
Fast-mapping: auditory linguistic vs. nonlinguistic information 58
Phonologically frequent vs. phonologically infrequent conditions 59
Fast-mapping and phonology 60
Equality of conditions 60

CHAPTER 5 62
Discussion 62
A review of the hypotheses 62
The nature of word learning 70

APPENDIX A 73
Additional statistics..73

REFERENCES..76

LIST OF TABLES

Table 1., Subject Demographics....43
Table 2., Subject Description....45
Table 3., Reasons for subject exclusion....46
Table 4., Semantic Attribute Task Nonwords....48
Table 5., Phonological Sensitivity Nonword List....52

LIST OF FIGURES

Figure 1., Group comparison on name recognition task....57
Figure 2., Group comparison of two conditions....59

ABSTRACT

This study investigated the fast-mapping ability of young children with normal language (NL) and specific language impairment (SLI). It compared their ability to fast-map semantic and lexical information in different conditions. Children had to fast map visual information only, visual plus non-linguistic auditory information, and visual plus linguistic auditory information. Children with SLI performed worse than children with NL overall. They showed specific deficits when the task did not meet their expectations and when they were asked to map phonologically infrequent linguistic information. A nonword repetition task was correlated with both semantic and lexical fast-mapping. The findings are discussed in light of their support for a limited capacity model of processing, and for the need to evaluate children with SLI for semantic deficits.

SEMANTIC ATTRIBUTES AND AURAL ENCODING: A STUDY OF YOUNG CHILDREN

CHAPTER 1

Introduction

The presence of vocabulary deficits has long been established for children with SLI (Rice, Oetting, Marquis, Bode & Pae, 1994). Most research in the area of vocabulary focuses on expressive labeling or receptive identification. In other words: do these children know the *name* of a given object or concept? Functional word knowledge clearly involves more than labeling alone. The purpose of this study is to gain insight into the way children with SLI learn words beyond the realm of labeling.

What's in a name? Levels of word knowledge.

Word learning is an essential component of receptive language. Word knowledge is multidimensional. Two of the most obvious indicators of word knowledge are single word comprehension or verbal production. For example, a child may point to the picture of a bird in a book when told to 'Find the bird'. Or, the child may say 'bird' when one flies overhead. In these examples, the child is demonstrating receptive and expressive knowledge of the word. However, the story doesn't end there. Does the child also identify a hummingbird or ostrich or other unusual exemplar of 'bird' correctly? This further expansion of the exemplar 'bird' requires generalization of the concept 'bird', which includes knowledge of semantic attributes (e.g., has feathers, has a beak, etc.) Does the child refrain from including a feather duster in the category 'bird' (overgeneralization)? This requires knowledge of the semantic attributes associated with the concept, as well as knowledge about which attributes are most important (e.g. 'was/is alive' takes precedence over 'has feathers'.) Additionally, a child needs to be able to use his or her knowledge of 'bird' to describe or understand a description that takes the word out of its concrete context (e.g. bird-like, flies like a bird). To understand the use of the word 'bird' in slang, the child needs to realize that words are only symbols that can represent more than one idea. To be truly facile language users, a child's word knowledge must be extensive enough so that he or she could explain what a 'bird' is clearly without using the label 'bird'. One can see how simply measuring a child's expressive or receptive knowledge of a word's label may be inadequate to characterize his or her true word knowledge and accordingly, his or her true level of language function.

How do typically developing children learn words?

There is a larger literature concerning receptive vocabulary of typically developing children than there is for children with SLI. One focus of the normal language (NL) literature has concerned how children learn new vocabulary. In a fast-mapping paradigm subjects are tested on their knowledge of new words after only 1-3 exposures to the words. Fast-mapping has been a focus of researchers trying to understand how children with NL acquire words. It has been observed in children who are younger than age two (Evey & Merriman, 1998), pre-schoolers (Alt, Plante, & Creusere, submitted; Behrend, 1988; Golinkoff & Jacquet, 1996; Heibeck & Markman, 1987; Wilkinson & Dube, 1998, 2001), school-aged children (Wilkinson & Dube, 2001) and adults (Behrend, 1988). Children have shown the ability to fast-map lexical labels for nouns (Alt et al., submitted; Evey & Merriman, 1998, Heibeck & Markman, 1987; Wilkinson & Dube, 1998, 2001) verbs (Alt et al., submitted; Behrend, 1988; Golinkoff & Jacquet, 1996), and adjectives (Waxman & Markow, 1998). Fast-mapping of specific semantic qualities associated with new words also has been examined. Children are sensitive to different attributes of nouns including color, animacy, presence of eyes, texture, shape, and pattern (Alt et al., submitted; Heibeck & Markman, 1987). Behrend (1988) noted that children and adults were sensitive to the action, and its result associated with verbs. Alt et al. found that children with NL could fast-map the speed, initiator, and presence of sound for verbs. The literature is clear about the fact that children with NL are able to fast-map both novel words and their semantic attributes.

There is also evidence that children are influenced by syntactic factors when learning words, and not simply by general cognitive principles. Studies have shown that children are sensitive to the syntactic context when a novel label is presented. (Baldwin, 1992; Jaswal & Markman, 2001; Waxman, 1994). Children showed different patterns of selection when questions were phrased in particular ways. For example, when a label was presented as a proper name, children chose an animate object to accompany it. When the same label was presented as a common noun ("a ---"), the children chose an animate object at chance rates (Jaswal & Markman, 2001). Cross-linguistic studies have added to the information about supposed universal word-learning constraints. The Japanese language does not have the same cues to distinguish nouns as English does. Therefore, the lexical cues English-speaking children demonstrated in the studies mentioned above would not be expected in the Japanese-speaking children. Indeed, Japanese-speaking and English-speaking preschoolers classified novel objects and substances according to different rules (Imai & Gentner, 1997; Imai, 1999). This is evidence that the way children learn new words is dependent not only on cognition but also by the specifics of the child's native language.

Learning Labels

Fast-mapping is often used as a means to an end within the NL literature. Researchers may vary the fast-mapping paradigm in order to test hypotheses concerning word learning. For example, a child may be given a new word and asked to map it onto an array of objects. In one paradigm, only one of the objects may be unfamiliar to the child. Other, more involved paradigms give children a new word and ask them to map it onto several unknown objects that differ in terms of function, size, shape, or other features. Some paradigms include familiar objects, novel objects, and objects that have been recently named.

Several principles to explain how children map novel words have emerged from this work. The first principle is that of mutual exclusivity (Markman, 1991, 1996). The mutual exclusivity principle states that children will not give two names to the same object. This greatly limits the referents to which a label can refer, and eases a child's acquisition of words. Fast-mapping, therefore, becomes a process of rejection, in which the child will reject labeling a known object with a second, unknown name. A related idea is the principle of contrast (Clark, 1990), which states "Every two forms contrast in meaning." (p.417). Clark posits that words have very specific meanings and connotations such that there are no true synonyms. The Principle of Contrast goes hand-in-hand with the Principle of Conventionality, which assumes that the easiest, most conventional form is the proper one to use. Therefore, if children are familiar with a given object/label pair and a new word is introduced, they will assume that the word refers to a different, or novel object. This, too, can be seen as an idea of rejection ("It can't refer to the cat. That other one is clearly and usually called a cat."). An alternative view is the NC3 (novel name-nameless category) principle proposed by Golinkoff, Hirsh-Pasek, Bailey, & Wenger (1992). The NC3 principle is based not on a process of rejection, but rather on the concept that children strive to find words and objects with shared characteristics. It assumes that children will seek out a novel object to go with a novel name based on the shared characteristic of novelty (Wilkinson & McIlvane, 1997).

Although these principles are independent, their outcome often looks the same; children map novel words onto novel objects (Wilkinson & McIlvane, 1997). The authors argue their points, but the evidence is equivocal. For example, Golinkoff et al. (1992) examined children's fast-mapping of novel words onto novel objects. Subjects were asked to hand the examiner a given object, and their choice of object was used to indicate their mapping. The task was varied so that the subjects chose from four objects, one of which was unfamiliar, or from four objects, two of which were familiar, one of which was just-named, and one of which was unfamiliar. Young children mapped the novel name to the novel object at rates much higher than chance (78% and 80%). Golinkoff, et al. argue that the NC3 principle best explains the subjects' performances. They cite the fact that young children routinely have more than one label for an object, and that mutual exclusivity requires that children override it in order to learn new words. This, they claim, is "an extra, unparsimonious step" (p.107). It has never been contested that the mutual exclusivity principle needs to be overridden in the natural process of children learning synonyms, superordinate categories, or in the case of bilingual children (Imai, 1999; Markman, 1991, 1996; Savage & Au, 1996). As convincing as those arguments are, the fact remains that the outcome looks the same for both principles. As long as the subjects are choosing one known object from three unknown objects (no matter how recently learned) it is impossible to distinguish between the two hypotheses subjects are using.

Wilkinson & McIlvane (1997) tried to circumvent the problem of identical outcomes using a technique called blank comparison analysis. This technique "...is a matching-to-sample analog of a "yes"-"no" task" (Costa, McIlvane, & Wilkinson, 2001, p. 345). The subject is presented with a word and asked to point to either a picture that matches a word, or a blank. The inclusion of the blank allows the subject to directly reject a picture (which would provide evidence for the mutual exclusivity principle) or choose for a novel object (in line with the NC3 principle). This technique was first used with English-speaking preschool children, who were found to use both principles

(Wilkinson & McIlvane, 1997). In other words, the children showed evidence of rejecting labeling a familiar object with an unfamiliar name (mutual exclusivity) as well as seeking out a novel object to map onto a novel name (NC3). However, there were only 8 subjects included in that study. Costa, et al. (2001) replicated the procedure with 52 Portuguese-speaking children (aged 3- to 13-years-old) and found evidence for both lexical learning principles. An individual child may use both rejection and relation of novel stimuli to learn new words. This duality is not surprising, given the complex nature of word learning.

Word Extension

Another way to look at word learning extends beyond the concept of labeling. Word extension refers to a child's ability to take a known object/label pair and use the label with other, appropriate objects. Typically, word-extension studies present children with a label (sometimes novel, sometimes known). Children are then asked to choose another object of either the same name, or of like kind. The child's choice will offer researchers some insight into what children focus on as important when learning new words. As with the principles of lexical learning described above, word-extension hypotheses may appear to be in opposition to one another. One example is the concept of whole-object learning versus taxonomic learning. The whole-object view presumes that children learn words based on the conception of the whole object, and do not attend to smaller parts, such as attributes. The taxonomic view is that children learn to extend words to objects of like kind, which might imply knowledge of parts (Markman, 1991;

Wilkinson & Dube, 1998). Evidence has been found for each of these constraints and some researchers believe that all of the constraints are available to children (Markman, 1991).

Specifically, some of the evidence in the literature suggests that children will choose words that are linked taxonomically (e.g. horse, cow) rather than thematically (e.g. horse, cowboy) (Markman, 1989). Baldwin (1992) confirmed this finding, and extended it by discovering that children used shape as a deciding factor, even before taxonomic classification. Golinkoff et al. (1992) found that children related words based on taxonomic classification; in this case the objects differed only in color. Liu, Golinkoff, and Sak (2001) found that young children could relate novel words at the superordinate level. In a related study, McGregor & Hashimoto (2002) used semantic priming to see its effects on an object decision task. They found that both taxonomic and thematic primes resulted in faster object selection for 6- and 8-year-old children. However, primes related to an object's shape were less effective than unrelated primes. These differences in finding could be related to the age of the subjects, suggesting that learning strategies change with age.

Instead of focusing on very young children's relational strategies or older children's priming behaviors, McGregor, Friedman, Reilly, and Newman (2002) directly investigated the relationship between semantic representations and naming. In their studies, 4- and 5-year-old children were shown pictures of words and asked to name the words. They were later asked to both describe and draw the words. There was a relationship between how fully elaborated a child's semantic knowledge of the word was and the child's accuracy in naming. The range of semantic knowledge associated with a word's label was thought to be representative of the process of fully encoding a word. In other words, although a child can say a word, he or she may not fully understand the word. The child may be adding levels of semantic knowledge with each new experience with the word or the object/concept it represents. This process of ongoing encoding is referred to as slow mapping.

In summary, the literature on children with NL provides evidence of different constraints and rules that children use when they are learning words. The fact that there is evidence for many of the individual rules, and evidence for multiple usage of rules within the same children, speaks to the complex nature of word learning. Despite all the information about word learning (labeling and extension) in the NL literature, there is still much to discover. The existing literature does not fully address the issue of how children code multiple semantic attributes of words or what effect learning a word's label has on the encoding of semantic attributes.

Phonological/Phonotactic Frequency

There is a literature to support the sensitivity of human beings to phonotactic structure, or "the configuration of speech sounds within syllables and words..." (Vitevich, Luce, Charles-Luce, & Kemmerer, 1997, p.47). Phonotactics, in addition to referring to the configuration of speech sounds, refers to the probability of their particular order. That probability is, of course, influenced by the frequency of those patterns in one's native language. For example, in English, one is more likely to encounter a word beginning with "ba-" than with "bh-". Although a person's sensitivity peaks within the first year of life, some degree of sensitivity is present throughout a person's lifetime. Vitevich et al. (1997) present a brief review of studies showing phonotactic sensitivity in infants, both across languages and within their own language. They also note studies in which adults made frequency-based decisions about single syllable nonwords based on phonotactic information and processed phonotactically frequent nonwords more quickly than infrequent ones. Vitevich et al. extended the findings of these previous studies to include bisyllabic words, all of which were phonotactically legal. They found that adults with no reported history of speech or language impairment were sensitive to the phonotactics of the nonwords presented to them. This study also added weight to the argument that people's perceptions of "wordlikeness" are consistent with the actual phonotactic probability of the nonwords; subjects' perceptions were in line with the objective measures of phonotactic frequency. In addition, subjects were able to process the phonotactically frequent nonwords more quickly than the infrequent ones. This suggested that the more a nonword is phonotactically like a real word, the easier, and therefore faster, it is to process.

A literature exists in which the connections between phonological frequency and word learning were examined. Two studies involved 7- and 8-year old children who were asked to recall and recognize real words as well as nonwords. The nonwords were classified as high- or low-probability based on their phonological structure. Children were consistently able to remember real words and high probability nonwords better than low probability nonwords (Gathercole, Frankish, Pickering, & Peaker, 1999; Gathercole & Pickering, 1999).

However, the picture is not as straightforward as it might seem. Additional evidence suggests that people process words through competing strategies: phonological and lexical (Storkel & Morrisette, 2002; Vitevich & Luce, 1998). In normal adults, lexical strategies are thought to take precedence for familiar words, while phonological strategies are stronger with novel or nonwords. So, when a word is real and familiar, an adult is thought to pay less attention to the phonology of the word; phonology is by-passed in favor of the lexical information. This would make sense, because once a word is phonologically 'recognized' a person needs to move into the lexical/semantic arena in order to use it or put it in context. However, an unfamiliar word first needs to be recognized, and phonology is a logical place to start encoding an unfamiliar word. Vitevich and Luce's (1998) study validated this scenario. These authors noted that the words that are the most phonotactically frequent, also have the highest neighborhood densities, that is, they have a large number of words with similar phonological patterns. Vitevich and Luce report that when adults process words with high neighborhood densities, they are slower than when processing words with low densities. For example, if a person heard the word "baf" he or she might be compelled to contrast the word with its many neighbors (bat, ban, bass, back, bad, laugh, etc.), possibly to make sure it was not misheard. Contrasting words this way could slow down overall processing. Longer processing time is the opposite of what would be expected by the phonotactic frequency finding. Vitevich and Luce tested the hypothesis that words are subject to lexical processes and nonwords to phonotactic frequency by manipulating lists of frequent and infrequent words and nonwords. The implication for research is that not only should researchers be concerned with a word's phonotactic frequency, but also with its neighborhood density.

However, the previous research has focused on adults who have lexical and phonological systems that are already in place. It is possible that in children, whose systems are still developing, the story would change. Remember that Gathercole, et al. (1999) found that 7- and 8-year old children were consistently able to remember real words and high probability nonwords better than low probability nonwords. Roodenrys and Hinton (2002) challenged these findings. These authors not only manipulated biphones, like Gathercole et al., but also controlled for lexical neighborhoods. With these controls in place, they found no effect for biphone frequency and therefore argue that lexical processing is implicated in non-word serial recall. In other words, non-word recall is not a one-dimensional index of phonological memory. Storkel and Morrisette (2002) describe neighborhood density as a lexical variable, and phonotactic frequency as phonological variable. When real words are used as parts of experiments, the additional lexical variable of word frequency is introduced. (Word frequency is the number of times a word appears in a language. For example, "the" would have a higher word frequency than "xylophone".) Storkel and Morrisette reviewed the literature surrounding developmental word processing and propose that, in children who are still acquiring words, there will be an interaction between lexical and phonological processing.

Phonology as a predictor of vocabulary acquisition

There has been support in the literature for a connection between phonology and vocabulary knowledge (Bowey, 1996; de Jong, Seveke, & van Veen, 2000; Gathercole & Baddeley, 1989; Gathercole, Hitch, Service, & Adams, 1997; Gathercole & Pickering, 1999; Gathercole, Service, Hitch, Adams, & Martin, 1999, Michas & Henry 1994, Schwartz & Leonard, 1982). However, there has been debate in the literature as to what aspect of phonology contributes to vocabulary. A link between phonological memory and vocabulary acquisition has been proposed (Gathercole & Baddeley, 1989, Willis & Gathercole, 2001). Bowey (1996, 1997) suggests that the link may be less specific, and related to general phonological processing. A brief outline of the research will be presented below.

Gathercole and colleagues have been studying the relationship between phonological memory and vocabulary acquisition for years. Gathercole and Adams (1993) established that measures of phonological memory were linked to receptive vocabulary knowledge in two- and three-year-old children with normal language. They first found evidence for a relationship between phonological memory (as defined by nonword repetition) and vocabulary in four- and five-year-old children with normal language (Gathercole & Baddeley, 1989). They reported additional studies of novel name learning that provided evidence for a causal relationship, as opposed to simply a correlational one. In one such study, children were asked to learn the proper names of stuffed animals. One set of animals had common names, and the other had phonologically comparable, but unusual names. Children learned the common names more easily than the novel names. Because the phonology was the only difference in the task, the authors took this as evidence of the unusual phonology causing the poorer performance in lexical learning. However, as their research progressed, the nature of the relationship between phonological memory and vocabulary shifted. Continued study of the subjects in the 1989 paper revealed that vocabulary knowledge appeared to exert more of an influence on phonological memory as the subjects aged (Gathercole, Willis, Emslie, & Hazel, 1992). In a later study, Gathercole, Service, Hitch, Adams and Martin (1999) found that phonological memory maintained a causal link to vocabulary even for 13-year-old children, in contrast to their earlier findings.

The theoretical construct that Gathercole et al. use to explain the link of phonological memory to vocabulary relates to Baddeley's conception of short-term memory. In his explanation of short-term memory, Baddeley proposed a construct called the phonological loop (cited in Baddeley, Gathercole, & Papagno, 1998). This loop acts like a mental scratch pad, and helps one maintain a novel phonological structure until the representation can be stored in long-term memory. It follows that those children who have better phonological memories have better chances of maintaining novel word representations and eventually committing them to long-term memory.

The Case for Phonological Sensitivity/Awareness[1]

A number of Gathercole et al.'s findings and propositions have been specifically challenged. Few researchers challenge the fact that nonword repetition or memory play a role in vocabulary acquisition. Rather, the questions have to do with how unique or strong these links are. For example, the unique nature of phonological memory in relation to vocabulary has been challenged. Metsala (1999) found that vocabulary was linked to nonword repetition, but attributed the shared variance to phonological awareness (as an index of lexical items), and not phonological memory. Bowey (1996, 1997) found that phonological sensitivity accounted for as much variance in vocabulary as phonological memory. In contrast, de Jong et al. (2000) found that phonological sensitivity and not phonological memory was linked to the acquisition of new words. Also, Lonigan, Burgess, Anthony and Barker (1998) found that phonological sensitivity was significantly correlated with oral language scores in young children. Therefore, phonological sensitivity appears to have some relation to vocabulary acquisition as well.

Although Bowey (1996, 1997) found a link between phonological sensitivity and vocabulary, she contends that there is no theoretical link between the two. However, de Jong et al. (2000) outlined several reasons one would expect a link between the two. The first has to do with the supposition that phonological memory and phonological sensitivity in fact represent a unitary phonological ability (Bowey, 1996; de Jong et al., 2000; Wagner & Torgesen, 1987). de Jong et al. argue, "...if this common ability is responsible for the relationship of phonological short-term memory

[1] Although different researchers have preferences for one or the other of these terms, for all intents and

with vocabulary acquisition, a similar relationship should be observed for phonological sensitivity" (p.276). A second reason proposed by de Jong et al. for a relationship is that phonological sensitivity may allow for a better initial representation of a novel word. Accordingly, a better representation may lead to an "improved ability to learn novel words" (p.278). Indeed, de Jong et al. found that children who were trained on phonological sensitivity tasks did indeed have increased word learning compared to children who did not.

As with the literature on which hypotheses children use when they learn words, the literature related to phonology and word learning is complex. It is clear that phonology is related to the acquisition of vocabulary. There is support for both phonological memory and sensitivity as (possibly) causal contributors to novel word acquisition. However, it is clear that more work needs to be done to separate out the true nature and direction of the relationship. In this study, children will be presented with phonologically frequent versus infrequent words to see if there is any change in their performance associated with this variable.

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purposes, phonological sensitivity and phonological awareness are synonyms.

CHAPTER 2

Word learning in children with SLI

Given the complex nature of word learning in children with NL, it is not surprising that we know even less about how children with SLI learn new words. The SLI literature does not directly follow the scope or path of the NL literature. There are significantly fewer studies specifically addressing word learning. This is due, in part, to the focus on the expressive morphosyntactic deficits that are considered a 'hallmark' of this disorder. Receptive vocabulary is often relegated to a mention of a child's score on a test such as the *Peabody Picture Vocabulary Test*. However, there are several lines of research that directly address word learning in children with SLI. These studies have looked at word learning in different contexts including supported learning contexts, quick incidental learning contexts, and fast-mapping contexts. Findings from these specific contexts will be highlighted below.

Different contexts

A supported learning context is "...an instructional approach designed to facilitate successful word learning in preschool children with SLI." (Kiernan & Gray, 1998, p. 165). A supported learning context roughly mimics a therapy session. Therefore, children learning words in a supported learning context would typically be involved in a play situation, receive modeling and feedback on their efforts, as well as being expected to imitate words. Two studies examined how children with SLI acquire words in such a context. Kiernan and Gray (1998) had preschool children with SLI attempt to learn real but low frequency English words in a supported learning context. Word knowledge was measured in terms of comprehension (in which children were asked to non-verbally identify the object associated with the word) and production (in which children were asked to correctly label an object). The word learning of children with SLI was then compared to the word learning of age-matched peers with NL. In this context, the SLI group did not learn as many words as the group of children with NL, with learning defined as correct word production. However, Kiernan and Gray found that children with SLI typically comprehended words they did not produce. Gray (in press) also used a supported learning context to measure word learning in children with SLI. Her results concurred with Kiernan and Gray. Not only did children with SLI produce and comprehend fewer words than peers with NL, but they also required more trials to reach criterion for the words they did learn. Gray's study also examined children's generalization to an alternate format. In this case, children looked at photographs or drawings of the objects they had studied and were asked to recognize, comprehend, and produce the name of the object in the pictures. Children with SLI did not perform as well as children with NL on any aspect of this task. Although children with NL could perform each of the tasks (recognition, comprehension, production) equally well, children with SLI showed a particular deficit for production of word labels. This replicates Kiernan and Gray's findings and leads to a consistent picture of word learning in a supported learning context.

Other researchers have been interested in how children learn words when they are not in a therapy-like situation, but rather in a situation that is closer to real life.

Rice, Buhr, & Oetting (1992) developed a paradigm they called quick incidental learning. In this paradigm, children are exposed to a word up to ten times. The word is typically embedded in a sentence and is not explicitly taught. In the study by Rice et al. (1992), five-year-old children with SLI were shown videotapes in which clear visual exemplars were paired with novel (real, but infrequent) words embedded in sentences. Children heard each target word three times. The children were shown four pictures and asked to point to the one that matched the target word in order to test their word knowledge. Children with SLI learned fewer words than their peers with NL, but as many words as younger children with NL who were matched for mean length of utterance (MLU). Rice et al. (1994) continued exploring the quick incidental learning context by manipulating the number of exposures children had to a word, as well as the syntactic category of the word children were asked to learn. Children heard words zero, three, or ten times. Rice et al. found that children with SLI could learn as many new words as children with NL, but only with the maximum number of word exposures. All children learned nouns more readily than verbs. Rice et al. also examined children's retention of the newly learned words. Children were probed for comprehension immediately following word learning and one week later. Children with SLI did not retain the new words as well as children with NL. Oetting, Rice, and Swank (1995) extended this work in a quick incidental learning study of school-aged children with SLI. This study included words from four semantic classes: objects, actions, attributes, and affective state. Children with SLI learned significantly fewer words than peers with NL, and appeared to have particular difficulty learning verbs (Oetting et al., 1995). The work in the quick incidental learning context has been fairly broad with questions examining word learning from after three exposures to retention up to one week later. It shows that word learning is not a problem that is confined to the preschool years.

Researchers also have been interested in how children with SLI learn words when first exposed to them, hence the use of the fast-mapping context. Two studies found that there were no differences in how well children with SLI and children with NL fast-mapped low frequency real words (Gray, in press; Dollaghan, 1987). However, other studies have found differences in the performances of children with SLI and children with NL. Alt et al. (submitted) found that children with SLI fast-mapped fewer lexical labels than their age-matched peers with NL. Rice, Buhr, and Nemeth (1990) found that children with SLI fast-mapped fewer words than children with NL who were matched for age and children with NL who were matched for MLU.

In order to learn more about how children with SLI learn words, one would hope to find converging evidence regarding the performance of these children on the subtleties of word learning (e.g. context, word type). The main trend across each of these variables is that, in general, children with SLI tend to perform worse than their peers with NL. However, there are effects on word learning that occur not only across learning contexts (as might be expected) but within contexts as well.

Factors that influence word learning

It seems that one of the main factors that influences how children with SLI learn words is quantity. Quantity can impact learning in terms of the number of words a child is asked to learn, as well as how many times they are exposed to a word. There are noticeable differences in the literature on both aspects of quantity. This difference is most obvious in the fast-mapping studies. The two studies in which no significant difference was found between children with SLI and NL (Dollaghan, 1987; Gray, in press) asked children to fast-map one and four words, respectively. The relative ease of these tasks may account for the comparable performances. In the studies where group differences were found, the demands were more rigorous. Alt et al. required children to map twelve novel words (six nouns and six verbs) and choose from four possible lexical labels for a total of 48 responses per child. Rice et al. (1990) required children to fast-map 20 novel words representing four different semantic categories. The series of quick incidental learning studies performed by Rice and colleagues illustrates the importance of quantity in another way. The only time that children with SLI performed at a level equivalent to their age-matched peers with NL was when they had at least ten exposures to a word. Oetting et al.'s (1995) study in which the children with SLI did not match the performance of the children with NL allowed only five exposures to the novel words. The evidence seems to indicate that children with SLI will perform better on word learning tasks when they are asked to map fewer words and provided with more exposures to those words. Frequency of the input is important.

Syntactic factors also affect word learning. Consistently, children with SLI appear to have more difficulty learning verbs compared to other word types (Alt et al., submitted; Leonard, Schwartz, Chapman, Rowan, Prelock, Terrell, Weiss & Messick, 1982; Rice et al., 1990; Oetting, et al. 1995). In SLI, this difficulty appears to span both comprehension and production of new words (Leonard et al., 1982). This pattern also has been documented for children with NL (Alt et al., submitted; Leonard et al. 1982; Terrell & Daniloff, 1996).

A third factor, perceptual salience, has been examined for its influence on word learning. Rice et al.. (1992) inserted pauses into the sentences that contained the target words, with the intention of making the target words more salient. In fact, the pauses did not aid the children with SLI, showing that not all perceptual features have a significant impact. However, Ellis-Weismer and Hesketh (1998) found that presenting words with emphatic stress did facilitate word learning. Both children with SLI and NL had increased success repeating words that had been presented with emphatic stress. Decreased rate of word presentation also has been linked to better word-production performance of children with SLI (Ellis-Weismer & Hesketh, 1996). In both Ellis-Weismer studies, task difficulty interacted with perceptual salience. The perceptual manipulations only came into play when the task became difficult.

In tasks requiring labeling of objects or actions, motor sequencing is another factor that may influence the performance of children with SLI. It may be the case that their perception of words is adequate, but their ability to produce the words is hampered by deficient motor sequencing abilities. Dollaghan (1987) found that the only difference between the children with SLI and NL on her task was that children with SLI were less accurate at producing the phonemes of the novel word. There may be many reasons for this difference, but it is worthwhile to consider the evidence that children with SLI tend to have subtle motor signs (Bishop, 2001; Bradford & Dodd, 1994; Hill, 2001; Trauner, Wulfeck, Tallal & Hesselink, 2000). It is a possibility that motoric problems may impede production when the phonology of a word is unfamiliar.

A final factor that appears to influence the word learning performance of children with SLI across contexts is the individual learning characteristics of the study participants. Variability in word learning skill has been documented for children with SLI as well as NL (Oetting, et al. 1995). For example, although Kiernan and Gray (1998) found group differences in word learning performance, the majority of the scores of the SLI group overlapped with those of the NL group. Given the wide range of skill levels in children, study outcomes could be influenced by subject selection criteria. Some researchers have selected subjects based on specific vocabulary deficits (Rice et al., 1990, 1992, 1994) and others have not (Alt et al., submitted; Gray, in press; Kiernan & Gray, 1998). In general the studies in which subjects were selected for vocabulary deficit always show a between group (SLI vs. NL) difference. Differences between groups are only found in some of the studies that do not select subjects based on known vocabulary deficits. By definition, one would expect to find word learning difficulties in subjects with documented vocabulary deficits. However, a finding of word learning deficits in a more broadly selected group of subjects has implications for children who may not typically be flagged for word learning issues. It is important to consider the results from each of these studies in the light of the subjects selected for study.

Beyond naming

Studies to date have tended to focus on how many words children with SLI can learn, and how fast they can do it. Although this is important, this information is at the surface level of word knowledge. There are several studies that examine aspects of word learning or word knowledge beyond the level of naming in children with SLI. McGregor and Hashimoto's (2002) semantic priming study found that 8-year-old language disordered children were sensitive to semantic priming cues (taxonomic and thematic) but were less sensitive than their non-impaired peers. This is evidence that broader semantic knowledge of words can be weak in children with SLI. Kail, Hale, Leonard, and Nippold (1984) studied word-finding as a way to test hypotheses about word storage and retrieval. They found that children with SLI recalled fewer words than NL peers in free and cued recall (using categories as cues, e.g. "fruit" to elicit "apple"). Their interpretation of these results is that the children with SLI had "...fewer representations in memory" (p. 38) for these words than children with NL. They go on to state that one's interpretation of what, exactly, that means depends upon one's theory of semantic memory. However, it brings up the possibility that children with SLI may have trouble with coding semantics along with word labels, or with the organization of semantic information in memory.

Alt et al. (submitted) investigated whether or not children with SLI could fast-map semantic attributes of novel nouns and verbs as well as their peers with NL. Although this design did not attempt to test a specific hypothesis about how children learn, the inclusion of semantic attributes assured that it did examine a deeper level of word knowledge than labeling. Alt et al. confirmed that children with SLI did not fast-map the semantic attributes of novel nouns and verbs as well as their peers with NL. The finding was consistent for both nouns and verbs. With the poor performance of children with SLI documented, the logical next step was to ask why they perform more poorly.

In order to answer that question, it may be helpful to examine the specifics of the study. In Alt et al. (submitted), children were presented with a novel noun or verb paired with a novel name. They were asked to recognize different semantic attributes associated with the noun or verb, as well as its lexical label. During the name-recognition portion of the task, children were presented with four choices: the real name, two phonological foils, and an unrelated foil. One trend emerged regarding children's ability to judge the accuracy of a novel name. Children with NL were easily able to reject the foils whereas children with SLI performed at chance levels suggesting a weaker grasp of the phonological features of the names presented to them.

The Current Study

The literature predicts that children with SLI should map fewer lexical labels than their peers with NL in a fast-mapping context (Alt et al., submitted; Rice, Buhr, &

Nemeth, 1990). Word learning deficits for children with SLI have been demonstrated in a variety of learning contexts (Gray, in press; Kiernan & Gray, 1998; Rice, Buhr, & Oetting, 1992; Rice, Oetting, Marquis, Bode, & Pae, 1994). However, word learning, specifically in a fast-mapping context, may be mediated by the phonological and lexical characteristics of the words to be learned (Storkel & Morrissette, 2001; Vitevich & Luce, 1998). In general, the greater the phonological frequency of a word, the more quickly that word is processed. However, in order to make a clear statement about phonological frequency, neighborhood density must be controlled (Roodenrys & Hinton, 2002; Vitevich & Luce, 1998). These factors have not previously been controlled in studies examining the word learning behaviors of children with SLI. In word learning, there can easily be an interaction between phonological and lexical processing. In order to see if children with SLI are sensitive to the phonological patterns of words, the nonwords presented with the objects in this study will be grouped by phonological frequency. If phonological frequency influences the difficulty of word learning, it should affect fast-mapping of lexical labels for both children with SLI and children with NL. Therefore, both groups of children will more easily learn nonwords that are phonologically frequent than those that are phonologically infrequent.

Alt et al. (submitted) have shown that word learning deficits for children with SLI during fast-mapping extend beyond lexical labeling. It is possible that poor encoding of semantic attributes is linked with poor encoding of word labels for children with SLI. It may be the case that the process of having to aurally encode a word negatively impacts other aspects of encoding for children with SLI. Given their linguistic deficits, children with SLI may be unduly burdened when language is involved in an encoding task. As such, when asked to aurally encode a word that labels an object, they not only fail to encode the word properly, but the introduction of a linguistic processing load may interfere with the child's ability to encode the other semantic attributes that are associated with the object. This is consistent with the theory that children with SLI are impaired due to a limited processing capacity (Edwards & Lahey, 1996; Ellis-Weismer & Hesketh, 1996, 1998; Leonard, 1998, Montgomery, 1995). This theory purports that children with SLI have limited resources for the task of linguistic processing. If processing linguistic information requires use of greater resources for children with SLI compared to children with NL, one might expect a decrement in the simultaneous encoding of nonlinguistic information along with word labels. Therefore, one would predict that poor fast-mapping would extend beyond lexical labels to semantic attributes as well. The prediction is that children with SLI will fast-map fewer semantic attributes than their peers with NL.

There are numerous theories and models in the literature to explain the performance of children with SLI. Why has the limited capacity processing theory been chosen for this study instead of some of the other possibilities? First, several theories in the field are simply too specific in their scope to address the issues presented in this study. There are a number of theories which focus on explaining the phenomenon of impaired grammar found in children with SLI. Examples of such grammar-specific theories include the Extended Optional Infinitive (Rice, Wexler, & Redmond, 1999), the subject-verb disagreement theory (Clahsen, Bartke, & Gollner, 1991) and the genetically-based grammar deficit model (van der Lely, Rosen & McClelland, 1998). These theories focus on explaining grammatical deficits and are not designed to explain the behavior of children with SLI associated with fast-mapping of semantic attributes or lexical labels.

A second possibility would be to use the working memory model adopted by Gathercole and colleagues (Gathercole & Baddeley, 1989; Gathercole & Adams, 1993; Gathercole, Hitch, Service, Adams & Martin, 1999). This model posits that children use a phonological loop to process incoming information, before it is stored in long-term memory. A child's performance on a phonological memory task might be thought to predict his or her performance on a lexical labeling task. However, this model is limited in explaining any possible differences due to phonotactic frequency. All phonemes should be equal within the construct of the phonological loop. Second, the working memory task does not offer a construct to explain performance on the semantic attribute mapping portion of the task.

Another class of theories seems to be more suited to explaining the phenomenon of word learning. These theories have been sub-typed as "input processing" theories. They focus on deficits at the level of processing. Examples include Tallal and colleague's assertion that children with SLI are impaired at processing all rapid auditory stimuli (Tallal, 1980; Tallal, Miller, Bedi, Byma, Wang, Nagarajan, Schreiner, Jenkins, & Merzenick, 1996; Tallal, Miller, Jenkins & Merzenich, 1997), Joanisse and Seidenberg's (1998) phonological model, and Chiat's (2001) mapping theory. Tallal et al's model is lacking in its ability to explain differences in performance based on phonological frequency. If all rapid incoming stimuli are difficult to process, there should be no effect of phonological frequency. All three models are limited in their ability to explain performance on semantic attribute mapping. Therefore, the model that seems to be most appropriate to illuminate the findings of this study is the limited capacity model.

Capacity limitations in children with SLI could manifest in a number of ways. Any linguistic task may be enough to tax the capacity of a child with SLI and impede performance on fast-mapping of semantic attributes. In order to see if this is the case, comparisons will be made between subjects' performances during the linguistic encoding conditions versus conditions that lack simultaneous presentation of an object and its label. If encoding lexical labels taxes the processing resources of children with SLI, then they will map fewer semantic attributes than children with NL. Furthermore, if phonological frequency influences the difficulty of learning lexical labels, it has the potential to interfere with other levels of word learning. A lexical label that is difficult to learn will take up more processing capacity and leave less capacity to learn semantic attributes. A limited processing capacity model would predict that children with SLI will show a decrement in performance for fast-mapping semantic attributes when the nonwords labels are phonologically infrequent versus phonologically frequent.

An alternative scenario is that the problem is not a phonological one. A limited capacity for processing could be thought of as a broader problem for children with SLI. It is possible that children with SLI may experience interference given any auditory stimulus during the visual encoding of semantic attributes. In this case, processing any auditory information would tax a child's capacity and leave them with limited processing resources to devote to encoding semantic attributes. In order to investigate this scenario, children will be compared on their fast-mapping ability when they are presented with either non-linguistic auditory information versus their performance when no auditory input of any kind is present. Deficits in simultaneous auditory-visual processing would be consistent with the version of the limited capacity theory that highlights processing demands in general rather than linguistic processing demands in particular. If this is the case, children with SLI will show a decrement in performance on tasks involving nonlinguistic auditory and visual input versus tasks involving only visual input.

As mentioned earlier, individual children come to the task of learning with characteristics that can impact their word learning. Two subject characteristics that may account for performance on word learning tasks are phonological sensitivity (the ability to identify or manipulate individual phonemes) and phonological memory (the ability to remember novel phonological sequences). A phonological memory task is an appropriate choice because, as described earlier, phonological memory has been linked to word learning in numerous studies (Bowey, 1996; de Jong, Seveke, & van Veen, 2000; Gathercole & Baddeley, 1989; Gathercole, Hitch, Service, & Adams, 1997; Gathercole & Pickering, 1999; Gathercole, Service, Hitch, Adams, & Martin, 1999; Michas & Henry 1994; Schwartz & Leonard, 1982). However, the nature of the relationship remains unclear. If the phonological loop construct is accurate, phonotactic frequency and neighborhood density should have no effect on word learning. This is clearly not the case. Word learning appears to be influenced by both lexical and phonological factors (Storkel & Morrissette, 2002; Vitevich & Luce, 1998). However, it is possible that other aspects of phonological memory tasks (i.e. nonword repetition) make it an accurate predictor of word learning. For example, the degree of sensitivity to phonotactic regularities in a nonword repetition task may facilitate both memory for nonwords and learning of real, but previously unknown word labels. The level of an individual child's familiarity with phonotactic regularities may facilitate or inhibit performance on both nonword repetition and word learning tasks. Therefore, nonword repetition may index a component of individual variability that may account for task performance. If so, nonword repetition will be correlated with performance on the lexical labeling portion of the fast-mapping task.

Likewise, the degree of familiarity with phonotactic regularities could also mediate the processing load during the semantic attribute portion of the task. This is another example of the limited capacity model in action. If lexical learning is difficult and demands a large processing load, the availability of processing capacity for semantic attributes is limited. In this case, the hypothesis is that performance on nonword repetition will correlate with performance of fast-mapping semantic attributes.

A phonological sensitivity task is another logical choice to try to account for individual variability in word learning. Phonological sensitivity is a child's awareness of or sensitivity to the phonology of words. Phonology can be thought of as the gateway to conceptual-level word learning, at least for young children. If there is a disruption at the gate, the remainder of the word-learning (such as coding of semantic attributes) will suffer, particularly in a fast-mapping condition. If phonological sensitivity is low, an accurate representation of phonemes may never make it into phonological memory, and a lexical label will not be learned. On the other hand, if a child has high phonological sensitivity, it may be very easy to enter a lexical label into phonological memory and then learn it, since little effort is used in recognizing a string of phonemes. Children who have low phonological sensitivity are more likely to have trouble learning lexical labels. Therefore, the prediction is that performance on a phonological sensitivity task will correlate with performance on the lexical labeling task. Following the same logic used earlier, any shared function that explains lexical learning has the ability to impact how semantic attributes are learned as a result of the limited capacity processing theory. Accordingly, the hypothesis is that performance on a phonological sensitivity task will be correlated with performance on the semantic attribute portion of the fast-mapping task.

To summarize, the specific hypotheses for this study are:

1) Children with SLI will fast-map fewer semantic attributes than age-matched peers with NL.
2) Children with SLI will fast-map fewer lexical labels than age-matched peers with NL.
3) There will be a decrement in how well children fast-map semantic features when there is auditory input versus when there is silence.

4) There will be a decrement in how well children fast-map semantic attributes when there is auditory linguistic versus non-linguistic information.
5) There will be a decrement in how well children fast-map semantic attributes when the aural input is phonologically infrequent versus phonologically frequent.
6) There will be a decrement in how well children fast-map lexical labels when the aural input is phonologically infrequent versus phonologically frequent.
7) There will be a significant correlation between fast-mapping of semantic attributes and performance on a test of phonology.
8) There will be a significant correlation between fast-mapping of lexical labels and performance on a test of phonology.

CHAPTER 3

Methods

Participants

Forty-six native English-speaking children participated in the study. The children ranged in age from 4:0 to 5:10 and were from a range of racial, ethnic and socioeconomic backgrounds. (See Table 1).

Table 1.
Subject Demographics

	SLI	NL
Race		
American Indian	1	1
Asian	0	2
White	13	12
Hawaiian/Pacific Islander	1	1
Black/African American	3	0
Multi-Racial	2	4
Not Reported	3	3
Ethnicity		
Hispanic or Latino	4	6
Not Hispanic or Latino	6	6
Both	1	0
Not Reported	12	11
Maternal Level of Education		
8th Grade	1	0
9th Grade	0	0
10th Grade	0	2
11th Grade	0	0
12th Grade	3	4
1 year college	2	1
2 years college	2	3
3 years college	0	2
4 year degree	5	6
Graduate degree	7	3
Not Reported	3	2

Half were children with SLI and half were children with NL. SLI and NL subjects were matched for age (±3 months) and sex. All children were free from known cognitive, motor, behavior, neurological or hearing problems. Children were recruited from the University of Arizona Wings on Words program (a language-centered program) as well as local Tucson, Arizona preschools and daycare centers.

To meet the definition of SLI, children must demonstrate language impairment in the presence of otherwise typical cognitive, motor, behavior, neurological, and hearing skills. To operationalize this definition, tests of language and nonverbal cognition were administered. In addition, parent and teacher questionnaires and a hearing screening were used to rule out other concurrent disorders.

Language skills were assessed using the Structured Photographic Expressive Language Test – Second Edition (SPELT-II) or the Structured Photographic Expressive Language Test –Preschool (SPELT-P). Children were included in the SLI category if their z-scores were lower than –3.25 on the SPELT-II and lower than –1.39 on the SPELT-P (Plante & Vance, 1994; Plante & Vance, 1995). Alternatively, children with purportedly normal language had to score above a z-score of –3.25 on the SPELT-II (all children with NL received the SPELT-II). Any child with NL exhibiting the use of obvious phonological patterns (e.g. stopping, fronting) was excluded from the NL category. To remain in the study a child's test scores had to concur with clinical judgment about their conversational speech and language behaviors.

All children had to be free from cognitive, motor, behavioral, neurological, or hearing problems to participate. Therefore, all children were required to achieve a standard score of 75 or receive a Kaufman Assessment Battery Score for Children (K-ABC) nonverbal intelligence standard score above 75 (70 + 1SEM) (See Table 2 for test score results.)

Table 2.

Subject Description

	SLI	NL
Sex	13 males 10 females	13 males 10 females
Age in Months		
Mean	57.9	58.2
Range	8.5	7.7
SD	48-71	49-69
K-ABC*†		
Mean	97.47	110.7
SD	12.2	11.3
Range	78-119	95-138
SPELT-II*†		
Mean	-5.04	-1.14
SD	1.67	.99
Range	-9.25 to -3.40	-3.00 to +1.60
SPELT-P*		
Mean	-3.35	n/a
SD	1.14	n/a
Range	-4.76 to -1.63	n/a

*K-ABC scores are standard scores and SPELT scores are z-scores.
†Statistically significant difference at $p<.01$.

Parent and teacher questionnaires concerning children's general development and history of services were used to identify the presence of any cognitive, motor, behavioral, or lack of frank neurological disorders. All subjects were required to pass a hearing screening. Passing performance consisted of reliable responses to pure tones at 25db HL at 500 Hz and 20 dB HL at 1000, 2000, and 4000 Hz. Two preschool settings had significant ambient noise during testing. At those centers, the criteria for passing were raised to 35dB HL at 500 Hz and 30 dB HL at 1000, 2000, and 4000 Hz. Overall, 94 children were evaluated for possible inclusion in the study. Reasons for exclusion are listed in Table 3.

Table 3.

Reasons For Subject Exclusion

	Number
*No SLI match	14
Teacher/Clinician Concerns	11
Not native English speaker	4
History of Seizures	4
+Sibling in study	3
Failed hearing screening	3
Low K-ABC scores	2
Tester error	2
Documented dysfluency	1
Documented hearing loss	1
Sporadic Attendance	1
Behavior Issues	1
*Displayed phonological error patterns	1
TOTAL	48

*Pertained only to children with NL.
+Violates the statistical principle of independent selection

Materials and Procedures

Semantic Attributes Task

The purpose of this task was to create a measure of a child's ability to fast-map semantic attributes to novel objects, as well as to measure name recognition of the novel object. This task was specifically designed to measure performance on these two skills (semantic mapping and name recognition) under four different encoding conditions. Novel items were used in accordance with the principle of mutual-exclusivity (Markman, 1991), which states that children with NL will not apply two labels to one object. There is evidence that this is an issue for children with SLI as well (Gray, in press; Kiernan & Gray, 1998). In addition, novel item use rules out previous experience with even low frequency words.

In all, there were 24 novel objects. Objects were created using modeling clay so that they would appear three-dimensional. Objects were then digitally photographed for computer presentation during the task. The task was designed to test mapping in four encoding conditions: names of high and low phonological frequency, nonverbal sounds, no auditory stimulus accompanying object presentations. Therefore, six objects were paired with phonologically frequent nonwords, 6 with phonologically infrequent nonwords, 6 with noise, and 6 were paired with silence. For each object, children were asked to map the following semantic attributes: color, pattern, shape, and the presence or absence of eyes. For the two conditions involving phonological manipulations, children were asked to recognize the object's name given a choice of the real name and three foils. Exemplars of phonologically frequent and infrequent novel words, noisy, and silent conditions were quasi-randomly varied. There were two versions of the task, each of which mapped objects to different labels in different conditions.

The novel names paired with objects were bi-syllabic (either CVCCVC or CVCVC) and conformed to a trochaic stress pattern. These names were developed for the Alt el al (submitted) study and were scored for phonological frequency and neighborhood density.[1] (See Table 4.)

Table 4.

Semantic Attribute Task Nonwords

Nonword	Condition	Frequency	Neighborhood Density
thurich	low	0.0000000000	0
bigib	low	0.0000000000	0
boziv	low	0.0000000000	0
shaytif	low	0.0000000010	0
joozup	low	0.0000000011	0
zootem	low	0.0000000048	0
foovis	high	0.0000005165	0
fayvid	high	0.0000007522	0
kidit	high	0.0000011695	0
mayvit	high	0.0000016683	0
babbin	high	0.0000019656	2
vipin	high	0.0000038755	2

English-speaking listeners judged the phonologically infrequent words less like English than the phonologically frequent words. This congruence between human judgment and numerical findings (also found in Vitevich et al., 1997) gives strength to the notion that

[1] All calculations were made using a program developed by Mike Hammond, Department of Linguistics, University of Arizona and based on the NEWDIC corpus. Neighborhood density was calculated using the substitution, deletion, or addition of any one phoneme. Frequency was calculated by multiplying the frequency of the onset times the frequency of the rime.

the two groups of words are noticeably different. The noise sounds that were paired with objects under the "noise" condition were non-speech sounds that were not easily associated with any given event (e.g. telephone ringing, fire alarm).

Stimuli were presented via computer (Jarvis, 2002). To make sure each child understood the semantic attribute task, subjects were first trained to assure they could recognize the semantic attributes involved in the task. In the training portion, the child saw a picture of a common object on the computer screen. The child heard the name of the object in the context of a carrier phrase (e.g. "This is a ball"). Then, a caped man appeared and said "See, this ball. Shh. I'm going to hide it." His cape closed over the object and both the man and the object disappeared. Next, the computer presented a cartoon detective who was trying to find the object ("I'm looking for a ball. Can you help me?). A camera produced snapshots of the attributes. The child was equipped with a button box with pictures of a happy and sad detective and trained to match the attribute pictured to the object. The child was trained to respond to the snapshots by pressing a button to indicate if the snapshot depicted the attribute (happy detective) or not (sad detective). Each child received decreasing cueing over the course of training. Initially, the child saw the snapshot next to the target object, and a voiceover explained exactly what to do and why. In the second phase of the training portion, the child heard instructions, but did not get to see the target object. In the final phase, the child still received explicit feedback, but was expected to respond to the snapshot without instructions. If a child hesitated, he or she was prompted by the examiner to "Give the detective the clue." If the child responded incorrectly, he or she was presented with the identical snapshot and given another try. Each child was allowed up to three training trials per attribute to make sure the task was understood.

Children were also asked to make judgments about the name of the object. While looking at the target object, the detective asked the child to help him remember the name. The detective would ask, "Is it a ball?" Each child was asked to make decisions about the real name and three foils (two phonologically related, one unrelated). All children were able to follow the instructions after three or fewer training trials for each attribute. No child had to be excluded based on failure during the training component.

At the end of the training session the detective showed the children an empty toy box and twelve toys. He told them that each time they helped him, he would put a toy in the box. When the box was full, the children would receive a prize. During the experimental session, the children were reminded that they were going to "Help the detective fill up his toy box." This provided periodic reinforcement for on-task behavior and helped to motivate the children to complete the task. The experimental portion followed the format of the training session. Each session began with an object presented with its lexical label, since this mimicked the training session. The remaining trials presented objects with high and low phonologically frequent labels, simultaneous noise, or in silence, in random order. If, during testing, children did not respond, they were prompted with "Give the detective the clue." in order to minimize the linguistic input during the semantic attribute portion of the task. Subjects were provided with differential feedback based on the accuracy of their responses. If a child correctly identified an attribute, the detective would jump up and down, throw his hat in the air, or blow bubbles. If a child correctly rejected an incorrect attribute, the detective would throw his hat down, or cry a puddle of tears. If a child's response was incorrect, a large black X accompanied by an error sound would appear. All responses were recorded on the computer via the response box.

Phonological Sensitivity

This task was used as a measure of phonological sensitivity with which a child's performance on semantic mapping could later be compared. This was a first-sound categorization task. Children watched a computer screen on which a fairy said two nonwords and told the children if the words were "friends" (started with the same phoneme) or "not friends" (started with different phonemes). After 6 training items, the children were told that it was their turn to make a decision. They heard new nonwords and the fairy asked, "Are they friends?" The examiner entered the child's response into the computer. When children responded correctly, they were rewarded with a clay animation scene. When they responded incorrectly, they saw a large black X accompanied by an error sound. The nonwords were single syllable and phonologically balanced for neighborhood density and frequency.[2] (See Table 5.) The task consisted of 6 training pairs and 10 items. Children were allowed to hear a pair up to two times, if requested.

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[2] Mike Hammond and Rachel Hayes, Department of Linguistics, University of Arizona created the nonwords based on the NEWDIC corpus. They calculated neighborhood density using the substitution, deletion, or addition of any one phoneme. Frequency was calculated by multiplying the frequency of the onset times the frequency of the rime.

Table 5.

Phonological Sensitivity Nonword List

Words Used as Matches

Word	F	ND	Word	F	ND	Total ND
poog	0	6	peend	0	5	11
gek	0	11	geev	0	11	22
dast	0	10	desh	0	12	22
tedj	0	9	tahz	0	7	16
keech	0	18	koag	0	16	34
Total ND		54			51	105
Average		10			10	21

Words Used as Mismatches

Word	F	ND	Word	F	ND	Total ND
tesh	0	4	gahv	0	5	9
keedj	0	11	poaf	0	11	22
poash	0	11	toov	0	12	23
doot	0	9	geb	0	8	17
boab	0	18	koadj	0	16	34
Total ND		53			52	105
Average		10			10	21

F=Frequency
ND=Neighborhood Density

Phonological Memory

The purpose of this task was to generate a measure of phonological memory against which a child's semantic mapping performance could be compared. This was a non-word repetition task using the list of nonwords created by Dollaghan & Campbell (1998). Children watched a computer screen where a fairy explained the task. Children listened to the nonwords through headphones equipped with a microphone. When they repeated the nonword, it was recorded for later playback and analysis. Children repeated 16 nonwords that varied in length from one to four syllables. They heard each nonword one time. After repeating each nonword, children were rewarded with a visual reinforcer. Accommodations were made for scoring the nonwords of children with known phonological patterns. The nonword repetition task was scored by: percentage of total words correct, percentage of syllables correct (scored individually for 1-, 2-, 3-, and 4-syllable nonwords) and percentage of total syllables correct. This was the scoring system used by Dollaghan & Campbell (1998) with the addition of the percentage of total words correct measure. This scoring system was used to try to capture differences in performance based on nonword length. The addition of the total words correct was added to capture differences in frequency of errors.

General Procedures

Children participated in two sessions. The first session always commenced with a hearing screening to confirm normal hearing at the time of the study. On successful completion of the screen, each child completed the first portion of the semantic attribute task along with standardized testing (cognitive testing, language testing), experimental tasks (phonological sensitivity task, nonword repetition task) or both. In the second session, the subject completed the second portion of the semantic attribute task as well as any tasks not completed in the first session. The number of tasks performed in a given session was dependent upon a child's energy and interest in the task. Some of the younger children required three sessions to complete all of the tasks. All children were tested individually and completed computer tasks with one on one supervision by a research assistant. At the end of each task the children received stickers and at the completion of each session, they chose a small prize.

CHAPTER 4

Results

<u>Fast-mapping semantic attributes: NL vs. SLI</u>

The first hypothesis was that children with SLI would fast-map fewer semantic attributes than age-matched peers with NL. To test this hypothesis, the data in this study were analyzed using a fully-crossed mixed analysis of variance (ANOVA) design. Group (NL, SLI) served as the between factor and condition (Noise, Silence, Phonologically Frequent, Phonologically Infrequent) and attribute (Color, Presence/Absence of Eyes, Pattern, Shape) served as the within factors. Between group differences were subjected to post-hoc comparisons (Tukey HSD) and within group differences were measured using least-squares tests.

There was a significant main effect for group on mapping of semantic attributes when conditions and attributes were combined ($F = 5.80$, $p < .02$). The total number of attributes tested was 96 (4 attributes times 24 objects). The mean for the SLI group was 56.91 with a standard deviation of 11.13. The mean for NL group was 64.65 with a standard deviation of 10.82. The eta^2 was .1164 ($f = .3629$) indicating a moderate effect size (Cohen, 1988). This indicates that children with SLI mapped fewer semantic attributes than their NL peers.

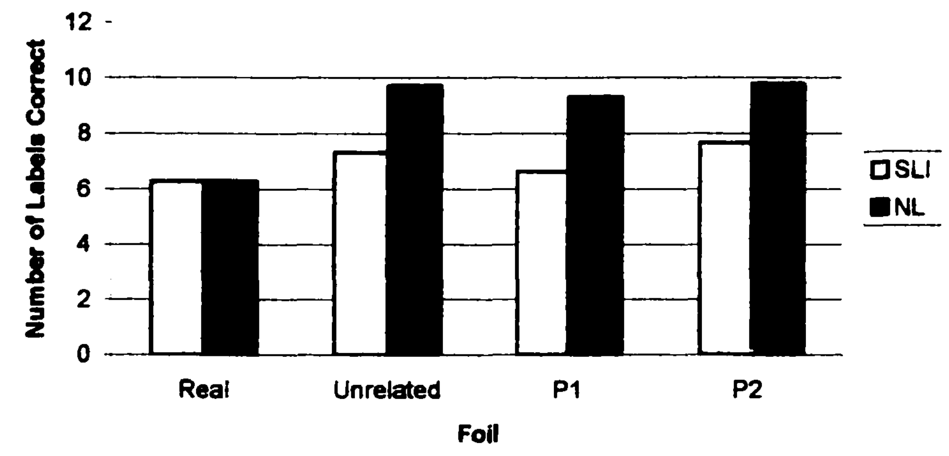
There was also a main effect for attribute ($F = 3.57$, $p < .01$). A least squares difference test (LSD) with an alpha=.05, revealed that all subjects performed better on the shape attribute than on any of the other attributes.

Fast-mapping lexical labels: NL vs. SLI

The second hypothesis was that children with SLI would also fast-map fewer lexical labels than their peers with NL. This hypothesis relates to the name recognition portion of the task. Recall that the receptive name identification task involved discriminating between the real name, a completely unrelated name, and two different phonological foils. An ANOVA with Group (SLI, NL) as the between factor and Condition (Noise, Silence, Phonologically Frequent, Phonologically Infrequent) and Foil (Real name, Phonologically related 1, Phonologically related 2, Unrelated) was used to test this part of the hypotheses. There was a statistically significant difference between groups on this component of the task ($F=8.62$, $p<.005$). The total number of responses possible was 48 (4 choices times 12 words). The children with SLI had a mean of 27.82 items correct with a standard deviation of 9.51. The children with NL had a mean of 35.04 items correct with a mean of 6.95. The $eta^2=.1638$ ($f=.4425$) for this effect (Cohen, 1988). Again, the NL subjects performed better on this aspect of the task.

There was also a significant effect for foil ($F=7.94$, $p<.00006$). A least squares difference (alpha=.05) revealed that all children performed the worst when they had to make a decision about the real label for the object. In addition, the analysis revealed a significant group x condition x foil interaction ($F=3.71$, $p<.01$). A least squares difference test (alpha=.05) helped reveal the nature of the interaction. In both the phonologically frequent and infrequent conditions, children with NL had the most success determining that the unrelated word was incorrect. They had more difficulty accepting as correct the real name of the noun or verb. The SLI subjects, on the other hand, displayed no significant differences between their choice of label, which is indicative of guessing. (See Figure 1.)

Figure 1. Group Comparison on Name Recognition Task



Fast-mapping semantic features: auditory input vs. silence

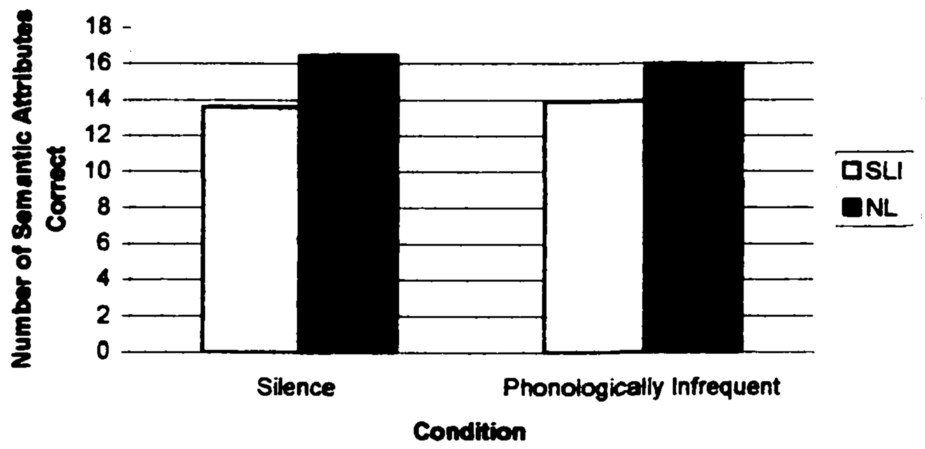
The third hypothesis was that there would be a decrement in how well children fast-map semantic features when there is auditory input versus when there is silence. This comparison was between the Noise and Silence conditions. A planned comparison was used in order to compare these three conditions to the single Silence condition. There were no significant differences between the conditions.

Fast-mapping: auditory linguistic vs. nonlinguistic information

The fourth hypothesis was that there would be a decrement in how well children fast-map when there is auditory linguistic versus non-linguistic information. This was also tested using a planned comparison. Here, the Phonologically Frequent and Phonologically Infrequent conditions were grouped to represent the linguistic condition and the Noise and Silence conditions were joined to represent the non-linguistic condition. There was no significant effect for condition.

To gain a more in-depth picture of the relationship between Group and Condition, several specific post-hoc analyses were conducted. Although there was no significant overall interaction effect for group x condition, there were two specific post hoc tests that were significant. According to a Tukey HSD test (alpha=.05), children with SLI performed significantly worse than children with NL in the Silence and Phonologically Infrequent conditions. The mean for the SLI group on silence was 13.60 with a standard deviation of 3.42. The mean for the NL group on silence was 16.43 with a standard deviation of 3.98. The mean for the SLI group on the phonologically low condition was 13.91 with a standard deviation of 3.71. The mean for the children with NL was 15.91 with a standard deviation of 2.79. (See Figure 2.)

Figure 2. Group Comparisons of Two Conditions



Phonologically frequent vs. phonologically infrequent conditions

The fifth and sixth hypotheses were that there would be a decrement in how well children in each group fast-map semantic attributes and lexical labels in the Phonologically Infrequent condition versus the Phonologically Frequent condition. These hypotheses were both tested using planned comparisons. There was no significant effect for condition for fast-mapping of either semantic attributes or lexical labels for either group.

The seventh hypothesis was that there would be a significant correlation between fast-mapping of semantic attributes and lexical labels and performance on a test of phonology. The nonword repetition task was scored by: percentage of total words correct, percentage of syllables correct (scored individually for 1-, 2-, 3-, and 4-syllable nonwords) and percentage of total syllables correct. There were three significant correlations between nonword repetition and semantic attribute fast-mapping. The strongest correlation (r=.308, p<.04) was between the percent correct for 3-syllable nonwords and semantic attribute fast-mapping. There also was a significant correlation between semantic attribute fast-mapping and total percent syllables correctly repeated (r=.292, p<.05). In comparison, the correlation between the semantic attribute fast-mapping task and the phonological sensitivity task was non-significant.

Fast-mapping and phonology

The final hypothesis was that there would be a significant correlation between fast-mapping of lexical labels and performance on a test of phonology. The same basic pattern was found for fast-mapping of lexical labels and the nonword repetition task. The strongest correlation was between the fast-mapping task and the percent correctly repeated for 3-syllable words (r=.305, p<.04). Total percentage correct repetition also correlated significantly with the fast-mapping of lexical labels (r=.326, p<.02). There was no significant correlation between fast-mapping of lexical labels and the phonological sensitivity task.

Equality of conditions

In addition to testing the main hypotheses statistically, several t-tests were run to make sure the differences in findings were real and not due to artifacts of the different versions of the experiment that were run. There were no significant differences found between versions. There was also no difference in performance between the children who had the 'happy detective' on the left button of the response box versus those who had it on the right button. Additional statistics regarding means and standard deviations for the phonological tasks, as well as a correlation matrix of standardized and experimental measures can be found in Appendix A.

CHAPTER 5

Discussion

A review of the hypotheses

The results of this study show that children with SLI fast-mapped fewer lexical labels and semantic attributes than their peers with NL. Specifically, children with SLI fast-mapped fewer semantic attributes than their peers in the Silence and Phonologically Infrequent conditions. They also showed a different pattern of choice of foils during lexical labeling than the children with NL. Finally, the nonword repetition task, and not the phonological sensitivity task, was correlated with performance on the fast-mapping task.

It may be useful to examine the findings through the lens of each of the individual hypotheses. The first hypothesis was that children with SLI would perform more poorly than children with NL on a fast-mapping task. The evidence from this study supports that hypothesis and replicates the findings of Alt et al. (submitted). One implication of this finding is that children with SLI have difficulty with word learning that extends beyond the process of attaching lexical labels to objects. The fact that the children who participated in the study were not specifically chosen for vocabulary deficits adds weight to the idea that the semantic aspect of word learning may be problematic for the population of children with SLI as a whole. The effect size for group difference can be considered moderate (eta^2=.1164) (Cohen, 1988). This strength of the effect size, in conjunction with a continuous distribution, suggests that deficits are not just attributable to a subgroup of poor learners (c.f. Kiernan & Gray, 1998).

Furthermore, there were also moderate effects for the lexical labeling portions of the fast mapping task. The effect size for the lexical labeling portion of the task was even stronger than for the semantic attribute portion ($eta^2 = .1638$). The portions of the task involving linguistic information were more difficult for the children with SLI than the nonlinguistic portions. As the effect sizes suggest, children with SLI have difficulty with the nonlinguistic aspects of fast-mapping, although it appears that their language problems are greater still. There are numerous reasons why a child might have difficulty with fast-mapping. The remaining hypotheses were set up to test some of these possibilities.

Let us consider the hypothesis that children would fast-map fewer semantic attributes when there was auditory input versus silence. Remember that the semantic mapping condition was a visual task. Visual mapping was chosen to reduce the linguistic load and render a true picture of semantic knowledge. Therefore, effects for a visual task cannot be explained directly by auditory processing. Instead, decrements in performance would be attributed to the additional demands on the children's overall processing capacity. If children with SLI had performed as well as their NL peers when they only needed to attend to a visual stimulus instead of simultaneously processing auditory and visual stimuli, we could conclude the problem was linked to the additional processing load involved with auditory input. However, the results of this study do not support that construct. Rather, there was a counterintuitive finding: one of the conditions in which the children with SLI performed significantly worse than peers with NL was in the Silent condition.

It is important to examine why this finding may have occurred, as well as discuss what it may mean. The Silence condition was different from the other three conditions; there was no auditory stimulus presented with the object. Many children (both SLI and NL) noted this difference with comments like "He's not saying anything" or "I can't hear it." It is entirely possible that the children with SLI did more poorly in this condition because it was 'out-of-set.' This speaks to an effect of expectancy. When the expectations (for an auditory stimulus) of children with NL were not met, they were nevertheless able to proceed with the task successfully. However, children with SLI may have been unduly distracted by the difference of the Silent condition from the expected pattern they had noticed. This finding is similar to the results of McNamara, Carter, McIntosh and Gerken (1998). These authors found that children with SLI chose fewer correct pictures than NL peers when presented with grammatically incorrect requests (e.g. "Find was dog for me.") than when presented with grammatically correct requests (e.g. "Find the dog for me."). When the expectation of grammaticality was violated, children with SLI may have been too distracted by the difference to correctly execute the request.

One might be tempted to explain the performance difference between children with SLI and NL by assuming that children with NL have superior attention skills. Attention is certainly an important factor in learning, and particularly so in a fast-mapping context. It may be the case that children with SLI have decreased attention skills. However, the finding of the expectancy effect speaks to the fact that children with SLI are paying sufficient attention to the task to enable them to recognize a pattern to the presentation of stimuli, and be affected by deviations from that pattern.

The finding that children with SLI did not perform better when they only had to map (visual) semantic attributes in the Silence condition (versus visual plus auditory information in the other conditions) does not lend support to the generalized capacity limitation hypothesis. However, it does not refute the hypothesis because the reason for the difference in performance on that condition likely had to do with the way the experiment was set up. It would be interesting to repeat the study using a between subjects design. This way, there would be groups of randomly-assigned children who would fast-map attributes in only one condition, and a comparison between conditions, unaffected by shifts in learning context, would be possible.

Another hypothesis was that there would be a difference in performance when objects were paired with linguistic versus non-linguistic stimuli. However, there was no difference for fast-mapping of visual semantic attributes when these conditions were compared. This could be because there truly is no difference for children who are fast-mapping semantic attributes. This interpretation makes sense for children with NL. As a group, they tend to learn words well and easily under many different conditions. However, it is more surprising for children with SLI. The interference hypothesis would predict that it was the linguistic input was differentially interfering with the processing of semantic attributes. That was not the case. However, children with SLI still perform worse than peers with NL overall. This lack of difference in the linguistic/non-linguistic contrast coupled with an overall worse performance from the children with SLI would be support for a generalized deficit theory. In other words, for children with SLI, the nature of their deficits is not truly 'specific' to language, but rather more general. Certainly there is support in the literature for that belief (c.f. Hill, 2001; Leonard, 1998; Trauner et al., 2000). However, before this idea is explored in more depth, it is important to consider the effects of phonological frequency.

Children with SLI performed more poorly than their peers in the Phonologically Infrequent condition but not in the Phonologically Frequent condition. This finding offers some support for the linguistic interference theory. Linguistic (and in particular, phonological) input may hamper a child's ability to process semantic attributes as a result of a child's limited capacity for simultaneous processing of linguistic and nonlinguistic information. The next question to ask is: why didn't a difference emerge in the Phonologically Frequent condition? The literature provides support for the idea that high frequency sequences of phonemes are easier to process than low frequency sequences (Gathercole, Frankish, Pickering, & Peaker, 1999; Gathercole & Pickering, 1999; Vitevich, Luce, Charles-Luce, & Kemmerer, 1997). Sequences of phonemes with high phonotactic probability may be overlearned or eventually become second nature in children with SLI. A child who demonstrates facility with high frequency sequences of phonemes likely has a well-established representation of the basic phonological patterns of his or her language. However, phonology is not the only aspect of language processing. Neighborhood density, a lexical measure, interacts with phonological frequency (Storkel & Morissette, 2002;Vitevich & Luce, 1998). A word that is phonologically frequent alone may be processed quickly, but if it also has a high neighborhood density, processing time will increase (Roodenrys & Hinton 2002; Vitevich & Luce, 1998). Because the neighborhood density of the nonwords in this study was controlled (the majority of these non-words had no neighbors), the burden of additional lexical processing was removed. Therefore, it seems that children with SLI are sensitive to phonology, and are able to process familiar phonological sequences with relative ease. However, when phonological sequences are unfamiliar, children with SLI do not process them as well as children with NL. One possibility is that children with SLI may have a poorly established representation for the breadth of English phoneme combinations. The difficulty of processing these infrequent phoneme patterns may use up a substantial portion of their limited processing capacity and interfere with their ability to process semantic information. The finding that a group difference only showed up on the more difficult (infrequent) task is in line with other findings in the literature (Ellis-Weismer & Hesketh, 1996, 1998). Remember that when discussing the effect of perceptual salience on word learning, many of the effects of salience did not manifest until a task reached a certain level of difficulty.

The phonological effect on semantic mapping also was found for mapping lexical labels. Not only were there group differences on this task (NL>SLI), but there was a group x condition x foil interaction. In both the Phonologically Frequent and Phonologically Infrequent conditions, children with NL were able to eliminate incorrect options on the name recognition task. They did not always recognize the real label for the object, but they knew what it was not called. However, children with SLI showed no identifiable pattern of response in terms of lexical labeling. In other words, children with NL appeared to be reacting to the phonology of the label, whereas the children with SLI did not. Alternatively, children with SLI may have reacted to the phonology of the label, but did so with less accuracy than their NL peers. This finding is a replication of Alt et al. (submitted).

At first there seems to be a mismatch between the implications of these findings. Above, it was noted that children with SLI had adequate representations of frequent phonological patterns. This statement was made in light of the fact that children with SLI processed phonological information without the phonological processing load interfering with their mapping of visual semantic information. However, for the lexical labeling task, children with SLI performed poorly on the phonological portion of the task in both the frequent and infrequent conditions. Does that mean that their representation of phoneme sequences was not adequate after all? It may depend on the demands. Their phonological representation appears to be adequate when the demand is to simply listen to a sequence of phonemes (semantic attribute task). However, when asked for more information about that phoneme sequence (name recognition task) the representation may be inadequate. The limited capacity theory is again relevant at this point. The name recognition portion of the task came after the questions about semantic attributes. It could be the case that the child's processing capacity had been used up during the semantic portion of the task and that there were limited resources left for the more in-depth phonological processing. A final alternative is that the phonological representations of the familiar sequences are adequate, but the child's phonological memory is inadequate.

The final hypothesis was that there would be a correlation between the fast mapping task and at least one of the phonology tasks. There was a significant correlation for nonword repetition and of both the semantic attributes and lexical labeling components of the fast-mapping task. This finding is in agreement with many of the other findings in the literature indicating nonword repetition is related to word learning (Bowey, 1996; de Jong, Seveke, & van Veen, 2000; Gathercole & Baddeley, 1989; Gathercole, Hitch, Service, & Adams, 1997; Gathercole & Pickering, 1999; Gathercole, Service, Hitch, Adams, & Martin, 1999, Michas & Henry 1994, Schwartz & Leonard, 1982). It is particularly interesting that the task correlated not only with the lexical labeling portion of the task, but also with the visual semantic attribute portion. If nonword repetition were a unidimensional index of phonological memory (as described by the phonological loop), a finding of shared variance with a visual semantic task would be unexpected. Therefore, one interpretation is that nonword repetition is indeed, more than a strict measure of phonological memory. It could possibly be a measure of phonological representation (which could interfere with semantic mapping as discussed above) or knowledge of lexical characteristics. (Recall the relationship between nonword frequency and neighborhood density.) Processing of a novel word or nonword can rely on both lexical and phonological information (Storkel and Morrisette, 2002). Either of these characteristics would raise the level of processing demands when children simultaneously encounter new visual objects and their labels.

There was no significant correlation between the phonological sensitivity task and any portion of the fast-mapping task. It is possible that there is no shared variance between these two tasks. However, a more likely explanation is that this particular task did not discriminate well, and therefore the scores on the task were not representative of the children's true phonological sensitivity. This particular task was prone to guessing. Several children chose a strategy of always giving the same answer. This enabled them to get correct scores for half the questions although they clearly did not understand the task. A different (or re-designed) version of this task might provide better evidence on the relationship between phonological sensitivity and word learning.

The Nature of Word Learning

The data from this study can address the more specific issue concerning the nature of word learning. One issue that emerges from the literature is the need for an understanding of the relationship between the components of word learning. Specifically, how do phonological, lexical, and semantic components interact when children are learning words? [3]

The literature has established a link between phonological and lexical processes affecting one another during word learning. Connections have also been found between semantic and lexical processes (McGregor et al., 2002). Phonology is related to lexical and semantic performance, and lexical and semantic performance are related to one another. Lexical, semantic and phonological processes seem to blend well for children with NL and result in effective word learning. However, for children with SLI, the process of word learning appears to be vulnerable to both linguistic and non-linguistic threats.

Given this scenario, it may be clinically important to assess word knowledge beyond the scope of lexical labels. Children who demonstrate adequate lexical knowledge may have inadequate semantic knowledge. Also, since phonology seems to have a direct impact on lexical and semantic knowledge for children with SLI, it would be interesting to explore therapy techniques that incorporate all three processes. Finally, the data support the notion that children with SLI have deficits beyond the scope of language. This idea is certainly not new. However, if this notion is embraced, it may help those who work with children with SLI to look beyond linguistic deficits to see what other aspects of learning contribute to language learning.

Although this study has clearly not unraveled the complicated nature of word learning, it seems to have made clear the interconnected nature of semantic, lexical, and phonological information that go into word knowledge. Future inquiry into word learning needs to take these different processes (and their possible effects on one another) into consideration. Discussions of word learning that limit themselves to one domain of word knowledge should do so intentionally, and not as a result of oversight. Likewise, clinical consideration of word learning must incorporate semantic, lexical,

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[3] Although syntax is undoubtedly part of word learning, it was not addressed as part of this study, and

and phonological assessments to make sure children with SLI have word knowledge that is sufficient for academic and communication success.

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therefore will be excluded from the discussion.

APPENDIX A

Additional Statistics

Group Performance on Nonword Repetition Task

	SLI N	NL N	SLI Mean	NL Mean	SLI Std.Dev.	NL Std.Dev.	SLI Min	NL Min	SLI Max	NL Max
% Total Words Correct	22	23	31.39	58.55	17.49	19.73	0.00	0.00	68.75	81.25
%1	22	23	88.63	95.29	12.74	10.61	58.33	58.33	100.00	100.00
%2	22	23	81.59	93.19	14.30	10.25	40.00	53.33	100.00	100.00
%3	22	23	69.58	88.22	17.26	12.13	28.57	57.14	92.85	100.00
%4	21	22	61.57	76.34	16.82	13.18	30.55	41.66	88.88	97.22
% Total Syllables Correct	22	23	71.45	85.86	12.30	9.80	42.70	62.50	91.60	97.91

Group Difference on Nonword Repetition Task

T-Test for Independent Samples

Dep. Var.	t	df	2-Tailed p
% Total Words Correct	4.87893	43	0.000015
%1	1.907507	43	0.0631483
%2	3.138475	43	0.003065
%3	4.205791	43	0.0001295
%4	3.212081	41	0.0025654
% Total Syllables Correct	4.356077	43	0.0000807

Group Performance on Phonological Sensitivity Task

	SLI N	NL N	SLI Mean	NL Mean	SLI Std. Dev.	NL Std. Dev.	SLI Min	NL Min	SLI Max	NL Max
Phonological Sensitivity	23	23	5.174	5.696	1.466	1.55	3	3	8	9

Group Difference on Phonological Sensitivity Task

T-Test for Independent Samples

Dep. Var.	t	df	2-Tailed p
Phonological Sensitivity	1.173	44	0.24726

Correlation Matrix for Study Variables

	1	2	3	4	5	6	7	8	9	10
1	1	-0.05438	-0.49747	-0.15613	-0.59693	-0.53988	-0.55333	-0.43559	-0.42528	-0.38024
	p< .000	p< .723	p< .001	p< .306	p<0.000	p<0.000	p<0.000	p< .003	p< .004	p< .010
2	-0.05438	1	0.46517	0.15711	0.2299	0.29809	0.31669	0.50485	0.45183	0.47327
	p< .723	p< .000	p< .001	p< .303	p< .129	p< .047	p< .034	p<0.000	p< .002	p< .001
3	-0.49747	0.46517	1	0.16851	0.40387	0.45744	0.44235	0.73881	0.60384	0.73811
	p< .001	p< .001	p< .000	p< .269	p< .006	p< .002	p< .002	p<0.000	p<0.000	p<0.000
4	-0.15613	0.15711	0.16851	1	0.17117	0.16459	0.15168	0.24657	0.22535	0.22744
	p< .306	p< .303	p< .269	p< .000	p< .261	p< .280	p< .320	p< .103	p< .137	p< .133
5	-0.59693	0.2299	0.40387	0.17117	1	0.71981	0.82506	0.30825	0.32666	0.2487
	p<0.000	p< .129	p< .006	p< .261	p< .000	p<0.000	p<0.000	p< .039	p< .029	p< .099
6	-0.53988	0.29809	0.45744	0.16459	0.71981	1	0.88626	0.33392	0.30516	0.30803
	p<0.000	p< .047	p< .002	p< .280	p<0.000	p< .000	p<0.000	p< .025	p< .042	p< .040
7	-0.55333	0.31669	0.44235	0.15168	0.82506	0.88626	1	0.29184	0.23755	0.29233
	p<0.000	p< .034	p< .002	p< .320	p<0.000	p<0.000	p< .000	p< .052	p< .116	p< .051
8	-0.43559	0.50485	0.73881	0.24657	0.30825	0.33392	0.29184	1	0.89651	0.93624
	p< .003	p<0.000	p<0.000	p< .103	p< .039	p< .025	p< .052	p< .000	p<0.000	p<0.000
9	-0.42528	0.45183	0.60384	0.22535	0.32666	0.30516	0.23755	0.89651	1	0.68368
	p< .004	p< .002	p<0.000	p< .137	p< .029	p< .042	p< .116	p<0.000	p< .000	p<0.000
10	-0.38024	0.47327	0.73811	0.22744	0.2487	0.30803	0.29233	0.93624	0.68368	1
	p< .010	p< .001	p<0.000	p< .133	p< .099	p< .040	p< .051	p<0.000	p<0.000	p< .000

1=Diagnosis
2=Age in Months
3=K-ABC
4=Phonological Sensitivity
5=Percentage of Nonwords repeated correctly
6=Percentage of syllables repeated correctly for 3-syllable nonwords
7=Percentage of total syllables repeated correctly
8=Overall Fast-Mapping
9=Overall Name Recognition
10=Overall Semantic Attribute

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