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Morphosyntactic cues to verb comprehension for typically developing toddlers and children with specific language impairment

Brenda L. Beverly

To the Graduate Council:

I am submitting herewith a dissertation written by Brenda L. Beverly entitled "Morphosyntactic cues to verb comprehension for typically developing toddlers and children with specific language impairment." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Speech and Hearing Science.

Lori A. Swanson, Major Professor

We have read this dissertation and recommend its acceptance:

Pearl Gordon, Harold Peterson, Stephen Handel

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Morphosyntactic Cues to Verb Comprehension for Typically Developing Toddlers and Children With Specific Language Impairment

A Dissertation
Presented for the
Doctor of Philosophy Degree
The University of Tennessee, Knoxville

Brenda L. Beverly
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Dedication

This dissertation is dedicated to my parents: to the memory of my father, Bennett Beverly, who taught me faith in God, and to my mother, Barbara Beverly, who taught me faith in myself.

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Abstract

Function morphemes assist typically developing (TD) children in segmenting speech, identifying syntactic categories, and mapping meaning onto words, yet function morphemes pose particular difficulty for children with specific language impairment (SLI). This investigation examined the effect of morphosyntactic context on verb comprehension for two groups of telegraphic speakers at the same expressive language stage as measured by mean length of utterance (MLU). The following two research questions were posed. Do young telegraphic speakers show increased verb comprehension given sentences containing a grammatical morpheme compared with sentences containing an ungrammatical morpheme, a nonsense syllable, or no morpheme? Do children with SLI differ in verb comprehension for sentences with varying morphosyntactic contexts when compared with younger, MLU-matched TD children?

Two MLU-equivalent groups participated, 16 TD children (age = 26 mos.) and 16 children with SLI (age = 48 mos.). Similar to Gerken and McIntosh (1993), a picture selection task was used to test verb comprehension in 4 contexts: grammatical auxiliary (Who is pushing?); omitted auxiliary (Who ϕ pushing?); ungrammatical morpheme (Who in pushing?); and nonsense syllable (Who id pushing?). Auditory stimuli were digitally edited to control duration and naturalness.

Experimental manipulation of "is" did not result in significant differences across morpheme contexts for either group. Verb comprehension probably was supported by verb lengthening associated with utterance-final position. Verbs also were marked by morpheme -ing. This morphosyntactic cue (i.e., morpheme -ing) may have aided verb

comprehension regardless of auxiliary "is" variation. Findings suggest function morphemes are only one among many input cues available to language learners during comprehension, including prosodic, phonological, and contextual cues.

Children with SLI had significantly higher verb comprehension than TD children across morpheme contexts. Group differences favoring children with SLI (e.g., chronological age and receptive language) may explain this finding. Despite morpheme anomalies, children with SLI demonstrated verb comprehension when the input cues were redundant and correlated with meaning. Discrepancies between these results and report of a grammaticality effect by McNamara, Carter, McIntosh, and Gerken (1998) are relevant to theories of SLI regarding limited processing capacity and memory limitations.

TABLE OF CONTENTS

CHAPTER PAGE

CHAPTER PAGE

CHAPTER PAGE

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

Chapter 1

Introduction and Review of the Literature

Introduction

Art of Language Acquisition

It is well known that language is both rule-governed and highly creative. Language requires exposure to be learned, yet children learn the ambient language without formal instruction by care givers. Beyond these facts, there exists controversy regarding the process of language acquisition and the role of speech input.

Much of the current controversy still can be summed by reviewing the major concerns framed by Gleitman and Wanner's 1982 discussion of the "state of the art." Language development research continues to focus upon three vital tasks of acquisition (Hirsh-Pasek & Golinkoff, 1996). One task is perception of the environment in linguistically salient ways, such that objects are observed as different from actions. A second is the ability to organize unsegmented speech input into phrases, words, syllables and phonemes. Representation of input in a manner which maps real-world events to linguistic units is a third task faced by language learners.

Investigations of the development of syntactic knowledge continue to question the relative contributions of early exposure and learning compared with innate, and possibly specialized processes. Regardless of the model of acquisition to which one subscribes, any account must ultimately explain how the input and the child converge such that most young children exhibit near adult levels of grammatical competence. Specifically, a complete picture of language development must include knowledge of how unsegmented speech input relates to syntactic categories and grammatical proficiency.

Typical Development from Two to Three Years of Age

The process of language acquisition is nothing short of miraculous because the majority of children demonstrate considerable skill in perception, segmentation and representation by age 3, and basic syntactic knowledge is acquired between 2 and 3. Children start this period of development with the beginnings of combinatorial language, simple telegraphic sentences that consist of content words (e.g., nouns, verbs) without inflection or function words (e.g., verb tense suffixes, articles). Before their fourth birthday, young language learners have begun to produce complex, adult-like constructions. For example, 3-year-olds use mature noun phrases incorporating articles and modifiers. Verbs often are marked by regular-tense suffixes, and children begin to use copula and auxiliary forms. Questions and more complex forms for expressing negation emerge. Incredibly, linguistic development during this period moves children from telegraphic speakers to relatively sophisticated users of the adult grammar.

Specific Language Impairment

For one group of language learners, children with specific language impairment (SLI), language acquisition and grammatical competence prove more challenging. SLI has been defined as a significant lag in language acquisition despite normal development in the areas of cognition, peripheral hearing, and social-emotional and behavioral skills (e.g., Stark & Tallal, 1981; Watkins, 1994). These children, who initially exhibit delayed language development, begin their second year with a greatly restricted vocabulary and no word combinations. Most striking, English-speaking children with SLI show protracted periods of telegraphic speech with severe deficits in morphology (e.g., Leonard, 1989, 1994; Leonard, Bortolini, Caselli, McGregor, & Sabbadini, 1992; Leonard, Eyer, Bedore, & Grela, 1997).

Function Morphemes: An Essential Ingredient

Function morphemes have received increasing attention because of their ability to assist researchers in understanding language acquisition for both typically developing (TD) children and children with SLI. Function morphemes are a universal syntactic category distinguishable from content words, and include, in English, elements marking tense and aspect, conjunctions, determiners, prepositions and pronouns (Morgan, Shi, & Allopenna, 1996). In normal development, function morphemes are presumed to play a role in the acquisition of syntax, specifically for speech segmentation and the identification of syntactic categories such as noun and verb (Gerken & McIntosh, 1993; Golinkoff, Hirsh-Pasek, & Schweisguth, in press; Hirsh-Pasek & Golinkoff, 1996; Maratsos & Chalkley, 1980; Morgan et al., 1996). Function morphemes also are known to pose extreme difficulty for children with SLI relative to other areas of linguistic deficit (e.g., Leonard, 1994; Leonard, Bortolini, et al., 1992; Leonard & Eyer, 1996). Thus, the investigation of young children's comprehension of function morphemes promises to contribute importantly to advancing knowledge of language development.

The purpose of this investigation was to examine the effect of a grammatical function morpheme "is" compared to an ungrammatical morpheme "in," a nonsense syllable "id," and an omitted morpheme context on verb comprehension by telegraphic speakers. Of interest was whether a difference for verb comprehension and sentence processing would be observed between TD toddlers and preschoolers with SLI. Results revealing the role of function morphemes should increase understanding for the process of comprehension and syntax acquisition in typical language learners and for the nature of these processes in children with language impairment.

Function Morphemes and Development of Syntax

It is suspected that function morphemes assist the typical language learner in the tasks of segmenting the speech stream and mapping meaning onto linguistic units (Gerken & McIntosh, 1993; Gleitman & Wanner, 1982; Morgan et al., 1996). It has been argued that function morphemes can aid the language learner in segmenting the speech stream, because they co-occur with cues to phrase boundaries (e.g., Gerken & McIntosh, 1993; Morgan, 1986). For instance, function morphemes are known to occur consistently in either the initial or final positions of phrases within languages. In English, freestanding function morphemes occur phrase-initially. Function morphemes also are important prosodic markers within the English sentential stress pattern because function morphemes generally are unstressed while content words contain stressed syllables and receive focal emphasis.

Additionally, researchers have suggested that function morphemes might guide language learners in the discovery of phrasal categories, such as noun phrase as distinct from verb phrase (Gerken & McIntosh, 1993; Maratsos & Chalkley, 1980; Morgan et al., 1996). The child might notice the co-occurrence of articles before nouns (e.g., a ball, the dog), auxiliaries before verbs (e.g., is jumping) and syllabic suffixes following verbs (e.g., barking) and apply this knowledge to new word learning or sentence comprehension (Gelman & Taylor, 1984; Gerken, 1994; Gerken & McIntosh, 1993;

Golinkoff et al., in press; Katz, Baker, & Macnamara, 1974; Landau & Gleitman, 1985; Naigles, 1990).

It is difficult to conceive of syntactically naive language learners utilizing cues from function morphemes, especially when they show limited or no function morpheme production. Researchers, therefore, have speculated that children do not perceive or comprehend them (e.g., Gleitman & Wanner, 1982; Leonard, 1989). This assumption led to alternative proposals that stress the use of semantic cues in the acquisition of language and specifically for labeling syntactic categories (Pinker, 1987). Contrary to semantic hypotheses, several studies have revealed that young TD children perceive function morphemes in sentence contexts (Gerken & McIntosh, 1993; Golinkoff et al., in press; Leder & Egelston, 1981; Petretic & Tweney, 1977; Shipley, Smith, & Gleitman, 1969; Shady & Gerken, 1999). In these studies, children as young as 18 months of age who had just begun to form two-word combinations demonstrated improved comprehension for utterances presented with adult syntax when compared to telegraphic utterances or utterances in which the function morphemes were replaced by nonsense words. These results suggest that young children who do not yet produce function morphemes may be capable of perceiving and using function morphemes for sentence level processing and comprehension.

An alternate conclusion can be drawn from these same results. That is, children may simply be sensitive to the prosodic regularities of the language (Gerken & McIntosh, 1993; Jusczyk & Kemler Nelson, 1996; Morgan & Saffran, 1995). Impaired comprehension for telegraphic utterances or modified sentences compared to adult-syntax might be associated with disrupted prosody; but perhaps, morphological elements and syntactic phrases cue the language learner.

Function Morphemes Provide Cues to Meaning

Studies have indicated that TD toddlers map meanings onto novel words when the new words are presented within specific syntactic frames (Gelman & Taylor, 1984; Katz et al., 1974; Landau & Gleitman, 1985; Naigles, 1990). It appears that young children who are not yet producing sentences are affected by sentence-level syntactic cues when attempting to learn new words. Thus, children appear to be sensitive to at least some of the properties of function morphemes.

Recent research has provided increasing evidence that young children are aware of the distributional relationships between both free and bound morphemes and their associated phrases within sentences (Gerken & McIntosh, 1993; Golinkoff et al., in press; Shady, 1997). Gerken and McIntosh found that TD children, with a mean age of 25 months, showed better noun comprehension for sentences which contained the grammatical article (e.g., Find the bird for me) rather than an ungrammatical auxiliary (e.g., Find was bird for me) or a nonsense syllable (Find gub bird for me). Likewise, Golinkoff et al. concluded that children between 18 and 20 months were sensitive to the presence of bound morphemes, such that comprehension for verbs was improved for sentences containing the verb stem plus -ing versus contexts in which the verb was incorrectly marked with -ly or -lu. These investigations, which used two different comprehension assessment procedures, found that TD 2-year-olds show improved content word comprehension for sentences which contain grammatical function morphemes when compared to sentences in which an ungrammatical morpheme or nonsense syllable is substituted.

Function Morphemes Interact With Other Input Cues

Gerken and McIntosh (1993) concluded that successful noun comprehension for adult syntax sentences by telegraphic speakers was facilitated through a blend of prosodic information (higher and more exaggerated pitch) and syntactic information (the use of a function morpheme). They speculated that a higher pitch with wider pitch excursions as observed in child-directed speech (CDS) assisted the children in phrase segmentation thereby reducing the processing load for distributional analysis of the function morpheme. The idea that comprehension is benefitted by multiple cues in the input is predicted in a model of comprehension proposed by Hirsh-Pasek and Golinkoff (1996). Their coalition-of-cues model of comprehension suggests that "relatively regular and redundant mappings between prosodic, semantic, and syntactic units [will be needed] to comprehend words and sentences" (p. 177) when children's comprehension is still "fragile" (Hirsh-Pasek & Golinkoff, p. 176). In fact, Golinkoff et al. (in press) were careful in their investigation of 1-year-olds to maintain multiple cues in the input by creating video depictions for maximum extralinguistic support and by using a child-directed prosody for auditory stimuli.

In summary, there is evidence that TD children are sensitive to morphosyntactic contexts of sentences at a young age (Gerken & McIntosh, 1993; Petretic & Tweney, 1977). Indeed, TD children are capable of employing sentence contexts, especially function morphemes, in the acquisition of novel noun and verb meanings (Gelman & Taylor, 1984; Katz et al., 1974; Naigles, 1990). Their knowledge also appears to extend to a relatively accurate representation of the distributional relationships between function words and syntactic phrases such that the presence of an ungrammatical or nonsense morpheme disrupts sentence comprehension.

Children With SLI and Function Morpheme Cues

Understanding language acquisition and comprehension for telegraphic TD children is enhanced by including a group of telegraphic speakers with SLI. English-speaking children with SLI exhibit severe difficulty with morphological production; such that, they often demonstrate a protracted period of telegraphic speaking beyond expectations for their age or language stage (e.g., Leonard, 1989; Leonard, Bortolini, et al., 1992). Like young TD children, it is difficult to conceive of children with SLI utilizing function morphemes to discover word meanings and syntactic categories. Two studies have investigated SLI children's sentence comprehension in varying syntactic contexts (Leder & Egelston, 1981; McNamara, Carter, McIntosh, & Gerken, 1998). Results suggested that children with SLI, like young TD children, are sensitive to function morphemes in sentences.

Purpose of Present Investigation

This study endeavored to extend the findings of Gerken and McIntosh (1993), Golinkoff et al. (in press), and McNamara et al. (1998) for TD toddlers and children with SLI by shifting the focus to the verb phrase and to the auxiliary "is" in a sentence context, "Who is verbing?". As in Gerken and McIntosh's investigation, four different morpheme contexts were tested: the grammatical morpheme "is," the ungrammatical morpheme "in," a nonsense syllable "id," and omission of the function morpheme. Two other modifications were made in an attempt to control for extraneous factors given the "coalition-of-cues." First, linear predictive coding (LPC) synthesis was used to create the auditory stimuli. Unlike many previous studies that relied upon live voice (e.g., Golinkoff et al., in press; Petretic & Tweney, 1977) synthesized stimuli result in greater control over prosodic variables during administration. Also, LPC synthesis is considered to be highly intelligible and natural compared to rule-based synthesized speech (e.g., DECTalk).

Secondly, the ungrammatical morpheme "in" and the nonsense syllable "id" were selected to maintain the general phonological characteristics of function morphemes and to be equivalent with the target word in this study (i.e., "is"). Although the nonsense syllable, "gub," used by Gerken and McIntosh (1993) and McNamara et al. (1998) had the same vowel as the other morphemes (i.e., "the" and "was"), the syllable shape and consonants may have resulted in perception of a content word by the children.

The second group of language learners, children with SLI, participated in this study to investigate their ability to perceive and utilize function morphemes for sentence comprehension. Prior research suggested that children with SLI, like TD children, are capable of perceiving and using information provided by function morphemes in sentence contexts, such that they show improved comprehension for adult-syntax contexts (Leder & Egleston, 1981; McNamara et al., 1998). Children with SLI, however, performed more poorly than their age-matched peers. An important question remained: Do preschoolers with SLI show a significant difference in sentence comprehension for varying morphological contexts when compared to younger TD peers? If children with SLI show poorer comprehension than younger TD children who are at the same expressive language level, then theories that hypothesize a perceptual or processing weakness for low phonetic substance morphemes as a contributor to the severe morphological deficits seen in individuals with SLI (e.g., the surface account, see Leonard, 1989, 1994) would be supported. To investigate this question, two groups of children participated in the present study, and they were matched for the linguistic variable most closely associated with telegraphic speech, mean length of utterance (MLU). Of particular interest was the level of comprehension demonstrated by children with SLI when compared to younger TD peers.

Review of the Literature

Child-Directed Speech: Input Contains Cues

Studies have revealed manifest differences between child-directed speech (CDS) and adult-directed speech (ADS) across several languages (e.g., Ferguson, 1964; Fernald et al., 1989; Kuhl et al., 1997). Input for children learning English has been found to contain more simple declarative sentences, a reduced MLU, and increased pause durations (Broen, 1972). Acoustic analysis of English CDS has revealed the presence of highly exaggerated prosody (Fernald et al., 1989). Furthermore, Fernald and Mazzie (1991) reported that mothers of 14-month-old infants not only had wider pitch excursions when talking to their children than when talking to an adult, but key words in the mothers' utterances tended to occur on exaggerated pitch peaks and in the utterance-final position. These and other studies provide evidence that CDS contains cues which could allow infants to begin to analyze language. Fernald and her colleagues proposed that the characteristics of CDS serve to arouse the attention of the infant and also to assist in parsing and in the development of syntactic knowledge. Kuhl et al. (1997) stated that language input provides a "rich and detailed source of information" for the language learner in the process of linguistic mapping (p. 686).

One obstacle is the variable nature of the speech signal with linguistic mappings that are many to one. There is, however, less variability overall in CDS than in ADS which could serve to increase cue reliability for highlighting important elements of the signal (Cross, 1981; Ratner, 1996). For example, CDS is characterized by generally fluent utterances with fewer revisions than ADS (Cross, 1981). Research also has shown that mothers speaking in three languages produced vowels that were acoustically more distinct when talking to their 2- to 5-month-old infants than in ADS (Kuhl et al., 1997). Moreover, the vowels of function morphemes are produced more clearly in speech to 1-year-olds who are beginning to use combinatorial speech (i.e., MLUs between 2.0 and 3.0) than in ADS (Ratner, 1985). In another report, Ratner (1986) shared findings that mothers of preverbal children (i.e., 9 to 13 months) doubled the vowel durations for words in clause-final position whereas mothers of older children did not produce comparable vowel lengthening. Not only is there less variability in CDS, Ratner (1996) has suggested that the input may be systematically manipulated across the child's development.

It is not sufficient to show that cues exist in the input; it is also necessary to demonstrate that infants are able to perceive these cues. Studies have shown that infants prefer speech which is directed to them rather than toward adults. Fernald and Kuhl (1987), in a head-turning procedure, found a strong preference by 4-month-old infants for speech which was derived from frequency contours characteristic of CDS rather than ADS. Very young infants also begin to demonstrate preferences for features of their ambient language, including pauses located at clause boundaries. Kemler Nelson, Hirsh-Pasek, Jusczyk, and Cassidy (1989) found that 7- to 9-month-old infants learning English preferred speech which contained interruptions consistent with clause boundaries in English rather than interruptions that did not occur at clause boundaries. Infants also have been found to prefer the stress patterns for two-syllable words which are predominant in English (i.e., trochaic or strong-weak), and words that have been previously presented in sentence contexts (e.g., Jusczyk, Cutler, & Redanz, 1993; Jusczyk & Kemler Nelson, 1996). These findings suggest that sentential cues not only exist, but that they are available for use by infants as they begin to segment the speech stream and discover syntactic units.

Unique Role of Function Morphemes

Function Words and Content Words

In addition to the prosodic information of CDS, languages appear to have syntactic structures that could guide the language learner. For example, all languages have a grammar which incorporates open-class and closed-class elements. Open-class terms are generally equivalent to content words (i.e., nouns, verbs, and adjectives, etc.) whereas closed-class terms are function morphemes (e.g., pronouns, articles, verb suffixes, etc.) which carry information about word relationships and grammar (Cutler, 1993; Hirsh-Pasek & Golinkoff, 1996; Morgan et al., 1996). Function morphemes are considered closed-class because new function morphemes cannot be easily added to the language. In contrast, open-class words such as nouns and verbs are easily and frequently created (e.g., e-mail, rollerblades, and downsizing). These categories are of central importance to linguistic theories of syntax and are increasingly relevant to theories of child language acquisition.

Function and content words can be distinguished in languages on the basis of corresponding sets of phonological cues, and they serve very distinct purposes semantically and syntactically (Morgan et al., 1996). Function morphemes are differentiated from content words by features of "minimalness" according to Morgan et al. Function morphemes have reduced vowels; that is, they tend to have unstressed central vowels that are nondiphthongized. In addition to being unstressed, the syllables of function morphemes are short, often with a null or single phoneme onset and coda. And, function morphemes are often cliticized (e.g., he's for he is) losing even their syllabicity.

Beyond these phonological differences, function and content words have distinct identities. Within a language, individual function morphemes are fewer in number than content words. Despite this, or perhaps because of it, function morphemes occur with greater frequency than content words comprising almost half of all words in any discourse (Cutler, 1993; Morgan et al., 1996). This characteristic of high frequency for a few exemplars makes it possible for listeners to predict occurrence from context (e.g., "the" clearly completes the utterance, "Put _ bowl here"). Semantically, function morphemes carry little of the message and tend to have highly constrained meanings. In combination, these unique characteristics distinguish function morphemes from content words and suggest that the ability to categorize function and content words is a vital skill for syntactic development.

Language Acquisition and Function Morphemes

One way the distinction between function and content words can facilitate syntactic knowledge is the cue that function morphemes provide for phrase segmentation because they routinely occur in either phrase-initial or phrase-final position in languages (Morgan, 1986). In English, free-standing function morphemes occur phrase-initially (e.g., the boy; is running.) thereby marking the syntactic phrase boundary and contributing to phrase bracketing within an utterance (Morgan, 1986; Morgan et al., 1996). Phrase structures are associated with individual function morphemes and classes of content words. For example, noun phrases are characteristically identified by articles (e.g., a dog) and prepositions (e.g., to the house). Verb phrases are often signaled by an auxiliary verb (e.g. is playing) and final position, bound morphemes (e.g., is playing). The classes of content words, or syntactic categories, may be efficiently separated simply by attending to the co-occurring function words that appear as "phrase-mates" (Morgan et al., 1996, p. 280; see also Hirsh-Pasek & Golinkoff, 1996; Maratsos & Chalkley, 1980).

Knowledge of syntactic categories not only is imperative for the development of adult grammar, it also can assist the child in mapping meaning onto words. It is apparent that the task of learning new words is hampered by the presentation of new vocabulary within an unsegmented utterance. If the child perceives that nearly half of the words are function morphemes, then the number of possible mappings is greatly reduced (Morgan et al., 1996). Morgan et al. propose that this constraint on word learning, although insufficient for vocabulary development without contextual meaning, can make an important contribution to language acquisition. Furthermore, studies have shown that young children are capable of determining whether nonsense words are common nouns or proper nouns based on the presence of the article (Gelman & Taylor, 1984; Katz et al., 1974). Function morphemes may thus provide cues to aspects of meaning for many word classes and individual lexical items. In summary, the distinction between function and content words may affect at least three important aspects of language development: speech stream segmentation through phrase bracketing, identification and classification of syntactic categories, and vocabulary acquisition. Thus, function morphemes likely play a critical role in the development of sentential grammar by providing the language learner a leg up in the acquisition of adult syntax.

Bootstrapping to Syntax

Given that relatively reliable cues exist in languages (e.g., function versus content words) and in CDS (e.g., exaggerated prosody, more distinct vowels) and that children are capable of perceiving these cues, it has been hypothesized that children use these cues in the direct discovery of syntactic information contained in the input. Multiple theories based on these premises have been proposed and are known collectively as "bootstrapping" theories (for reviews, see Bedore & Leonard, 1995; Morgan & Demuth, 1996). The notion of bootstrapping is based on the idea that young language learners may utilize the input to pull themselves "up by their bootstraps" into adult syntactic knowledge. Bootstrapping theories seek to explain how the input drives the infant forward into language development without formal training. Individual researchers have often been associated with one or another theory of bootstrapping which emphasizes the types of cues (i.e., semantic, prosodic, syntactic or stochastic) responsible for the child's progress.

Semantic Bootstrapping

The theory of semantic bootstrapping places maximum importance on the child's ability to isolate and match linguistic units to real-world events. Pinker (1987) reviewed four basic assumptions of this model for lexical acquisition and the development of syntactic categories: (a) children can learn meaning without grammar; (b) context and individual word meanings may assist the child in forming semantic representations of input sentences; (c) syntactic categories have universal connections to meaning, such that names are universally nouns; and (4) CDS is a special form of input which contains the above regularities accompanied by prosodic properties. This last assumption represents a modification of earlier semantic bootstrapping proposals by Pinker. In his 1987 revision, Pinker concedes that a viable model of language acquisition must include various input cues. In general, however, proponents of semantic bootstrapping have assumed that syntactic categories are easily perceived and therefore learned from extralinguistic meanings (Bates & MacWhinney, 1982; Pinker, 1987).

Phonological Bootstrapping

The research of Morgan and his colleagues (Morgan, 1986; Morgan, Meier, & Newport, 1987, 1989; Morgan et al., 1996) has been closely associated with prosodic bootstrapping accounts of language acquisition. (More recently, this has been termed phonological bootstrapping [Morgan & Demuth, 1996].) This model emphasizes prosodic regularities (e.g., pause, duration, and fundamental frequency) as well as segmental aspects (i.e., phonetic, phonotactic, and stochastic patterns) that are evident in the input. Such prosodic and phonological cues promote perceptual analyses of speech and possibly lead to lexical and syntactic knowledge (Morgan & Demuth, 1996). Again, the model incorporates cues which are semantic in nature despite its focus on the prosodic information. Recent research by Morgan and Saffran (1995), in fact, has highlighted the integration of sequential segmental elements with rhythmic properties in the recognition of multisyllabic word-like stimuli.

Syntactic Bootstrapping

Finally, the syntactic bootstrapping hypothesis argues that neither semantic nor prosodic cues are adequate for syntax learning, especially for verb acquisition and the formation of adult syntactic categories. An early form of this hypothesis was described by Maratsos and Chalkley (1980) in their "distributional-semantic" approach. They stated that children can analyze the patterns of morphemes (e.g., the occurrence of -ed and -ing with words that are verbs) in utterances to determine meanings and to begin to form syntactic categories. This model emphasized that language learning moves from form to meaning through the use of distributional evidence and syntactic frames. Their theory, however, also considered the role of contextual meaning, hence the term distributional-semantic.

Gleitman and Wanner (1982), also proponents of syntactic bootstrapping, granted contextual meaning a role in language acquisition and possibly in the initial formation of precursors to syntactic categories. They pointed out, however, that relationships between meaning and form are less simple and direct than many theorists had suggested. Furthermore, the assumption that syntactic categories can be formed from meaning fails to describe how the young child moves from semantically formed categories to categories required for adult syntax (Gleitman & Wanner, 1982). A discontinuous model of this type is less than parsimonious because the shift in perspective to achieve adult syntactic categories remains unexplained. Gleitman and Wanner, therefore, concluded that the initial units must be syntactic, not semantic, in conception.

The syntactic bootstrapping theory has been specifically applied to verb learning as outlined by Landau and Gleitman (1985) in their report of a blind child's language acquisition. Landau and Gleitman found that the set of subcategorization frames for the verbs "look" and "see" provided specific cues to the meanings of these verbs, including the knowledge that they are verbs of perceptual motion involving the child as actor. Thus, different syntactic frames furnished a reliable distinction between "look" and "see." For example, "look" is active, expressing activities, so it can occur in an imperative (i.e., Look!). However, "see" is a stative verb which does not occur in imperatives, but is often used to inquire about another's condition (e.g., See?). Furthermore, syntactic frames in this maternal corpus also separated the meanings of "look" and "see" from all other verbs frequently used in the input. Landau and Gleitman concluded that converging syntactic cues for each verb combined with contextual evidence led to verb learning.

<u>Cues Across Domains</u>

Although individual theories of bootstrapping have tended to emphasize a particular set of input cues believed to provide syntactic information, all models included some cross-domain cues. Pinker (1987) recognized the role of the prosodic characteristics of CDS even while stressing the use of semantic knowledge to form syntactic categories. Morgan (Morgan, 1986; Morgan & Demuth, 1996), Gleitman (Gleitman & Wanner, 1982; Landau & Gleitman, 1985), Maratsos (Maratsos & Chalkley, 1988) and their colleagues never ignored the unmistakable contribution of extralinguistic knowledge in proposals that emphasized phonological, syntactic, or distributional information. The enduring interest in these models is most likely due to their ability to view the importance of several levels of related cues. As noted by Morgan and Demuth, "the deductive consequences of these [phonological] inductions allow infants to exploit new forms of information (semantic, syntactic, or pragmatic)....access to these new forms of information paves the way for the development of more detailed linguistic representations, which then serve as bases for making more complex linguistic inductions" (p. 20).

Development of Comprehension

Hirsh-Pasek and Golinkoff (1996) stressed the importance of various cues across different domains in their model of the development of comprehension. This model describes the role of combined cues and differential cueing during various stages of language learning. Hirsh-Pasek and Golinkoff link bootstrapping hypotheses in a single model for the development of sentence comprehension and grammatical competence. They claim that the child is able to analyze input in multiple ways, with shifting areas of focus and skill. The earliest bias is for prosodic cues, changing later to a semantic focus, and ultimately to a syntactic one.

Developmental Phases in Comprehension

Hirsh-Pasek and Golinkoff (1996) offer a three-phase model, the coalition-of-cues model of language comprehension. In the first phase, the child between birth and 9 months of age is able to perceive acoustic units such that information about the ambient language is being extracted and "packaged." The Phase I child may be able to comprehend a few words, although production is rare. Simultaneously, but separately, the child is learning about the world.

Phase II, when TD children are between 9 and 24 months of age, is proposed as a time for development of segmentation and linguistic mapping abilities. In this phase, children begin to analyze within phrases and words, and to map this information onto real-world knowledge. When cues from multiple sources (phonological, semantic, syntactic) are redundant, children show sentence comprehension. In the beginning of Phase II, the child maps words to events and objects; by the end of Phase II, the child is able to map relationships or syntactic information to the meaning of utterances. Hirsh-Pasek and Golinkoff (1996) theorize that, in this phase, children discover syntactic categories.

Phase III, when the child is between 24 to 36 months, is the level of complex syntactic analysis. Unlike Phase II, the child is now able to show sentence comprehension even when multiple and redundant cues are not present. For example, during this phase the child begins to comprehend passive constructions. These authors also believe that during this phase children begin to understand the subcategorization frames for verb meanings and the hierarchical structure of language described by linguists (Hirsh-Pasek & Golinkoff, 1996).

Comprehension and Production

Any model for the development of comprehension must also attempt to describe the relationship between comprehension and production. Language comprehension and production generally are considered to be fundamentally different. Comprehension involves recognition rather than recall; thus, comprehension should utilize fewer cognitive processes. For example, the listener does not need to use processes of organizing and constructing schema because the input already is related to an existing schema and is organized by the speaker (Hirsh-Pasek & Golinkoff, 1996). For these reasons, comprehension should be easier than production for children during development.

In their coalition-of-cues model, Hirsh-Pasek and Golinkoff (1996) viewed the three phases of comprehension development as a continuum moving from a "fragile" state to a "resilient" one for sentential comprehension (p. 191). They suggested that two interacting variables, syntactic complexity and the amount of support from correlated cues in the input, affect comprehension. So, for example, when cues are high and syntactic complexity is low, comprehension is apparent despite a lack of production. At the opposite end of the continuum, comprehension may appear to lag behind production for syntactic forms that are complex or in situations with little support from extralinguistic cues. Overall, the coalition-of-cues model provides a framework for continuing investigation into the role of function morphemes in the acquisition of syntax.

Telegraphese in Production and Comprehension

In addition to categorical distinctions between function and content words, these words differ in productive development. Universally, children tend to acquire open-class before closed-class items (Hirsh-Pasek & Golinkoff, 1996). In English, investigators have long been aware that children begin combining words in a telegraphic manner. Telegraphic speech is characterized by content words initially combined without inflectional endings or function morphemes. It cannot be assumed that function morphemes are omitted because of their relatively limited semantic import. For example, there is evidence that inflectional affixes coding important thematic relationships are learned late in Russian (as cited in Gleitman & Wanner, 1982). Early proposals suggested that children who do not produce function morphemes also do not accurately perceive or comprehend these words. For example, Gleitman and Wanner theorized that the prosody of these elements, their unstressed nature, may render them difficult to perceive and encode.

Telegraphic Speakers' Comprehension of Adult Syntax

An early study to assess the ability of telegraphic speakers to comprehend sentences was conducted by Shipley et al. (1969). They investigated the ability of preschoolers who were telegraphic speakers to follow commands in which the syntax was systematically varied. The comprehension task, which consisted of eight forms of commands, was administered within a play environment. Eleven participants ranged in age from 18 to 33 months. Two subject groups were created, the telegraphic group who had an average utterance length of 1.4 to 1.85 words and a holophrastic group who had limited ability to combine words.

Six nouns labeling familiar toys and their related verbs were targeted for each subject. Eight utterance types included a grammatical command (e.g., "Throw me the ball"), a telegraphic command (e.g., "Throw ball"), a noun only command (e.g., "ball"), and a telegraphic command expanded by an introductory phrase to control for utterance length (e.g., "Please Amy, throw ball"). Four other commands had the same syntactic frames, but nonsense words were substituted for either content or function words (e.g., "Throw ronta ball" for "Throw me the ball;" "Gor ball" for "Throw ball"). Stimuli were delivered, after training, by each mother at random intervals in play with her child and the experimenter. Children's responses were scored as touching, looking, replying, or repeating.

For children in the telegraphic group, significant improvement in performance for the grammatical command compared to the telegraphic or noun-only forms was revealed. This result was not seen, however, for children in the holophrastic group. The poorest performances occurred for nonsense commands; in fact, children responded appropriately more frequently to the noun-only command than to the nonsense verb command. Shipley et al. (1969) state that this finding cannot be the simple result of children noting the presence of nonsense words. Because children at this age routinely encounter novel words, there is little reason to suspect that poorer performance was due to semantic anomaly. In conclusion, the authors interpreted the increased comprehension in the adult syntax condition as support for their hypothesis that children's linguistic competence cannot be judged as telegraphic simply because their production is telegraphic. An equally plausible interpretation of these results would be that children are sensitive to sentential prosody and that telegraphic sentences violated the expected rhythmic properties.

Petretic and Tweney (1977) sought to replicate the findings of Shipley et al. (1969), using the same comprehension task and similar stimuli, but improving several methodological aspects including the number of subjects and the scoring procedures. In this study, 36 children, aged 21 to 42 months, were placed in three groups based on their MLUs such that Group 1 had an MLU of 1.45 morphemes, Group 2 had an MLU of 2.03, Group 3, 2.76 morphemes. Again, eight forms of sentences varying syntactic contexts were created. The authors developed their stimulus sentences from six imperative (e.g., Throw me the ball) and six declarative forms (e.g., The dog eats the bone).

Results indicated that all subjects, including the youngest children, showed significantly improved performance during the adult-syntax condition (90% accurate for adult imperative form and 75% for adult declarative) compared to the telegraphic condition (61% accurate for telegraphic imperative form and 59% for telegraphic declarative). Significant main effects were found for subject group and type of sentence, with the more linguistically mature children showing improved performance, especially for declarative sentences (Petretic & Tweney, 1977). As in the Shipley et al. (1969) investigation, sentences with nonsense words produced the fewest correct responses from all subject groups.

This study replicated and extended the findings of Shipley et al. (1969) because even the least-advanced subjects showed better performance for the adult-syntax condition. The authors concluded that children attend both to function and content words such that modifying function words in utterances results in impaired comprehension (Petretic & Tweney, 1977). As in the investigation by Shipley et al., it is possible that the children were only responding to deviations in natural prosodic patterns.

Investigation of Function Morphemes and Sentence Comprehension

Syntactic Frames and Noun Learning

In a separate series of studies, investigators began to demonstrate that function morphemes are not only perceived by young children who do not yet produce them but are used to determine aspects of meaning and form (Gelman & Taylor, 1984; Katz et al., 1974; Taylor & Gelman, 1988). In the first of these studies, Katz et al. sought to determine how language learners distinguish common nouns (e.g., spoons, blocks) from proper nouns (e.g., Peter, Mommy). Katz et al. manipulated syntactic frames that are typically found with common and proper nouns, by consistently introducing an article (e.g., This is a zav) before the nonsense noun for half of the subjects and omitting it (e.g., This is Zav) for other subjects. They also varied an aspect of the semantic bias by using dolls, which are often associated with proper names, and blocks, which are rarely given proper names. Children were tested individually in one session during which they were given either dolls or blocks and presented either common noun or proper noun labeling. Following five presentations, children were asked to follow directions with the objects. During both presentations and testing, only one object was consistently named.

The only significant result was for 22-month-old girls who were exposed to a new label in the proper noun frame while playing with dolls. Neither the common noun condition nor the boys' performance resulted in better than chance levels. These results indicated that girls' use of the syntactic frame to learn a nonsense word was related to their prior knowledge about which objects are typically individualized with names and which are generally viewed as classes.

Gelman and Taylor (1984) noted results of the Katz et al. (1974) study - especially the seeming interaction between the semantic cue (type of object) and the morphosyntactic cue (presence of article) - and developed a replication of that study. These investigators selected novel, stuffed animals and block-like manipulatives so that the children would not already possess labels for the objects. Subjects were 32 children who ranged in age from 26 to 36 months. Unlike the previous study, both boys and girls more often selected the individual animal in the proper name condition. One sex difference was determined: the boys who were taught a proper name for an inanimate object selected an "out of category" object, the stuffed animal, during testing. Gelman and

Taylor concluded, "...that, even for 2-year-olds, linguistic form class is a powerful source of information for children acquiring new words" (p. 1539).

Taylor and Gelman (1988) extended findings from their earlier study by applying the same methodology to distinguish an adjectival property (e.g., This is a tiv one) from a common noun (e.g., This is a tiv). Children were placed in either the adjective or noun condition for exposure and testing. Children also were given either familiar toys, stuffed dogs and birds, or two different kinds of novel, stuffed animal toys. Perceptually distinct fabrics were used to create all the toys (green fur versus a yellow and black plaid) affording salient groupings for the adjectival property. Nonsignificant results were obtained for the correct identification of the adjective concept; significant results were found for children's individual noun identification but only for familiar objects. Interestingly, children who heard the noun context never assumed the adjective interpretation. Overall, the authors concluded that children between 20 and 33 months use information about the form class of a new word when deciding word meanings, although the use of syntactic frame alone is not sufficient. Children also incorporate prior linguistic knowledge, such as the labeling of familiar versus unfamiliar referents into new learning.

Syntactic Frames and Verb Learning

Naigles and colleagues have conducted several investigations of novel verb learning based on the syntactic bootstrapping hypothesis. In one such study (Naigles, 1990), 24 TD 2-year-old boys and girls participated in the intermodal preferential looking paradigm. Half of the subjects were taught the novel verb in the transitive frame (e.g., Look! The duck is gorping the bunny) implying causality, whereas half were presented the intransitive stimuli (e.g., Look! The duck and the bunny are gorping). Testing trials during which both video events were presented with the stimulus (i.e., Where is gorping now?) revealed a significant difference in the visual fixation of subjects to the video event corresponding to the trained meaning. Significance was judged by comparing visual fixation times during testing trials to visual fixation in a control trial where both events were depicted with a neutral auditory stimulus (i.e., Oh! They're different now!). Similar to earlier investigations of noun meanings, Naigles concluded that syntactic frames provide one source of information for young children learning verbs.

Sentential Processing by Typically Developing Toddlers

In summary, these investigations provide evidence that sentence comprehension and sentence production are not equivalent processes in TD children, such that 2-year-old telegraphic speakers show significantly better comprehension for adult syntactic utterances as opposed to telegraphic or nonsense forms (Petretic & Tweney, 1977; Shipley et al., 1969). There is additional evidence that children attend to the syntactic frames when learning novel content words; specifically, function morphemes shape the decisions young children make about novel word meanings (Gelman & Taylor, 1984; Katz et al., 1974; Naigles, 1990; Taylor & Gelman, 1988). Function morphemes also carry part of the typical sentence prosody in English; thus, telegraphic utterances differ in prosody from complete adult-like utterances. It may be that children are sensitive to these prosodic aspects of sentences, but not to the function morphemes themselves. Or, it may be that children are sensitive to some of the properties of function morphemes, as in the studies which differentiated proper and common nouns. These studies cannot demonstrate, however, that children are differentially aware of function morphemes required to label different syntactic categories (e.g., "the" with nouns, and "is" with verbs) (Gerken & McIntosh, 1993). Another limitation of this research is the lack of control over prosodic aspects of the stimuli because stimuli in these studies were administered through live voice. Without better control of stimuli, bias could be unknowingly admitted.

Function Morphemes Cue Syntactic Categories

Noun Comprehension in Varying Morpheme Contexts

As the logical next step, Gerken and McIntosh (1993) conducted an investigation designed to determine if young children's noun comprehension was improved due to the presence of a grammatical function morpheme versus an ungrammatical morpheme. They devised a picture pointing task in which children were administered four sentential contexts: (a) the grammatical definite article (Find the bird for me); (b) omission of the function morpheme (Find bird for me); (c) the substitution of an ungrammatical auxiliary (Find was bird for me); and the substitution of a nonsense syllable (Find gub bird for me). Four lists of sentences using 16 target nouns were created, such that the four morpheme contexts were systematically varied across nouns. Twenty-eight subjects, 23 to 28 months old, with MLUs ranging from 1.04 to 2.55 participated. None of the children demonstrated productive mastery of "the;" although, evidence of use was between 0 and 68% in obligatory contexts. All children were randomly assigned to one of four lists of stimuli, and all auditory stimuli were created with rule-based synthesized speech (DECTalk) in a male voice (Perfect Paul). Children were engaged in a task to look at picture books, including the stimulus set, and were told that a toy robot would ask them to point to pictures.

Using data from all subjects, significant differences were found for comprehension of pictured nouns in the grammatical article context (62%) when compared to the ungrammatical morpheme context (48%) or nonsense word context (42%). Although children did not perform as well in the omitted context (51%), this result was not statistically significant when compared with the grammatical context. Gerken and McIntosh (1993) then reexamined their findings by separating subjects whose MLUs were greater than 1.5 morphemes and those below 1.5. While they still found the same pattern of responding for both groups of children, results for the less-advanced children did not achieve statistical significance.

Prosody Interacts With Function Morphemes

In a second experiment, Gerken and McIntosh (1993) replicated their results while exploring the role of prosodic factors typical of CDS. Sixteen participants, between 21 and 28 months of age with MLUs ranging from 1.00 to 3.47, performed the same task as in the first experiment. This time, stimulus items were presented in a female voice (DECTalk's Beautiful Betty). This presentation voice had a higher fundamental frequency as well as wider pitch excursions when compared with the male voice used previously. Results of this study indicated improved performance by all subjects, especially for subjects with MLUs under 1.5. Overall, the correct noun was identified with the following percentages of accuracy: (a) 81% for the grammatical morpheme, (b) 72% in the omitted context, (c) 52% given the ungrammatical morpheme, and (d) only 44% when a nonsense word was substituted. Again, there was a significant difference for the grammatical context over the ungrammatical and nonsense contexts, even though there was no significant difference between the grammatical context and the omitted context.

The results of these two experiments provide further evidence that children use function morphemes for comprehension, before they demonstrate mastery production. The children were sensitive to the type of function morpheme; thus, the ungrammatical and nonsense morphemes significantly disrupted their comprehension of the pictured noun. Following increases in comprehension for all subjects during the second experiment, Gerken and McIntosh concluded that a higher-pitched voice with wider pitch excursions might assist infants in segmenting speech. Thus, comprehension was maximally benefitted through a combination of the prosodic cues present in CDS and a morphosyntactic cue, the grammatical function morpheme. Gerken and McIntosh were not able to replicate results of earlier experiments which focused on telegraphic speech (Petretic & Tweney, 1977; Shipley et al., 1969) because the difference between the grammatical and omitted contexts did not reach statistical significance. They speculated that the omission of a single function morpheme may disrupt comprehension only minimally whereas comprehension is more clearly disrupted when all function morphemes are omitted.

Verb Comprehension in Varying Bound Morpheme Contexts

In an effort to extend the findings of Gerken and McIntosh (1993) to younger children and bound morphemes, Golinkoff et al. (in press) compared toddlers' comprehension in three contexts: the grammatical morpheme -ing (e.g., Which one is drinking?), an ungrammatical morpheme -ly (e.g., Which one is drinkly?), and a nonsense syllable -lu (e.g., Which one is drinklu?). Forty-eight children, who were between 18 and

20 months old, were randomly assigned to one of the three contexts. Only 3 of the 48 subjects were reported to use the morpheme, -ing, and all subjects showed comprehension for at least six of the eight target verbs. The intermodal preferential looking paradigm was used to assess comprehension. Actions were presented as video events (one matching and one nonmatching), and recorded auditory stimuli were natural CDS productions. The authors stated that they attempted to maintain identical productions across conditions with equal stress on the final syllables; no reliability measures, however, were reported.

Inspection of mean visual fixation times across children revealed a pattern of comprehension for the -ing context such that children watched the video event that matched the stimulus more often than a nonmatching video for all four target verbs. Results for the -ly context were less conclusive. It appeared that children were unable to comprehend stimuli for the first two verbs tested, although they showed increased attention for the matching video event for the third and fourth verbs tested. In the nonsense (-lu) context, children did not demonstrate comprehension for the verbs although there were differences between results for boys and girls. Boys showed equal attention to the matching and nonmatching events; girls consistently watched the nonmatching event. Golinkoff et al. (in press) concluded that children not yet producing grammatical morphemes are able to distinguish between correct and incorrect use. It also appeared that children recognize that a nonsense syllable is not a grammatical morpheme.

Sentence Processing by Telegraphic TD Children

This body of research has shown that young children who do not yet produce adult sentences are sensitive to the presence of function morphemes in sentence contexts (Gerken & McIntosh, 1993; Golinkoff et al., in press; Petretic & Tweney, 1977;

Shipley et al., 1969). It is important to note that these investigations demonstrated more than mere sensitivity to the morphemes; rather they suggested that children use function morphemes to segment the speech stream (Gerken & McIntosh, 1993), to begin to determine word meanings (Gelman & Taylor, 1984; Katz et al., 1974; Naigles, 1990), and to label syntactic categories (Gerken & McIntosh, 1993; Golinkoff et al., in press). These generally conclusive findings have been demonstrated in repeated studies across three different comprehension tasks: acting out, picture pointing, and intermodal preferential looking. Both boys and girls have displayed similar results overall, although, specific response patterns have varied for sex in several studies (e.g., Gelman & Taylor, 1984; Katz et al., 1974; Golinkoff et al., in press).

Interestingly, use of morphosyntactic cues by these young language learners never occurred in isolation from other types of cues. Children only demonstrated distinction between common and proper nouns when playing with a toy such as a doll that can take an individualized or proper name (Gelman & Taylor, 1984; Katz et al., 1974; Taylor & Gelman, 1988). Noun comprehension for children with MLUs below 1.5 morphemes benefitted from the combination of a prosodic cue, CDS, with a morphosyntactic cue, the function morpheme (Gerken & McIntosh, 1993). This pattern of multiple cues for accurate comprehension by young children beginning combinatorial productions confirms predictions set forth in the coalition-of-cues model (Hirsh-Pasek & Golinkoff, 1996).

<u>Comprehension and Grammatical Morphology in SLI</u>

Understanding language acquisition and comprehension for TD children is enhanced by research on language impairment. This is especially true when assessing the acquisition of function morphemes because research has found that English-speaking children with SLI exhibit more severe difficulty in morphological production than would be expected based on linguistic levels (e.g., Leonard, 1989; Leonard, Bortolini, et al., 1992). Children with SLI frequently demonstrate telegraphic speech characteristics beyond the predicted stage as measured by MLU. This result is apparent in studies that have employed a group of younger TD children matched for language age. For example, Leonard et al. (1997) demonstrated that children with SLI perform more poorly in grammatical morphology than younger TD children. They found that children with SLI had significantly fewer correct productions for 8 of 11 morphemes when compared to a language-matched group. Thus, children with SLI have less advanced function morpheme production than their younger language-matched peers.

Factors Underlying Theoretical Investigation of SLI

Three factors figure prominently in current theories of SLI deficits and are pertinent to the present investigation. First, some theorists claim that SLI is essentially a problem of auditory perception (Tallal & Stark, 1981). A second hypothesis focuses upon information processing and a limited processing capacity for individuals with SLI (Lahey & Bloom, 1994). A third factor relevant here is memory, memory for processing as well as for storage (Lahey & Bloom, 1994). Unfortunately, relatively few studies have been conducted in the area of comprehension and SLI, and existing evidence is confounded by the apparent interaction of factors.

Processing and Memory Factors

Rice, Oetting, Marquis, Bode, and Pae (1994) reported findings from their investigation of lexical comprehension and production in preschoolers with SLI. They suspected that the inability of children with SLI to utilize syntactic cueing strategies could result in limited vocabulary acquisition. Subjects were 30 children with SLI, 30 TD children at the same language level, and 30 children in a chronological-age control group. The children with SLI were between 51 and 69 months of age. Authors' findings led them to conclude that there were multiple factors that showed significant interactions with vocabulary learning. Children with SLI were similar to their MLU-matched peers in the number of exposures required for learning. Both groups, however, needed more exposures than chronological-age peers. The rate and pattern of learning for children with SLI was better than the MLU-matched group and more like the age-matched group, suggesting an intact mechanism for vocabulary learning. Rice et al. concluded that memory or retention was a significant problem for children with SLI because their performance during the final testing, which occurred one to three days following training, was significantly poorer than for even the younger TD children.

Children with SLI also showed an interesting difference for verb learning compared to noun learning. Both the age-matched controls and the children with SLI showed a higher rate of verb learning than noun learning from pre- to posttesting; the rates of retention, however, differed. Specifically, for children with SLI, verbs were more prone than nouns to loss over time. In addition, the verbs that were introduced in the input with the past tense -ed were the most poorly retained. Thus, Rice et al. (1994) proposed that phonological memory and aspects of verb morphology interact to interfere with one another because the associative properties of verb learning are likely to involve complex relationships between verb meanings and grammatical features. "Possibly, the number of associations or strength of these associations for verbs in long-term memory is tied to such linguistic markings.... [and] these associations may be what's vulnerable in children with SLI" (Rice et al., p. 118).

Montgomery (1995) focused more directly on sentence comprehension in his study of phonological memory. Fourteen children with SLI (mean age of 8:2) and 13 TD language-matched children (mean age of 6:7) participated. Montgomery tested their comprehension for long, redundant sentences and short, nonredundant ones encoding the same content. The TD group showed equivalent performance for both sentence types; children with SLI showed better comprehension for shorter nonredundant sentences. The performance of children with SLI also was significantly poorer for the longest items in a nonsense word production task when compared to the TD group. Montgomery concluded that these effects of length reflected limitations in phonological memory capacity rather than a specific linguistic deficit.

In an investigation of perceptual differences for children with SLI, Leonard, McGregor, and Allen (1992) examined syllable identification. They compared a group of eight children with SLI to a group of eight age-matched peers in a perception task. In addition to replicating findings of Tallal and colleagues (e.g., Tallal & Stark, 1981), they tested synthesized syllable contrasts created on the basis of phonological similarity to grammatical morphology. Results revealed that children with SLI were like age-level TD peers for discriminating [i] versus [u] and [dab] versus [dæb]. As predicted, however, children with SLI had decreased discrimination compared to age-level peers for [ba] versus [da], [das] versus [daʃ] and [dab]-[i]-[ba] versus [dab]-[u]-[ba]. Despite this evidence of difficulty for brief transitory auditory stimuli, authors hesitated to conclude that morphological deficits in SLI are caused solely by perceptual weaknesses.

Morphological learning also requires recognition of morphemes and creation of accurate morphological paradigms. Instead, Leonard et al. (1992) proposed that when discrimination is difficult, as in the above contrasts, more cognitive operations are required for the comprehension process resulting in the likelihood of loss. SLI could represent specific perceptual limitations or a capacity limitation threatened by increased cognitive operations in this perceptual process.

Surface Account

As described above, Leonard et al. (1992) investigated the relationship between difficult perceptual contrasts and processing for children with SLI. Their explanation for SLI children's relative difficulty with perceiving function morphemes and hypothesizing their functions is known as the surface account (e.g., Leonard, 1989, 1998; Leonard, Bortolini, et al., 1992; Leonard et al., 1997). The surface account draws upon both perceptual and cognitive capacity factors in describing the etiology of morphological weaknesses in SLI. The major premise of the surface account is that many function morphemes in English are difficult to perceive because they are characterized by low phonetic substance. That is, they are frequently unstressed syllables or phonemes of relatively short duration with lower acoustic amplitude and fundamental frequency. In addition, they generally do not occur in utterance positions, such as phrase-final, that are associated with significant lengthening. Function morphemes that frequently occur in phrase-final position with associated lengthening are acquired earlier (e.g., plural -s, present progressive -ing). Thus, the acoustic salience of function morphemes is a primary factor hypothesized to affect morphological learning for children with SLI.

Proponents of this account do not claim that children with SLI are incapable of perceiving these items, because children with SLI clearly are able to detect and produce these syllables and phonemes in nonmorphophonemic contexts. Thus, morphological difficulty in English SLI cannot be explained solely by the minimal nature of English function morphemes. To resolve this matter, Leonard invoked a procedure of paradigm building originally described by Pinker (as cited in Leonard, 1989). It was hypothesized that children initially create word-specific paradigms that later lead to general rule-based paradigms. Therefore, according to the surface account, function morphemes with low phonetic substance are late in being perceived and conceptualized for grammatical paradigms. These elements are overlooked as likely candidates in paradigm building in favor of forms with greater substance.

If the child with SLI has a limited capacity system and if certain perceptual processes require greater resources, then there is little cognitive capacity remaining to develop the kinds of paradigms needed for morphological acquisition (Leonard, McGregor, & Allen, 1992). Leonard and colleagues have stated that children with SLI have grammatical and linguistic mechanisms essentially like those of TD children, but altered intake of data due to processing limitations interferes with morphological learning. This difficulty with function morphemes can provide a broad explanation for the well-established morphological difficulties of SLI children (Leonard & Eyer, 1996). That is, Morgan and Demuth (1996) cite this interpretation by Leonard and Eyer: "this may then hinder accurate representation of the internal structure of phrases and clauses, thereby interfering with the development of higher level syntactic abilities." (p. 14).

SLI Children's Comprehension in Varying Morpheme Contexts

Two studies have been conducted which compare children with SLI to TD children for sentence comprehension in varying syntactic contexts (Leder & Egelston, 1981; McNamara, Carter, McIntosh, & Gerken, 1998). Leder and Egelston (1981) examined the interaction between comprehension and syntax for question forms. One research question sought to determine if there were differences in the comprehension of children with SLI compared to TD children for questions posed in adult (e.g., What kind of cake is this?) versus telegraphic (e.g., What kind cake?) form. There were 21 children in the SLI group and 29 in the TD group. All children ranged in age from 34 to 72 months. Children with SLI exhibited delays of at least six months on a standardized receptive measure, and performed more than 2 standard deviations (SD) below the mean (M) on an expressive syntax assessment.

Stimuli consisted of 15 different forms of questions presented in a story-telling context. Each child participated in two different story-telling probes. The first probe presented all question forms in adult syntax and the second consisted of telegraphic versions of the same question types. Results revealed significant differences in question comprehension across subject ages and for the SLI group compared to TD children. Only 4 of 15 interrogatives were comprehended differently based on syntactic context (telegraphic and adult). For three of these, subject groups preferred the adult syntax, but for the fourth, the difference in performance was in favor of the telegraphic version. The SLI children's pattern of performance did not differ from the pattern of the TD children for either the telegraphic or adult syntax conditions despite poorer overall comprehension abilities (Leder & Egelston, 1981).

In a more recent study, McNamara et al. (1998) expanded findings from Gerken and McIntosh (1993) by conducting two experiments involving groups of TD children and children with SLI. The purpose of the first experiment was to determine if children with SLI show sensitivity to grammatical morphemes in sentences. The same picture selection task and stimulus lists utilized by Gerken and McIntosh were administered to 12 children with SLI with a mean age of 3 years 11 months and to 12 age-matched TD peers. MLU for the SLI group, 2.78 morphemes, was significantly lower than MLU for the TD group, 3.99.

Unlike findings of Gerken and McIntosh (1993), results for the TD group indicated high levels of accuracy with no differences across morphosyntactic contexts. Results for the SLI group showed a significant decrease in noun identification for the ungrammatical morpheme "was" context (44%) when compared to their performance with grammatical "the" (77%). Subjects with SLI showed no differences in comprehension in the omitted (69%) and nonsense word "gub" (67%) contexts.

McNamara et al. (1998) concluded that children with SLI are sensitive to the morphosyntactic function of morphemes within sentences such that they show better comprehension for sentences containing a grammatical morpheme than an ungrammatical one. They speculated that the lack of difference for the omitted context may be related to the occurrence of nouns without articles in English (e.g., People eat apples.). They, also, suggested that the nonsense syllable did not affect comprehension because it was not part of children's prior experience of morphology. This interpretation would seem to be bolstered by the lack of correspondence between the selected nonsense syllable, "gub," and the known phonological properties of most function morphemes in English. That is, "gub" sounds like a content word and could be interpreted as a novel adjective or proper noun, "Find gub bird for me."

Interpreting the SLI group's poorer performance, McNamara et al. (1998) discuss two hypotheses. The first, the pre-access hypothesis, proposed that sentence processing by the SLI group showed interference from the ungrammatical morpheme which resulted in difficulty forming a semantic representation. The second, the post-access hypothesis, proposed that children with SLI had the ability to process sentences recognizing the target noun but were unable, during the ungrammatical context, to retain the noun in memory. To test these hypotheses, Experiment 2 was conducted with similar groups, 30 children with SLI (mean age = 4:10) and 30 children with normally developing language were matched for age and gender. The comprehension task was modified so that only two morpheme contexts were reexamined, grammatical "the" and ungrammatical "was" contexts. Also, one-third of the picture stimuli contained a semantic foil on the pages (e.g., "plate" when the target was "fork") whereas another third of the stimuli offered both semantic and phonological distractors (e.g., "plate" and "fox" for the target "fork") on each page.

As in Experiment 1, groups were significantly different in noun comprehension for the ungrammatical context but not the grammatical one. The condition which contained both phonological and semantic distractors disrupted performances for both groups, although only the difference in the SLI group's performance was statistically significant. As hypothesized, children with SLI were found to select the semantic distractor picture when making errors. Authors tentatively interpreted these findings as consistent with the post-access hypothesis that children with SLI formed semantic interpretations but were unable to retain them given distractor items. That is, correct representation for children with SLI was prone to loss in the ungrammatical context resulting in selection of the semantic distractor.

Several factors reduce the likelihood that the post-access hypothesis can explain findings unique to the SLI group. First, errors for children with SLI were not found for the condition which contained only semantic distractors without phonological distractors, as initially predicted. This suggests that the number or type of distractors was an uncontrolled variable. Second, TD children, like the children with SLI, had a similar decrease in accuracy in the presence of both phonological and semantic distractors. Thus, it is possible that the performance of children with SLI would be similar to younger children at the same language level.

Neither the pre-access nor post-access hypothesis can be fully considered without a third subject group, a group of younger TD children. It is well-established that for most language skills, except morphology, children with SLI perform like younger TD peers. TD children in Gerken and McIntosh's study appeared less advanced, based upon MLU, than children with SLI from McNamara et al. Mean MLUs were 1.75 and 2.78, respectively. Despite this MLU advantage, children with SLI in McNamara et al. performed no better than TD children in Gerken and McIntosh. This result suggests a pattern for morphological learning similar to predictions established by Leonard and colleagues in the surface account, whereby comprehension for function morphemes is poorer for children with SLI than for MLU-matched TD peers.

Purpose and Research Hypotheses

The purpose of the present investigation was to examine the role of function morphemes in sentence comprehension for children with SLI compared to children who are typically developing. To this end, the study was designed using the four contexts (i.e., grammatical, omitted, ungrammatical, and nonsense morpheme) established by Gerken and McIntosh (1993). The function morpheme "is" in the present progressive interrogative "Who is verbing?" was examined, because "is" is a low phonetic substance morpheme frequently omitted in telegraphic speech and known to undergo a protracted period of productive learning for children with SLI.

It was hypothesized that children with SLI who are telegraphic speakers would show significantly poorer verb comprehension than their younger MLU-matched TD peers in the sentential task which varied cues associated with the function morpheme. It was also hypothesized that the two groups of children would display similar patterns of comprehension across contexts. Both the TD and SLI groups were expected to show the best comprehension in grammatical "is" and omitted contexts, with poorer comprehension for ungrammatical "in" and nonsense word "id" contexts. This hypothesis was based on findings of Gerken and McIntosh (1993) and McNamara et al. (1998).

If TD children showed better verb comprehension for the grammatical function morpheme context (i.e., Who is jumping?) than ungrammatical sentences (i.e., Who in jumping?), the conclusion of Gerken and McIntosh (1993) would be supported; sentence comprehension for TD telegraphic speakers is enhanced by distributional relationships among function morphemes and their phrase-mates. This conclusion also would be extended from a function morpheme associated with nouns (i.e., "the") to one associated with verbs (i.e., "is"). If the children with SLI showed the same pattern of responding yet performed less well when compared to their younger TD peers, there would be support for the hypothesis that the morphological deficits of children with SLI may be based in a relative weakness for sentential elements of low phonetic substance. Consequently, the following specific research questions were proposed: (1) Do young telegraphic speakers show increased verb comprehension given sentences containing the grammatical auxiliary (Who is pushing?) compared with sentences containing an ungrammatical function morpheme (Who in pushing?), a nonsense morpheme (Who id pushing?), or no morpheme (Who pushing?)? and (2) Do children with SLI, who are telegraphic speakers, differ in verb comprehension for sentences with varying morphosyntactic contexts when compared with their younger, MLU-matched TD peers?

Chapter 2

Method

Participants

A total of 32 participants completed the experimental task. The two subject groups consisted of 16 typically developing (TD) toddlers and 16 preschoolers with specific language impairment (SLI). The TD group contained an equal number of boys and girls. All subjects, TD and those with SLI, met the following subject selection criteria:

1. Residence in homes where Standard American English is spoken. Dialect of parents present during preexperimental sessions was informally assessed by the investigator, and responses to questions on the case history form (see Appendix A) were examined.
2. Phonological skills adequate for reliable assessment of telegraphic speech. Specifically, phonological inventories of all subjects included both final position fricatives (e.g., bus) and unstressed final syllables in bisyllabic words (e.g., baby) produced correctly in at least five different words and ten opportunities.
3. Comprehension or production of 14 of the 16 target verbs as indicated by parent report on the MacArthur Communicative Development Inventory: Words and Sentences (CDI) Action Words subtest (Fenson et al., 1993).
4. Peripheral hearing within normal limits for the frequencies of 1000, 2000, and 4000 Hertz (Hz) at 25 decibels (dB) HL based on pure-tone, play screening. Screening was conducted by the investigator using guidelines of the American

Speech-Language-Hearing Association (ASHA, 1985) and a portable audiometer (Maico, Model MA 40, see ANSI, 1989) in a sound-proof booth. For children who were unable to be conditioned to the play screening task or tested under earphones, peripheral hearing was within normal limits for at least the better ear for the frequencies of 1000, 2000, and 4000 Hz pulsed tones at 25 dB HL based on visually reinforced audiometry in a sound-field conducted by the investigator (ASHA, 1991).

Typically Developing Subjects

TD toddlers were identified from a pool of eligible children from cooperating day care and Mother's Day Out programs. In addition to the above subject selection guidelines, TD subjects displayed the following criteria for inclusion:

1. A mean length of utterance (MLU) of 2.00 to 3.75 morphemes which is equivalent to Brown's Stages II to IV (as cited in Miller, 1981).

2. Infrequent use of "is" in obligatory contexts (i.e., a range of 0% to 60%) based on a language sample with a minimum of 100 spontaneous, complete and intelligible utterances.

4. Receptive and expressive language skills within normal limits based on the Preschool Language Scale - 3 (PLS-3) (Zimmerman, Steiner, & Pond, 1992). Thus, both receptive and expressive subtest standard scores were within 1 SD below the M or better (i.e., greater than 85). This language measure was selected because of the availability of age appropriate items, the large representative standardization sample, and high concurrent validity with other language measures.

5. Cognitive abilities within 1 SD from the M on the Cognitive Domain of the Battelle Developmental Inventory (BDI) (Newborg, Stock, & Wnek, 1984).

6. Unremarkable birth and developmental histories as reported by the parent on a case history questionnaire (see Appendix A).

Children With SLI

Children with SLI were recruited from caseloads of speech-language pathologists who serve 3- to 5-year-olds. The accepted standard for definition of SLI for research purposes is an identifiable language delay in the absence of hearing impairment, significant emotional problems, frank neurological impairment, or severe speech deficits (Stark & Tallal, 1981; Watkins, 1994). Based on this definition and a similar stage of language development as the TD 2-year-olds, children in the SLI group met the following criteria for inclusion:

1. Like the TD group, an MLU of 2.00 to 3.75 morphemes based on a language sample with a minimum of 100 spontaneous, complete and intelligible utterances.

2. Also like the TD group, occurrence of "is" between 0% and 60% accuracy in obligatory contexts.

3. Receptive or expressive language skills below average. Therefore, standard scores were at least 1 SD below the M (i.e., 85 or less) on the PLS-3 (Zimmerman et al., 1992) and/or the Clinical Evaluation of Language Fundamentals-Preschool (CELF-P) (Wiig, Secord, & Semel, 1992). The PLS-3 and CELF-P were selected due to their relatively high concurrent validity and their ability to discriminate between children with and without language impairment in this age range.

4. Cognitive skills within normal limits as indicated by a mental age score no more than six months below chronological age based on The Arthur Adaptation of the Leiter International Performance Scale (Arthur, 1952). The Leiter was selected because of the need to evaluate nonverbal cognitive skills in children under age 5.

5. No signs of frank neurological impairments or other handicapping conditions as reported by the parent on a case history questionnaire (see Appendix A) and as judged by the investigator.

Stimuli

Auditory Stimuli

Development of Auditory Stimuli

Based on the procedure of Gerken and McIntosh (1993), four interrogative sentences were created for each of 16 target verbs with the following morphosyntactic contexts: (a) grammatical auxiliary (Who is jumping?); (b) omitted auxiliary (Who ϕ jumping?); (c) ungrammatical function morpheme (Who in jumping?); and (d) nonsense syllable (Who id jumping?). Sixteen verbs, typically mastered by young children, were selected from the CDI Action Words subtest (Fenson et al., 1993) for the comprehension task (see Table 1). All target verbs had an initial phoneme acoustically distinct from the postvocalic consonants of the function morphemes (i.e., [z, n, d]) to improve segmentation and synthesis (e.g., kicking, pushing). Thus, words with prevocalic fricatives, glides, liquids, or alveolar plosives were avoided.

Table 1

Four Stimuli Lists With Sixteen Verbs in Varying Morpheme Contexts

List 1	List 2	List 3	List 4
1. Who is pushing?	Who ϕ pushing?	Who in pushing?	Who id pushing?
2. Who ϕ crying?	Who in crying?	Who id crying?	Who is crying?
3. Who in cutting?	Who id cutting?	Who is cutting?	Who ϕ cutting?
4. Who id biting?	Who is biting?	Who ϕ biting?	Who in biting?
5. Who is climbing?	Who ϕ climbing?	Who in climbing?	Who id climbing?
6. Who ϕ playing?	Who in playing?	Who id playing?	Who is playing?
7. Who in blowing?	Who id blowing?	Who is blowing?	Who ϕ blowing?
8. Who id cooking?	Who is cooking?	Who ϕ cooking?	Who in cooking?
9. Who is clapping?	Who ϕ clapping?	Who in clapping?	Who id clapping?
10. Who ϕ painting?	Who in painting?	Who id painting?	Who is painting?
11. Who in catching?	Who id catching?	Who is catching?	Who ϕ catching?
12. Who id pouring?	Who is pouring?	Who ϕ pouring?	Who in pouring?
13. Who is kissing?	Who ϕ kissing?	Who in kissing?	Who id kissing?
14. Who ϕ jumping?	Who in jumping?	Who id jumping?	Who is jumping
15. Who in building?	Who id building?	Who is building?	Who ϕ building?
16. Who id kicking?	Who is kicking?	Who ϕ kicking?	Who in kicking?

Four stimuli lists were created using 16 target verbs. Target verbs occurred in the same order for each list; however, morpheme context for each verb was varied among lists. Each list had four sentences for each of the four morpheme contexts for a total of 16 sentences (see Table 1). Subjects in both groups were randomly assigned to one of the four stimuli lists, with four subjects in each group receiving the same list.

The foil function morphemes (i.e., in, id) were selected to maintain equivalent syllable and segmental aspects of the auxiliary, "is." The three syllables have the same lax vowel, a null onset, and a simple coda consisting of a single voiced coronal phoneme (Shriberg & Kent, 1982). The form of the interrogative maintains a trochaic stress pattern (i.e., strong-weak strong-weak), a predominant pattern in English child-directed utterances. This is an important control because the stress pattern of the ambient language is a potential factor in acquisition theories for both comprehension and production (Cutler, 1996; Jusczyk & Kemler Nelson, 1996).

To control for variables of duration, frequency and intensity within and across sentences, stimuli were edited through linear predictive coding (LPC) synthesis using an LPC analysis and synthesis computer program (ASL software with the Computerized Speech Laboratory [CSL], Model 4300B by Kay Elemetrics). Previous studies have relied upon live voice stimulus delivery, except for studies by Gerken and McIntosh (1993) and McNamara et al. (1998) which utilized rule-based synthesized speech (DECTalk). For maximum intelligibility and naturalness, LPC synthesis starts with analysis of real speech and provides digital-editing capability, unlike rule-based synthesis which has a reduced frequency range and limited amplitude variation (for a description of LPC synthesis and equipment see Kent & Read, 1992).

The investigator initially created a benchmark sentence (i.e., "Who is pushing?) that conformed to desired prosodic features. A key feature of the benchmark sentence was the duration of the function morpheme, "is," which was 156 milliseconds (ms). The average duration of the vowel [I] in function words in child-directed speech (CDS) has been reported as 100 ms (Ratner, 1984). To create natural productions, target function morphemes (is, in, id) were allowed to vary in duration with the final position consonant. Average durations of these final consonants in unstressed syllables spoken by an adult are as follows: [z] = 60 ms, [n] = 70 ms, and [d] = 45 ms (Klatt, 1975). Although the final position consonant is known to be a variable influencing vowel duration, this influence has been reported as minimal for syllables which are non-phrase-final; vowel duration decreases of 1% for postvocalic fricatives and approximately 10% for voiceless plosives (Klatt, 1975). Based on these reported measures, durations of target morphemes were created to vary between approximately 130 and 170 ms. This difference is probably not noticeable to children; just noticeable difference (JND) for duration has been reported as 10 to 40 ms for adult listeners for syllables which are from 30 to 300 ms (as cited in Lehiste, 1970).

In addition to the variable of function morpheme duration, the overall duration of the benchmark sentence was typical of CDS, 1.349 seconds. An exaggerated frequency contour was used such that “who” displayed a pitch peak of 323 Hz while “is” peaked at 139 Hz and “push” at 253 Hz. The content words (“who” and “push”) were produced with full vowels, a higher fundamental frequency and amplitude, and longer durations than the function morphemes. The first syllable of the target verbs received focal stress primarily through increased length combined with increased pitch and loudness.

(For complete acoustic measurements of the benchmark sentence as well as the final, synthesized stimuli, see Appendix B.)

Because LPC synthesis starts with recorded real speech, the investigator recorded stimuli sentences to the digital computer in random sequence. The waveform of the benchmark sentence was displayed and replayed prior to production of each of the 64 sentences. Mouth to microphone distance was two inches. The microphone (Shure model SM48) was coupled to input channel one of the CSL. Input levels were monitored to maximize signal capture. The analog to digital conversion was captured at the maximum rate available, 20,000 (20k) samples per second or 20kHz. The capture duration was set at three seconds or slightly greater than the estimated duration of the utterances. No additional preemphasis or presampling filtering was used because a natural voice quality for the final product was desired. Each recorded digital signal was trimmed so that only the utterance, with brief pauses before and after, was transferred to disk for later measurement and synthesis.

Acoustic Analysis of Auditory Stimuli

After all stimuli were recorded, the investigator measured each sentence for seven aspects: (a) overall duration of the sentence to the closest 1.6 ms; (b) combined subject word and function morpheme (i.e., Who is) duration in ms; (c) duration of the verb (e.g., drinking) in ms; (d) peak amplitude for the function morpheme in dB; (e) peak amplitude for the first syllable of the verb in dB; (f) peak fundamental frequency (F_o) on the function morpheme in Hz; and (g) peak F_o for the first syllable of the verb in Hz. (See Appendix C for detailed acoustic measurement guidelines.) The CSL monitor was configured with two simultaneously visible windows. The top window depicted a waveform display. The bottom window was a wideband spectrogram (display range up to 8000 Hz) with the cursors linked to the waveform in the top window. A formant tracing and amplitude curve were overlaid on the spectrogram.

Although problematic, speech segmentation can be specified by observing changes that occur in the source of sound production or in articulation or filtering of the sound. Therefore, segmentation decisions can be made using a spectrogram by noting voicing changes, presence of noise and turbulation, and formant transitions (as cited in Chen, 1970). Decisions are supplemented by an amplitude curve that provides information about changes in source intensity typically associated with syllable boundaries (as cited in Chen, 1970, see also Allen, 1978). For these measurements, spectrographic and amplitude information were combined in an attempt to maximize precision and reliability (Allen, 1978).

Duration measurements were based upon specific onsets and offsets viewed on the spectrogram/amplitude display, and delta time was read from the linked waveform. For both overall sentence duration measurement and subject word with function morpheme duration measurement, onset for [w] in "who" was determined by vertical striations in the first and second formants (Swanson & Leonard, 1994). Offset of postvocalic [ŋ] of the verbs, needed for sentence duration and verb duration measurements, was determined by the last mark of the first formant using the formant tracing in combination with amplitude/spectrographic views. For other boundaries, when measuring subject and function morpheme durations, offsets for postvocalic consonants [z, n, d] were associated with spectrographic characteristics of these phonemes. The [z] offset was determined by cessation of turbulence in the spectrogram. The [n] offset was located at the last mark of the tracing of the first formant just as [ŋ] offset was determined. Offset for [d] was located in the middle of the burst on the spectrograph. For time zero of verb duration, onsets of prevocalic, plosive consonants were determined at the start of the burst on the spectrograph (Pickett 1991a, 1991b) accompanied by abrupt increase in the amplitude curve.

Peak amplitudes for function morphemes and first syllables of verbs were determined by placing the cursor at the highest point on the amplitude curve superimposed on the spectrogram, then recording digital readings provided by the computer. Following these measurements for each utterance, the bottom display window was changed to complete fundamental frequency measurements. Using the pitch extraction function, a frequency curve was overlaid on the spectrogram (sans amplitude curve). Peak F_0s for function morphemes and first syllables of verbs were initially measured by placing cursors on the highest visible part of the tracing and recording the associated frequency as provided by the CSL program. However, several errors in CSL pitch extraction process were discovered including reported peaks in unvoiced portions of the signal as well as fundamental frequencies reported at half the correct value. Thus, a verification procedure was added. The peak measurements were corroborated by measuring the duration of one impulse, an impulse associated with the peak in the contour, and calculating the fundamental frequency (i.e., 1 ÷ the duration of the impulse). When this calculation corresponded with the peak determined by CSL pitch extraction, this number was reported as the pitch peak. If the peak was not able to be verified, then the entire syllable was examined to locate the shortest impulse and peak F_0 was computed with the calculation described above.

To assess reliability for these preliminary acoustic measurements, all seven aspects for 12 of the 64 sentences were remeasured by the investigator after four days from the original measurement and without access to original measurements. The sentences for remeasurement were selected at random. Amplitude and frequency peak measurements were considered in agreement if remeasurement resulted in the same value. Note the verification procedures for fundamental frequency were not used for this preliminary reliability phase. Duration measurements were considered reliable if they fell within +/- 20 ms. Remeasurement resulted in 82 measurements within the acceptable range and 2 unacceptable measurements out of the total 84, or 98% agreement. Average difference between duration measurements for the 35 agreements was 1.4 ms, range was 0 to 5 ms. Nineteen measurements had 0 ms difference.

Synthesis of Auditory Stimuli

Synthesized sentences were created to model the benchmark sentence used in the initial recording. Duration and intensity parameters were manipulated to control prosodic features across stimuli sentences and contexts. Frequency was not edited. Because of limitations in LPC synthesis, editing frequency would have introduced distortion. Acceptable ranges of variation for the acoustic parameters were predetermined based on JND adjusted for child listeners.

A range of +/- 20 ms was set as the acceptable extent of variation for duration measurements for stimulus sentences compared to the benchmark. For adult listeners, JND for duration is between 10 and 40 ms for syllables that are from 30 to 300 ms; JNDs greater than 60 ms have been reported for syllables over 500 ms (as cited in Lehiste, 1970). Thus, 40 ms was deemed acceptable in this study for children.

The intensity of "who" and the first syllable of the verb were allowed to vary within +/- 3 dB from the benchmark sentence. This range is considered approximately 2 times the JND for adult listeners, which is estimated as a 5% change (Judson & Weaver, 1965). Lehiste (1970) reported that adult listeners were unable to determine differences in a series of vowels produced when the range of amplitude varied by as much as 5 dB. This amount of variation in amplitude should not change young children's perception of the stimuli. Although not manipulated, amplitudes for function morphemes were less than those for stressed syllables, "who" and first syllables of verbs, as visually verified by the investigator during synthesis.

Based on these criteria, all 64 sentences were synthesized to bring the characteristics of each sentence to within acceptable ranges when compared to the benchmark sentence. Synthesis was completed primarily through the numeric mode of the ASL program. This digital-editing process resulted in highly intelligible and natural speech retaining many of the characteristics of the original recording yet controlling duration and intensity elements within and across sentences.

Synthesized sentences were converted from digital back to analog signals by downloading the sentences from the CSL to audiotape (Maxell High Bias) using an audiorecorder (Sony, model TC-RX606ES). Input levels were monitored to guarantee equivalent loudness across stimuli. The four lists of auditory stimuli were transferred to four separate audiotapes. Each sentence occurred one time with a three second pause between sentences. Twenty occurrences of all 64 sentences were also recorded individually to 64 audiotapes. In this manner, replaying a sentence during the experimental task was accomplished by inserting the audiotape with the individual sentence.

Reliability for Auditory Stimuli

Prior to remeasurement of synthesized stimuli, reliability procedures to confirm intelligibility of the function words and perception of focal stress were implemented. Three adult judges (who were not speech pathologists or audiologists by profession or in-training) were asked to listen and repeat aloud 20 randomly selected sentences to determine if the different function morphemes, "is," "in," and "id," were perceptible. Judges were told that some of the words they heard may not be real but to try to say the sentences as they heard them. They were also asked to state which syllable in the sentence was stressed. Stress was explained as an emphasis usually perceived by increased loudness, higher pitch, or longer duration. One hundred percent accuracy was obtained for identification of function words by two of three judges. The third judge labeled “id” as “it” consistently. This difference was considered acceptable because postvocalic devoicing is a phonetic variation in Standard English that is likely to be perceived by native speakers.

For identification of the “stressed” syllable, 90% accuracy was established across all three judges. Two judges selected a syllable other than the first syllable of the verb for 4 of 20 sentences. These four sentences plus a fifth sentence of concern to the investigator were recreated. Three new, untrained adult judges were selected to repeat reliability judgements with 25 sentences (i.e., 5 recreated sentences plus 20 additional, randomly selected sentences). Again, the three judges achieved 100% accuracy in identification of the function word and this time all judges labeled the nonsense syllable “id.” Ninety-five percent accuracy for identification of the stressed syllable was achieved. Although this percentage of accuracy met preestablished criteria, one sentence that received two judgements of stress on syllables other than the first syllable of the verb was recreated. Overall, 40 of the 64 sentences or 63% of stimuli underwent procedures to check function word and focal stress perception.

Finally, all 64 sentences were transcribed phonetically by a trained listener, a graduate student in speech-language pathology at The University of Tennessee with experience in phonetic transcription for research purposes. The trained listener also was asked to identify the stressed syllable in each sentence. Results revealed 100% agreement between intended utterances and transcription of synthesized sentences, and 100% accuracy for identification of the first syllable of the verb as the stressed syllable in all 64 sentences.

Reliability for Acoustic Measures

After completing the synthesis process for all 64 sentences as well as perceptual reliability procedures, final measurements for the seven aspects of each sentence (i.e., measurements a - g) were calculated. See Appendix B for a complete list of stimulus sentences and the acoustic measurements following synthesis. All measurement procedures previously described for measurement of the recorded sentences were used in measuring synthesized sentences. Appendix C contains a complete description of measurement procedures using the CSL. Reliability procedures for the constancy of acoustic parameters for synthesized sentences was undertaken.

Both intra- and interreliability were established for 24 randomly selected sentences (i.e., 12 for intrareliability plus 12 for interreliability), resulting in remeasurement of 168 of 448 parameters or greater than 37%. For duration, agreement was considered acceptable for measurements within +/- 20 ms. All measurements of peak F_0 and peak amplitude were identical to demonstrate agreement. Using these criteria, a point-by-point percentage of agreement was established.

A minimum of four days passed from completion of initial measurements before the investigator proceeded with intrareliability measurements. Intrareliability was 94% or 79 agreements from 84 measurements. No errors occurred for amplitude measurements and only one significant difference was found in duration measurement. Duration measurements in agreement revealed an average difference of 1.11 ms between initial measurement and reliability measurement (range = 0 to 5 ms). Measurement of F_0 for "who" proved the most problematic given the verification procedures needed due to CSL pitch extraction limitations; 4 of 12 measurements fell outside the acceptable range. There was 100% agreement (12 out of 12) for F_0 measurements on the first syllable of the verbs.

The interreliability judge was the same individual who conducted phonetic transcription of study stimuli. She was trained by the investigator for the procedures outlined in Appendix C. Recorded sentences, not synthesized sentences, initially were used to practice reliability and speech analysis procedures. Interreliability of 90% was established for the synthesized sentences. There were 76 agreements for 84 measurements. Two duration measurements fell outside of the acceptable range and two errors were found for amplitude recording. Four disagreements were noted in measurement of peak F_0. The average difference in the duration measurements between the investigator and the interreliability judge for the 34 of 36 measurements judged to be in agreement was 1.79 ms (range = 0 to 14 ms).

Picture Stimuli

Development of Picture Stimuli

In addition to the auditory stimuli, a picture book for the 16 items was created. The book consisted of four, 3 1/2 X 4 1/2 inch action pictures mounted on a 8 1/2 X 11 inch page. Original pictures were created by a professional artist and were simple, black, line drawings on white paper generally equivalent for background, overall interest and coloring (see Figure 1 for an example). Coloring was limited to children's hair and clothing; the same colors were used for all pictures. Stimulus pages were bound in a three-ring notebook. This one experimental book was used for all subjects regardless of group or assigned stimuli list.

Each page depicted one target verb and three foils. Target verbs appeared no more than one other time as a foil on another page. Foil pictures were not used more than twice. Foil actions were selected based on the developmental level for the verbs, the ease for depicting verbs, and balance among verbs on a page. For example, foils that involved full body actions were placed on pages with target verbs depicting full body actions. Action words that were similar referentially (e.g., "cooking and "pouring") or phonologically (e.g., "cooking" and "kicking") were not placed on the same page. Target verb pictures were randomized for page position with four targets appearing in each of four positions throughout the book. See Appendix D for a complete list of target and foil verbs and their page positions.

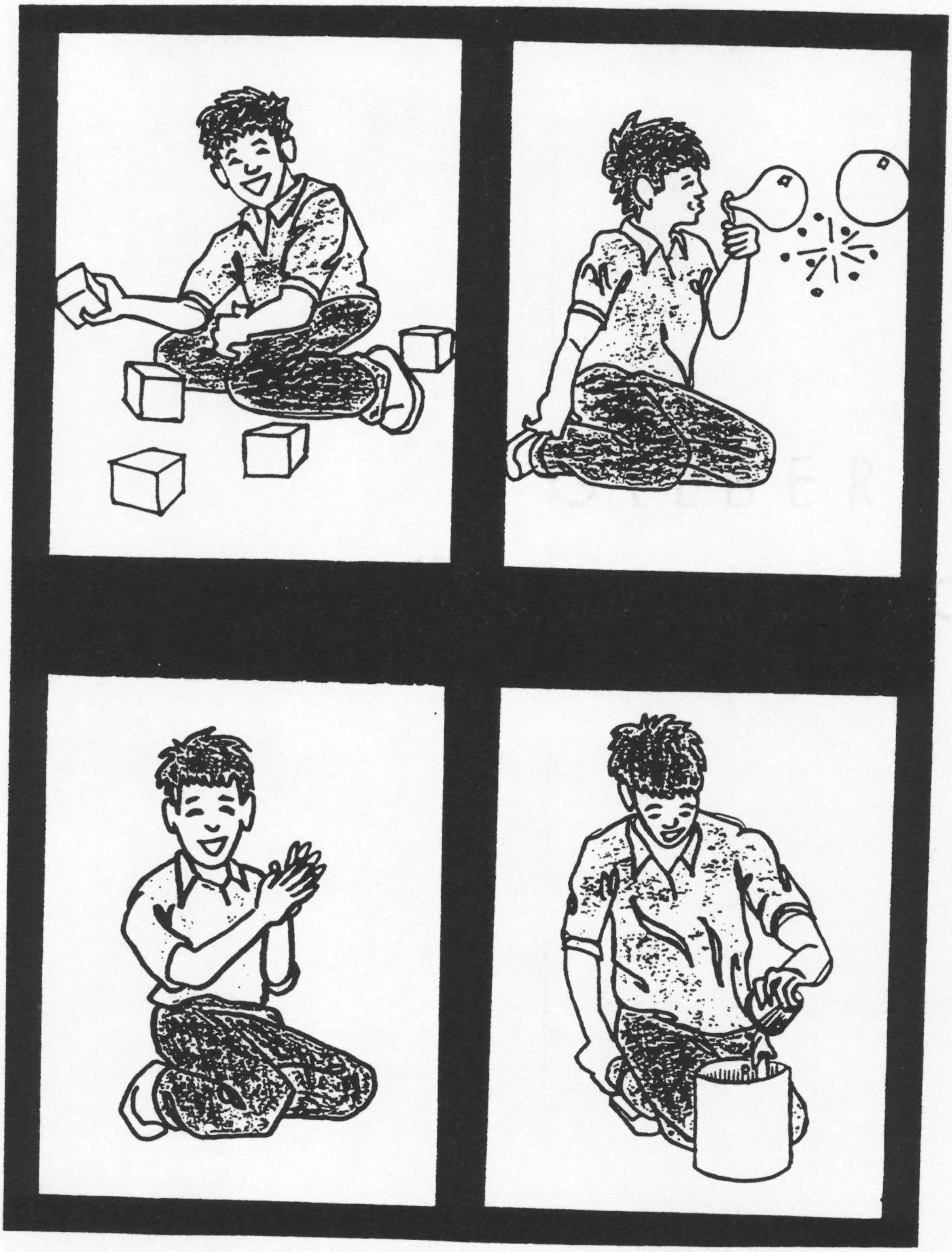

Figure 1. Sample of a page from the experimental stimulus book. Actual size for the page (8 1/2 X 11 inches) has been reduced for this format.

Reliability for Picture Stimuli

A reliability procedure to confirm that action pictures adequately depicted target verbs was conducted. Three 7-year-old child judges were asked to name target pictures. All three judges misidentified the same picture, clapping. Thus, 94% accuracy for naming target action pictures was achieved. The picture of clapping was recreated by the artist and approved by the investigator.

Procedures

Data collection was completed in two geographic locations. One-third of the data collection was completed at The University of Tennessee in Knoxville, Tennessee. The Institutional Review Board of The University of Tennessee, Knoxville authorized data collection with human subjects, and the Department of Audiology and Speech-Language Pathology sponsored the investigation. The remainder of the data was collected in Mobile, Alabama under the continuing sponsorship of the Department of Audiology and Speech Pathology at The University of Tennessee, Knoxville and in collaboration with the Department of Speech Pathology and Audiology at the University of South Alabama. Settings and equipment used for all aspects of data collection in the two locations were comparable if not identical.

Preexperimental Sessions

Setting

The first preexperimental session was conducted in the children's homes for maximum comfort and convenience and lasted approximately 90 minutes. Interaction was initiated through natural play on the floor. Parents were invited to be present in the room, but generally sat off to the side. Breaks were taken as needed during task administration.

If children remained eligible following the first preexperimental session, a second session of approximately 30 minutes was conducted to complete preexperimental criteria. This second preexperimental session was held in a sound-proof booth. One parent was invited to sit with the child inside the booth. All participants were seated in child-sized chairs at a child-sized table, yet children were allowed to move about the space as needed.

Preexperimental Tasks for Determining Eligibility

During the preexperimental session conducted in the home, the parent was asked to complete independently the case history questionnaire (see Appendix A) and the Action Words subtest of the CDI (Fenson et al., 1993). While the parent completed this paperwork, the child and investigator were engaged in play with toy sets (i.e., Fisher-Price preschool barn [boys and girls], Fisher-Price doctor's bag, two child-safe dolls with food/clothing accessories [girls], and Fisher-Price flip-track mountain vehicle play set [boys]). Vocabulary associated with toys provided opportunities for phonological screening of child productions of [s, z] in final position (e.g., "juice," "cars") and for unstressed, final syllables (e.g., "baby," "bottle"). A speech and language sample with a minimum of 100 spontaneous, complete and intelligible utterances was collected. Prior to the second preexperimental session, each sample was transcribed using conventions of Systematic Analysis of Language Transcripts (SALT) (Miller & Chapman, 1986) and analyzed to verify MLU, phonological productions, and use of "is." (See Appendix E for specific description of transcription guidelines.) The PLS-3 (Zimmerman et al., 1992) also was administered during the session in the home.

During the second preexperimental session conducted in the booth, cognitive screenings were administered, the Cognitive Domain of the BDI (Newborg et al., 1984) for TD subjects and The Arthur Adaptation of the Leiter (Arthur, 1952) for children with SLI. Both cognitive measures were administered according to standardized procedures with one exception. The investigator discontinued testing after subjects' completed chronological age-level items but before attaining ceilings. This modification may have resulted in an underestimate of subjects' cognitive performance. Subjects' performance on cognitive measures is interpreted as at least within normal limits.

A pure-tone play hearing screening under earphones was conducted by the investigator for frequencies 1000, 2000, and 4000 Hz at 25 dB HL using procedures in keeping with guidelines of the American Speech-Language-Hearing Association (ASHA, 1985). A portable audiometer (Maico, Model MA 40, see ANSI, 1989) in the sound-proof booth was used. If the child's hearing could not be screened under earphones, visually reinforced audiometry in a sound field was conducted by the investigator.

All preexperimental testing was analyzed for subject eligibility before the experimental session. Only children who met subject selection criteria were seen for the experimental session.

Experimental Session

Setting

The experimental session, like the second preexperimental session, was conducted in a sound-proof booth. The experimental session lasted from 20 to 40 minutes and was completed within two weeks of the initial preexperimental session. One parent was invited to be present in the booth with the child and the investigator. The child was seated at a child-sized table across from the investigator. The parent was directed to sit beside the child and asked to provide general encouragement for the child to remain attentive to tasks but not to restate instructions from the investigator or the stimuli. The parent was cautioned against using eye gaze to the correct picture response. Some children sat on the lap of the parent.

Auditory stimuli were presented using an audiotape player (Marantz, Model PMD-430) coupled to a single, small speaker (Magnavox, Model AZ8055). The speaker was placed in front of the investigator facing the child. The audiotape player was placed on a shelf under the table within the investigator's reach but out of the child's view to decrease distraction from its operation. Picture stimuli were placed directly in front of the child.

Training Task

A training procedure was used before introduction of the experimental task. Six pages using foil action pictures were created. Two pages had two pictures; two pages had three pictures; and two pages had four pictures. Third person present tense in an interrogative sentence using "who" was used (see Table 2). This was selected to introduce the question word, "who," without training the present progressive auxiliary plus verb -ing used in the experimental stimuli. Auditory stimuli were presented via audiotape recorded by the investigator using a child-directed prosody. Care was taken to introduce pictures and actions before playing the training stimuli, so that subjects were trained to scan picture stimuli and to match the auditory stimulus to the correct action picture. The investigator gradually faded prompts to point and labeling of pictures across training

Table 2

Stimuli for Training Task

Stimulus	Target Actions and Foils
1. Show me who talks.	washing (1), talking (2)
2. Find who drinks.	drinking (3), playing (4)
3. Hey! Who sleeps?	playing (1), sleeping (3), sitting (4)
4. Look! Who reads?	reading (1), drumming (2), drinking (3)
5. Who waves?	skating (1), waving (2), crawling (3), swinging (4)
6. Who splashes?	sweeping (1), skating (2), pushing (3), splashing (4)

Note. Page positions are in parentheses. They are numbered from 1 to 4: 1 = top, left; 2 = top, right; 3 = bottom, left; and 4 = bottom, right.

items. Picture scanning, listening, attempts to point, and correct responses were reinforced with verbal praise and clapping by both the investigator and parent. Children were considered adequately trained if they correctly identified three of six items, then the experimental task was initiated.

Experimental Task

Following training, the stimulus book was placed before the child and the child was reminded verbally of the task to listen and to find the picture. For most children, the investigator needed to point to each of the four choices on each page to assist children in scanning pictures before presenting the auditory stimulus. The auditory stimulus was played as the child looked at the picture page. For children who began to name pictures spontaneously, the investigator engaged in pointing and labeling all pictures before proceeding with the experimental stimulus. Labeling by the investigator focused on labeling objects or people (e.g., "a book" for reading or "look at the girl here"). Time to respond was provided. Only pointing and touching responses were accepted, thus children who responded verbally or with eye gaze were prompted to touch the picture. If children did not respond given a prompt to touch the picture, that item was scored as no response. If the child remained attentive, repetitions of stimuli initially scored as no responses were provided after all 16 items were attempted.

All responses were reinforced with administration of tangible (i.e., large pegs with peg board, pennies, and stickers) and food reinforcers (i.e., fruit-flavored gummy candies and bite-sized cookies) immediately following the child's response. Verbal praise for participation and reinstruction were introduced following presentation of the reinforcer. When children did not respond to an item, reinstruction and repetitions of the stimulus were presented. Only first responses were counted unless the child self-corrected before the investigator administered the tangible reinforcer. As in Gerken and McIntosh (1993), children who attempted to point to fewer than 4 of 16 pictures were excluded from the study. Children's responses were recorded by the investigator during administration and rescored using the videotape.

Audiotape and Videotape Recording

The preexperimental session in the home was recorded on audiotape (Maxell High Bias) using an audiocassette deck (Sony, model TC-RX606ES) and two tie-clip microphones (Sony, model ECM-T150) placed on a stand in close proximity to participants. For sessions at The University of Tennessee, Knoxville and the University of South Alabama, audiorecording was accomplished with this same audiocassette deck located outside of the booth and connected to an omnidirectional microphone. Videorecording of the preexperimental testing in participants' homes involved a videocamera (Panasonic, model AG-195MUP) and videotapes (Maxell P/I Plus). This videocamera was set up inside the booth for recording sessions held at the University of South Alabama, but a wall-mounted camera (Panasonic, model WV-CS304) was used at The University of Tennessee, Knoxville. Volunteers monitored recording during all experimental sessions.

Reliability

Following data collection, intra- and inter-judge reliability for subjects' responses to the comprehension task were completed for eight videotapes. Four tapes were randomly selected from the SLI group and four were selected from the TD group. A point-by-point percentage of agreement criterion of 95% was set. If 95% agreement was not achieved, the investigator would remeasure points of disagreement for error analysis. All subjects' responses judged prone to error would be rescored and reliability procedures would be repeated.

A separate reliability procedure for subjects' transcripts was completed using four randomly selected subjects, two SLI and two TD. Agreement for MLU, as computed by SALT, was established to determine if original and remeasured MLUs were computed within 0.2 morphemes. For MLU reliability, the standard error of measurement (SEM) was determined by calculating differences between original and reliability scores and squaring the differences. The sum of the squared differences was then divided by 2 X N (where N = total number of observations). The square root of this number was the SEM. "Is" use was remeasured via original audiotapes with a criterion of 90% agreement for number of "is" productions. Phonological screening criteria were rechecked with a standard of 90% agreement. If predetermined levels of agreement were not reached, specific measurements would be repeated by the investigator. Aspects that were problem-prone would be corrected, and reliability procedures would be redone.

Statistical Analyses

Before completing statistical analyses to test research questions, summary statistics were completed for preexperimental language measures. Means for MLU, receptive and expressive language standard scores, and percentage of "is" use were computed, and t tests were performed to determine differences between groups.

Research questions addressed one between-subjects variable and one within-subjects variable. The between-subjects variable was group, TD children versus children with SLI. The within-subjects factor was morpheme context with four levels of varying function morphemes. A second between-subjects factor, gender, was included in the model because of related research that found gender effects.

The behavior under investigation was the number of correct responses given a limited yet variable number of trials for each of the four morpheme contexts on the comprehension task. The response for each trial was a discrete outcome that could attain only two values, correct or incorrect (Ott, 1993). Correct responses for subjects within contexts were summed to obtain the total number of correct responses for *n* trials ($n = 0$, 1, 2, 3, or 4 representing the number of trials completed by the subject for a given morpheme context). Thus, the profile of these data fit the definition of a binomial random variable with a small discrete *n*.

General estimating equations (GEE) was the statistical modeling procedure considered optimal for use with binomial data with a small *n* and a repeated measures design. Specifically, the Generalized Linear Modeling (GENMOD) procedure of the SAS System was used. Other well-known statistical modeling procedures (ANOVA, t-tests, and linear regression) were less appropriate because they assume a response variable that is normally distributed and at least interval level. Likelihood ratio chi square (χ^2) estimates were reported, and a significance level of 0.05 was used.

Chapter 3

Pilot Study

Piloting occurred in two phases. Phase 1 was conducted to obtain preliminary results of verb comprehension abilities for typically developing (TD) subjects in four morpheme contexts: (a) grammatical auxiliary “is,” (b) omitted auxiliary, (c) ungrammatical morpheme “in,” and (d) nonsense syllable “id” or “il.” Phase 2 was conducted to test procedural modifications made after Phase 1 including picture and auditory stimuli with TD subjects who met all subject selection criteria.

Pilot Study: Phase 1

Participants

A total of 19 TD children, age 23 to 33 months, participated. Only 4 of the 19 children received complete speech, language, hearing and cognitive testing, therefore linguistic levels were generally unknown. Most children produced telegraphic utterances, but some children showed contracted and uncontracted use of "is." Five of the 19 children participated in piloting of declaratives for the four morpheme contexts (e.g., “Pete is jumping.), and the other 14 heard interrogative stimuli (e.g., “Who is jumping?). These 14 were divided into two subject groups: an "older" group consisting of 9 subjects older than 30 months who displayed evidence of "is" use, and a "younger" group of 5 children under 30 months of age with limited or no use of "is." Subjects in the younger group were generally representative of the intended population for this investigation, whereas subjects in the older group may have had “is” use closer to mastery levels.

Method

At the start of pilot testing, the experimental task consisted of declarative sentences (e.g., Pete is kicking.) rather than interrogatives (e.g., Who is kicking?) for the four morpheme contexts. The picture book was designed as described in the method chapter and sentence stimuli were recorded and measured, although not digitally edited. Five children were easily trained to point to pictures in a children's book, however they were not successful in the picture selection task given recorded declarative stimuli. Therefore, modifications were made, and these children were not included in the following results.

Fourteen subjects participated in the picture selection task with sentence stimuli presented via live voice in the interrogative (e.g., Who is pushing?). The nonsense syllable was changed from "il" to "id" to avoid confusion with "Who'll _" or "Who will _" forms. Thus, half of the pilot subjects heard "il" and half heard "id" in the nonsense context.

Results

Unlike statistical procedures described in the method chapter, a two-factor analysis of variance (ANOVA) with one repeated measures factor was utilized. The between-subjects factor was older TD group compared with younger TD children. The four levels of the repeated measures factor were "is," omitted, "in," and nonsense morpheme (either "il" or "id") contexts.

All subjects in both groups responded to all 16 stimulus items. Group verb comprehension scores are reported in Table 3. These scores are based on number of correct responses from a total possible correct of 4.0 in each context. Main effect of group was significant in a two-tailed test, F (1,12) = 32.14, $p < 0.01$. Older subjects had better verb comprehension than the younger group regardless of morpheme context. Main effect of context, using data from both groups, did not achieve significance, F (3, 36) = 2.41, $p > 0.05$. The p value (i.e., $p = 0.08$), however, suggested a trend toward significance given the small number of subjects. Results for the younger group indicated better comprehension for grammatical "is" context (2.60) than for omitted context (1.20), "in" context (1.00), or nonsense context (1.40). No significant interaction between subject group and sentence context was found, F (3, 36) = 1.33, $p > 0.05$.

Given the trend toward within-subjects differences for the younger group, planned comparisons between each ungrammatical context and "is" were conducted. A significant difference was found between verb comprehension in "is" compared to the omitted context and "is" compared to the "in" context ($p < 0.05$). The difference between "is" performance and the nonsense context did not reach statistical significance.

Discussion

Although preliminary, results of Phase 1 revealed higher verb comprehension for young TD children with limited "is" production in the grammatical context "is" than for sentences where "is" was omitted or ungrammatical but not nonsense. This was not true of older TD toddlers; they showed equally good verb comprehension skills across morpheme contexts.

These preliminary results support one research hypothesis. That is, verb comprehension for toddlers is positively affected by the presence of the grammatical auxiliary in a sentence context. Findings extend those of Gerken and McIntosh (1993)

Table 3

Mean Verb Comprehension Scores for Phase 1 of Pilot Study

Subject Group	n	Morpheme Context			
		Is	Omitted	In	Nonsense
Older	9	3.44	2.67	3.44	3.33
Younger	5	2.60	1.20*	1.00*	1.40
Groups Combined	14	3.02	1.93	2.22	2.37

Note. Mean scores represent the average number of verbs correctly identified, from a total of four different verbs in each context. The maximum possible score is 4.0. Asterisks indicate significant differences between these contexts and "is" for the younger group based upon planned comparisons.

* $p < 0.05$

from noun comprehension given a grammatical article to verb comprehension in the context of a grammatical auxiliary. Results for older TD children who were more advanced are consistent with predictions based on the coalition-of-cues model of comprehension (Hirsh-Pasek & Golinkoff, 1996). These children showed "resilient" comprehension abilities, overriding disruptions in sentence structure. TD 3- and 4-year-olds in the study by McNamara et al. (1998) displayed this same pattern of success across contexts.

Phase 1 uncovered several procedures that required modification. Most importantly, experimental sentences were changed from a declarative form (e.g., Pete is pushing.) to an interrogative one (e.g., Who is pushing?) so that young subjects would understand the task. This change in sentence form necessitated a change in the nonsense syllable (i.e., from "il" to "id").

Pilot Study: Phase 2

Participants

Ten TD toddlers, 3 boys and 7 girls, who met all subject selection criteria as outlined in the method chapter participated. Mean age was 27 months with a range from 24 to 31 months, and mean MLU was 2.53 with a range from 2.01 to 3.75 morphemes.

Method

Phase 2 involved digitally edited auditory stimuli and the picture book as described in the method chapter, however procedures for the experimental task differed in several important ways. During Phase 2, subjects were seen for one session in the home and one session at the lab, therefore preexperimental activities not completed in the home were conducted in the same session with the experimental task. Minimal training to the experimental task was provided; children were presented only one training item and no criterion for success in training was established. Additionally, the interstimulus interval for auditory stimuli was five to seven seconds resulting in long pauses between items.

Results

Results are reported in Table 4 as total number correct per total number of responses for each subject in each context. No statistical analyses were utilized, but percentages of accuracy for contexts were computed. Little difference was noted for percentages of correct responses across contexts: "is" = 22%; omit = 30%; "in" = 29%; and "id" = 28%. Of particular concern were low levels of accuracy for subjects regardless of context ($\underline{M}$ = 27%, range = 10% to 50%). These results were considered no better than chance; chance defined as 25% for selecting one correct picture from four choices.

Discussion

Unlike Phase 1, the ten 2-year-olds who participated in Phase 2 performed at chance levels. No differences were observed in percentages of accuracy across morpheme contexts; however, percentages were too low to be considered valid. Given findings, revisions to the experimental task were critical. Modifications to increase attention and improve task performance included: (1) completion of preexperimental criteria in an additional lab-based session; (2) decreased interstimulus intervals from 5-7 seconds to 2-3 seconds; and (3) addition of a six-item, preexperimental training phase with a minimum criterion of 50% accuracy.

Table 4

Subjects' Performance in Phase 2 of Pilot Study

Subject	Age	Sex	List	Morpheme Context Is	Omit	In	Id	Accuracy
01	28	F	1	0/4	1/4	1/4	2/4	4/16
02	25	F	2	1/1	1/1	0/1	0/1	2/4
03	25	F	3	0/3	1/3	3/4	1/4	4/14
04	28	F	4	0/2	0/2	0/1	1/1	1/6
05	30	M	1	2/4	1/3	0/4	1/4	4/15
06	31	F	2	1/4	1/4	2/4	2/4	6/16
07	27	F	3	2/4	1/4	1/4	1/4	5/16
08	25	M	4	0/2	1/4	0/1	0/3	1/10
09	24	F	1	0/4	2/3	1/4	0/3	3/14
10	24	M	3	1/4	1/4	1/4	1/4	4/16
	TOTAL			22%	30%	29%	28%	27%

Note. Age is reported in months. List is one of four stimuli lists with morpheme contexts systematically varied across verbs (see Table 1). Accuracy is the total across contexts for each subject. Performance is reported as number correct per number responses.

Following these modifications, three children repeated the experimental task. Their average percentage of accuracy increased from 27% to 75% across contexts indicating substantial improvements in overall task performance. The following group percentages of accuracy were attained for morpheme contexts: 92% for “is,” 67% for omitted, 58% for “in,” and 83% for “id.” These data fit the pattern established by five younger TD subjects in Phase 1 as well as supporting the research hypothesis of a grammaticality effect.

Conclusion

Phase 1 was conducted to obtain preliminary results for verb comprehension across morpheme contexts for TD subjects. After stimuli were modified from declarative sentences to interrogatives, results for five young TD subjects revealed significantly better verb comprehension in “is” compared to omitted and ungrammatical contexts. In Phase 2, task-related problems resulted in poor performance across contexts for 10 TD subjects. Experimental improvements, including a decreased interstimulus interval and the addition of a training phase, led to substantial increases in performance for three subjects. Their verb comprehension results, “is” better than omitted and ungrammatical contexts, matched trends established in Phase 1 and agreed with findings from previous research.

Chapter 4

Results

Participant Description

Eighty children were seen for preexperimental sessions. Of these, 34 children met all subject selection criteria, but two children were unable to complete the experimental task. A total of 32 children participated, 16 typically developing (TD) (mean age = 26 months, range = 22 to 31 months) and 16 children with specific language impairment (SLI) (mean age = 48 months, range = 42 to 58). Eight boys and eight girls were included in the TD group, but gender was not a selection factor for the SLI group. Thirteen boys and three girls with SLI qualified and participated, a ratio of boys to girls of 4.3:1. This falls at the high end of a range of prevalence ratios, 2.8:1 and 4.8:1, based on large-scale studies summarized by Leonard (1998). Table 5 depicts group performance on preexperimental language measures and Appendix F includes scores for individual subjects.

Receptive and Expressive Language

As expected based upon group definitions and subject selection criteria, independent t tests revealed significant differences between groups for mean language standard scores (see Table 6). The TD group was in the average to above average range commensurate with chronological-age peers, and the SLI group performed below age-level peers. Standard scores were utilized for group determination, but age-equivalents are reported for comparison between groups despite known psychometric limitations. Groups did not differ significantly for expressive language age, $t\ (30) = -1.12$, $p = 0.27$.

Table 5

TD and SLI Groups' Mean Performance on Preexperimental Language Measures

	Typically Developing (mean age = 26 months)			Specifically Language Impaired (mean age = 48 months)		
Language Measures	M	range	SD	M	range	SD
Receptive SS	116	93-137	11.6	78	57-96	9.4
Receptive LA	31	23-36	3.5	37	29-48	6.5
Expressive SS	122	98-139	10.6	76	66-83	5.1
Expressive LA	34	29-41	3.1	35	28-43	4.9
MLU	2.87	2-3.73	0.49	2.91	2-3.75	0.52
% "Is" Use	26%	0-45%	15%	41%	14-60%	14%

Note. SS = standard score (test M = 100, 1SD = +/- 15); LA = language age-equivalent score reported in months; % "Is" Use = percentage of correct "is" production in obligatory contexts from the language sample.

Table 6

T Test Results for Mean Language Measures Between Groups

Receptive Standard Score	10.18**
Receptive Language Age	-3.22**
Expressive Standard Score	15.61**
Expressive Language Age	-1.12
Mean Length of Utterance	-0.22
Percentage "Is" Use	-2.93**

Note. Degrees of freedom were 30 for each t test.
** $p < 0.01$

Receptive language ages for groups were significantly different (t [30] = -3.22, p = 0.003); 37 months for the SLI group and 31 months for the TD group.

The higher receptive language age for the SLI group could be reflective of group composition which included four subjects with average receptive skills for their chronological ages. In order, these subjects and receptive standard scores were as follows: Subject 18 (96); Subject 26 (90); Subject 29 (86); and Subject 32 (88). Receptive language age was averaged for the 12 of 16 subjects with receptive language below average. Despite this, mean receptive language age remained significantly higher for the SLI group (M = 35 months) compared to the TD group (M = 31 months). Note this was true for significance level of 0.05, but not 0.01 (t [26] = -2.39, p = 0.02).

Morphosyntactic Characteristics of MLU and "Is" Use

There was no significant difference between groups for MLU, t (30) = -0.22, p = 0.83. TD mean MLU was 2.87 morphemes and SLI mean MLU was 2.91. As shown in Appendix F, all 16 TD children had MLUs within or above 1 SD from the predicted MLU for their chronological ages. (MLU normative data is based on a 1973 study by Miller and Chapman as cited in Miller [1981].) All children in the SLI group except one, Subject 31, had MLUs more than 1 SD below predicted MLUs for their chronological ages. Subject 31, age 42 months, had an MLU of 3.7 which compared favorably to the predicted MLU of 3.78 for his chronological age. This subject's expressive language standard score of 83 fell only slightly below 1 SD from the test M of 100 (i.e., 85); however, he achieved a receptive language standard score of 78 which is 1.5 SD below the test M.

Another subject selection criterion was percentage of occurrence for "is" in obligatory contexts. Subjects qualified if their "is" use was between 0% to 60% for the 100-utterance language sample. Groups showed a significant difference for "is" use, $t(30) = -2.93$, $p = 0.01$. Mean percentage of "is" use for the TD group was 26%, but the mean for the SLI group was 41%. This difference was unexpected because groups did not differ for expressive language age and MLU.

Reliability

Reliability for Subject Selection Procedures

Reliability for preexperimental criteria was completed for two purposes: accurate description of subjects for comparison to populations of interest and evaluation of experimental findings. MLU, productive "is" use, and speech intelligibility were deemed important. The reliability judge was a masters degree candidate in speech-language pathology at the University of South Alabama. She had prior research experience and a masters degree in educational psychology.

MLU reliability was determined for eight randomly selected subjects; two TD subjects and two subjects with SLI for intrareliability and two from each group for interreliability. Language sample transcripts were checked while listening to original audiotapes, and these revised transcripts were analyzed with SALT to calculate MLU. A summary of original scores for MLU, reliability scores for MLU, and the differences are shown in Table 7. To achieve agreement, the original and reliability transcripts differed by less than 0.2 morphemes. All measurements showed differences substantially less than

Table 7

Reliability Measurements and Differences for Mean Length of Utterance (MLU)

Subject	MLU1	MLU2	Difference
Intrareliability			
TD 1	3.73	3.68	−0.05
TD 2	2.19	2.21	+0.02
SLI 1	2.89	2.92	+0.03
SLI 2	2.56	2.60	+0.04
Interreliability			
TD 1	2.00	1.95	−0.05
TD 2	3.10	3.03	−0.07
SLI 1	3.45	3.39	−0.06
SLI 2	3.21	3.24	+0.03

Note. MLU1 = MLU from original transcript for subject selection; MLU2 = MLU from reliability transcript.

the established criterion of 0.2 morphemes. SEM was also calculated and revealed 0.037 morphemes for intrareliability and 0.054 for interreliability.

Percentages of "is" production were recalculated using original audiotapes. These are reported with percentages of agreement in Table 8. Two separate percentages of agreement were calculated. The first was based on total number of productions, and the other was determined by number of obligatory contexts. The intrareliability percentage of agreement for number of "is" productions was 98% and for interreliability, 90%. Agreement for obligatory contexts was lower, 94% for intrareliability and 86% for interreliability.

Lastly, the above transcripts were rescored for compliance with preexperimental speech criteria. All subjects met the original speech criteria for final [s, z] and two-syllable word production. Agreement for intrareliability and interreliability measurements was 100%.

<u>Reliability for Experimental Task Results</u>

The same interjudge who performed preexperimental criterion checks also viewed experimental tapes for rescoring. A total of 16 randomly selected subjects or 50% were rescored; four TD subjects and four subjects with SLI for intrareliability and four TD and four with SLI for interreliability. Videotapes from experimental sessions were utilized; guidelines for scoring are in Appendix G. Item-by-item percentages of agreement were calculated. Intrareliability for the experimental task was 99% (i.e., 127/128 X 100). The investigator had 100% agreement (16/16 items) for seven of eight tapes reviewed; there was one disagreement (15/16) for one subject (Subject 19). Interreliability was 98% (125/128 X 100). Again, only one of the eight tapes had any disagreements. For this

Table 8

Reliability Measurements and Percentage of Agreement for "Is" Use

Subject	Correct Is T1	Correct Is T2	Correct Is % Agreement	Obligatory Contexts T1	Obligatory Contexts T2	Obligatory Contexts % Agreement
Intrareliability						
TD 1	1	1	100%	19	20	95%
TD 2	4	4	100%	17	16	94%
SLI 1	6	6	100%	10	10	100%
SLI 2	11	12	92%	19	22	86%
Intrareliability % Agreement =			98%			94%
Interreliability						
TD 1	0	0	100%	5	6	83%
TD 2	4	6	67%	15	18	83%
SLI 1	11	12	92%	20	21	95%
SLI 2	3	3	100%	14	17	82%
Interreliability % Agreement =			90%			86%

Note. T1 = count from original transcript; T2 = count from reliability transcript.

subject (Subject 7), the interjudge labeled three items that were scored by the investigator as no responses. Overall, reliability results exceeded the predetermined criterion of 95% agreement.

Statistical Analyses

Verb comprehension results for each group in the four morpheme contexts are reported in Table 9. Results are reported as percentages of accuracy or number of correct responses per total number of responses. Individual subjects' verb comprehension results are shown in Appendix H.

The general estimating equations (GEE) analysis was used to test for differences between groups and among morpheme contexts. Specifically, the Generalized Linear Modeling (GENMOD) procedure of Statistical Analysis System (SAS) for discrete data was used. Because data did not show compound symmetry for groups across repeated levels, the GEE model correlation structure was set to unstructured.

Table 10 includes likelihood ratio χ^2 estimates for between-subjects factors (group and gender), the within-subjects factor (morpheme context), and interaction terms. Results for the between-subjects factor of group, TD versus SLI, were significant ($\chi^2[1] = 6.27$, $p = 0.01$), but results for the within-subjects factor of morphosyntactic context were not significant ($\chi^2[3] = 0.82$, $p = 0.85$). A main effect of gender was not found, $\chi^2(1) = 2.35$, $p = 0.12$.

Table 9

Group Percentages of Accuracy for Varying Morpheme Contexts

Group	Morpheme Context			
	Is	Omit	In	Id
Typically Developing (n = 16)	63% (37/59)	62% (34/55)	70% (43/61)	61% (36/59)
Specifically Language Impaired (n = 16)	81% (50/62)	83% (53/64)	70% (45/64)	84% (54/64)

Note. Number of correct responses per total number of responses summed by group in each context are reported in parentheses.

Table 10

General Estimating Equations (GEE) Likelihood Ratio Chi Square Estimates

Source	df	χ^2
Group	1	6.27*
Context	3	0.82
Context X Group Interaction	3	4.86
Gender	1	2.35
Group X Gender	1	2.76
Context X Gender	3	0.64

*$p < 0.05$

The children with SLI demonstrated significantly higher verb comprehension (M = 80%) than the TD group (M = 64%). Children with SLI outperformed TD children for three of four contexts, "is," omit, and "id." Both groups had 70% accuracy for the "in" context. Thus, TD children demonstrated their highest performance in the "in" context, but the opposite was true of subjects with SLI who showed their poorest performance for the "in" context. Despite opposite trends for verb comprehension in the "in" context by the two groups, context by group interaction was not significant, $\chi^2(3) = 4.86$, $p = 0.18$.

A planned contrast for "is" context versus "in" context within the SLI group was tested. This contrast was of interest because of McNamara et al.'s (1998) report that subjects with SLI had higher noun comprehension given grammatical "the" compared to ungrammatical "was." Contrary to their finding, no significant difference was found, $\chi^2(1) = 0.36$, $p = 0.55$.

Qualitative Analyses

Because no significant differences were found for subjects' verb comprehension in varying morphosyntactic contexts, some qualitative analyses of data and stimuli were undertaken. The two purposes for these analyses were to examine differences between individual performance and group performance and to study the effect of scoring procedures on outcomes.

Individual Performance Factors

Although group results revealed no significant difference among morpheme contexts, one possibility was that subsets of the total group might show patterns of verb comprehension associated with morpheme contexts. The investigator studied individual

TD subjects' performance and observed that subjects loosely fit one of three patterns. (See individual subjects' results in Appendix F). For six subjects (Subjects 1, 6, 7, 11, 15, 16), "is" context was one of the contexts in which they showed their highest verb comprehension. However, for five subjects (Subjects 2, 3, 9, 12, 13), grammatical "is" was one of the contexts in which they showed relatively low verb comprehension. And, five subjects (Subjects 4, 5, 8, 10, 14) showed verb comprehension for "is" context at generally equivalent levels compared with their overall performance across the four morphosyntactic contexts. Results of this qualitative evaluation are consistent with findings from statistical analyses that revealed no differences for morpheme contexts.

Results of individual subjects with SLI were also studied for patterns of performance across morpheme contexts. Four children had 0 or 1 correct response in one context: Subjects 23 and 27 had relatively low accuracy for "is" context and Subjects 24 and 30 for "in" context. Pattern detection for the SLI group was hampered by overall high accuracy. Two subjects with SLI, Subjects 25 and 26, achieved 100% accuracy for all 16 items. Like the TD group, these observations are consistent with statistical analyses that revealed no differences for morpheme contexts.

Scoring Procedures

Scoring might have affected overall findings because responses were coded only as "correct" or "incorrect." Qualitative changes in responding (i.e., delays, no responses, self-corrections, and ambiguous responses) might have differed in morpheme contexts. To evaluate this possibility, all experimental task videotapes for the TD group were rescored. The investigator used a qualitative scoring system with the following response types: (1) correct; (2) correct, but delayed; (3) self-corrected; (4) correct after a repetition of the auditory stimulus; (5) incorrect; and (4) no response. Responses that required prompts by the investigator to complete the task (i.e., "touch the picture") or responses that were judged to be impulsive were tracked. Verbalizations (e.g., repeating the stimulus or requesting clarification) and gestures (i.e., acting out the action) were also registered.

Results revealed no changes in group findings. Only 2 TD children, Subjects 4 and 14, showed delayed responses and no responses in ungrammatical contexts more often than in the "is" context. The TD group's delayed responses were tallied by context revealing: 9 delays for "is," 4 for omitted, 11 for "in," and 6 for "id." Analysis of delayed responses by the SLI group was not conducted because of their high levels of accuracy overall.

Another aspect of the scoring procedure was the decision to allow repetitions. This could have masked poor responding behaviors associated with decreased comprehension. To assess this, results were rescored for the TD group eliminating repetitions and counting no responses as errors. Revised percentages of accuracy are compared to the original scoring results in Table 11. Changes were minimal; statistical analysis to test differences was not conducted.

Stimuli Factors

Although picture stimuli were carefully designed to reduce introduction of confounding variables, two aspects of TD children's responses related to picture stimuli were assessed. First, the investigator studied error rates for individual verbs. Mean number of errors for the 16 verbs was 5.25 (see Table 12). Two verbs, crying and

Table 11

TD Group's Verb Comprehension Results With Revised Scoring

Scoring Procedure	Morpheme Context			
	Is	Omit	In	Id
Original Scoring	63% (37/59)	62% (34/55)	70% (43/61)	61% (36/59)
Revised Scoring	60% (37/62)	52% (33/63)	62% (39/63)	51% (33/64)

Note. Number of correct responses per total number of responses summed by group in each context are reported in parentheses.

blowing, were correctly selected more often than others. Four verbs showed higher error rates: pushing, painting, cutting, and biting. Error rates associated with page position were also calculated. The highest number of errors (29) occurred for page position 3, the bottom, left corner. Page positions 1 (top, left) and 2 (top, right) had very similar error rates, 21 and 22 respectively. The fewest errors (12) occurred in page position 4, the bottom, right corner. This suggests that children preferred page position 4 when responding. Note that neither verb error rates nor page position preferences can explain findings for verb comprehension across morpheme contexts.

Table 12

TD Group's Error Rates for Individual Verbs Ordered by Page Position

Page Position	Verb	Number of Errors
1	playing	7
1	kissing	6
1	kicking	5
1	climbing	3
2	pushing	9*
2	painting	8*
2	catching	4
2	crying	1*
3	cutting	10*
3	biting	8*
3	cooking	6
3	clapping	5
4	pouring	4
4	jumping	4
4	building	3
4	blowing	1*

Note. Page positions are designated as 1 = top, left; 2 = top, right; 3 = bottom, left; and 4 = bottom, right.
* denotes verbs that had error rates >1 SD (+/- 2.67) from M (5.25)

Chapter 5

Discussion

Summary of Research Questions and Results

The purpose of the study was to examine the effect of morphosyntactic cues, specifically morpheme context, on verb comprehension for two groups of telegraphic speakers, typically developing (TD) toddlers and preschoolers with specific language impairment (SLI). Of primary interest was whether telegraphic speakers would show higher verb comprehension for interrogatives containing a grammatical auxiliary (Who is pushing?) compared with interrogatives containing no auxiliary (Who ϕ pushing?), an ungrammatical function morpheme (Who in pushing?), or a nonsense syllable (Who id pushing?). This research question was an extension of findings by Gerken and McIntosh (1993) that toddlers' comprehension of nouns was significantly greater for imperatives containing the grammatical article "the" when compared to imperatives containing an ungrammatical function morpheme "was" or a nonsense syllable "gub." Thus, it was predicted that TD children would show better verb comprehension for the grammatical "is" context than for ungrammatical "in" and nonsense "id" contexts.

The second research question asked if two groups of MLU-equivalent, telegraphic speakers would show similar verb comprehension performance. The investigator hypothesized that children with SLI would show decreased verb comprehension when compared to an MLU control group. This prediction was based upon two sources of evidence. First, children with SLI exhibit relative weaknesses for verb learning and morphosyntax compared with younger TD peers. Secondly, McNamara and colleagues

(1998) found children with SLI had low levels of noun comprehension accuracy, 64% and 73% for two experiments, using Gerken and McIntosh's (1993) task.

Contrary to predictions of an effect of syntax on verb comprehension, results of this investigation supported acceptance of the null hypothesis. Data analysis revealed no differences in children's verb comprehension across morphosyntactic contexts. Overall, children were successful comprehending the verb regardless of morpheme variation. Factors that likely supported children's successful performance are explored. Several possibilities regarding children's sensitivity to grammatical morphemes warrant evaluation.

The second research question, which projected group differences, showed a statistically significant result and the null hypothesis was rejected. A significant difference in verb comprehension performance was found for the two groups, TD children and children with SLI. However, unlike the initial hypothesis, the children with SLI performed with higher accuracy than the younger TD group for at least three of four morpheme contexts. Subject group comparisons revealed that the groups could be considered equivalent based on some language measures but that they diverged in other important ways; therefore, differences in verb comprehension performance may be based in group differences.

Group Differences in Verb Comprehension

Similarities and differences between subject groups are explored relative to differences in verb comprehension performance. Groups were equivalent on two measures, expressive language age and MLU. Thus, they are presumed to be from a population of children performing within the same expressive language stage; although subjects with SLI were older than TD subjects. An age-equivalent group of TD children was not included because of a ceiling effect on the comprehension task for a TD group (mean age = 47 months) in a study by McNamara et al. (1998). In addition to age differences, subject groups in this investigation differed for age-related cognitive skills, receptive language age, and productive "is" use. These factors are considered relative to higher verb comprehension scores by the SLI group compared to the younger TD group.

Age Advantage of SLI Group

The straightforward explanation for the significantly better performance of the children with SLI lies in chronological age differences. As a group, children with SLI were almost two years older (M = 48 months) than the TD group (M = 26 months). There are several reasons to consider increased age an advantage in a picture selection task of verb comprehension, although it is not clear that age by itself would benefit the older group because they were language-impaired.

Task analysis provides a basis for judging the developmental nature of verb comprehension using picture selection. Children had to scan four pictures and begin to conceptualize actions depicted. Children then had to attend to the auditory stimulus. They needed to grasp the idea of matching the auditory stimulus to a pictured action, and retention of the auditory stimulus in working memory probably played a role. Finally, children needed a pointing or touching response to indicate the selected picture. Older children in general have stronger skills for a picture selection task. Accordingly, developmental limitations for structured procedures are a hallmark of early childhood, and comprehension research with young toddlers has been beset by methodological challenges.

One indication that younger TD children had more difficulty in the verb comprehension task is the difference in total number of responses, both correct and incorrect, for the two groups. The TD group did not respond to 26 items, 10% of the total possible (16 possible items X 16 subjects = 256 total possible responses for each group). Only two items from the SLI group were forfeited, yielding <1% loss of total possible items. Thus, the TD group responded to substantially fewer items than the SLI group, 90% and 99% respectively. These results support the interpretation that the younger TD group had more task-related difficulty.

Prior exposure to picture selection tasks might have benefitted the children with SLI. All subjects with SLI had participated in standardized testing including picture selection tasks previously, and the majority of them were receiving speech-language services which likely included similar activities. Other than joint storybook reading with care givers, young TD children may have no experience with structured picture selection.

Conspicuously missing from the above task analysis is a description of linguistic processing. Language comprehension, afterall, was the focus of study. Because comprehension cannot be measured directly, behavioral results from the picture selection task are used to infer subjects' comprehension. Factors and theories related to processing the linguistic stimuli are addressed following this discussion of group differences.

<u>Age-Related Cognitive Advantage</u>

The subjects with SLI had nonverbal cognitive skills generally commensurate with their chronological ages, therefore a cognitive advantage accompanied the age difference. This was expected. Research has found that children with SLI outperform language-matched children on tasks of nonverbal cognition, although they perform significantly below chronological age-matched peers (Johnston, 1994).

Part of the cognitive advantage consists of additional life experience, and this world knowledge is the source for vocabulary development. All children in the study, both TD and SLI, reportedly knew at least 14 of the 16 verbs. The depth of their knowledge, however, was not assessed. Young children often show under-representations in word meanings (Owens, 1996). That is, 2-year-old children might know the verb "cut" but perhaps only in the context of a care giver cutting food into pieces. Older children with broader experiences and expanded definitions might understand "cut" with scissors and paper. Thus, higher verb comprehension performance by older children could be the result of expanded word associations due to greater world knowledge.

A drawback to this interpretation is that children with SLI often show limitations in vocabulary development. They are delayed in acquisition of their first words and show deficits in novel word learning, especially for verbs (Rice et al., 1994). These deficits, however, are most likely to emerge during word retrieval or production tasks, not identification tasks (Leonard, 1998). More pertinent to this discusson of world knowledge and word associations is the variable of receptive language age.

Receptive Language Advantage

Groups were not equivalent for receptive language age. Receptive language age for the SLI group (M = 37 months) was significantly greater than receptive language age for the TD group (M = 31 months). This advantage could explain higher verb comprehension performance because children with more mature receptive language skills are expected to have superior vocabulary breadth and depth.

McNamara et al. (1998) found that TD 3- and 4-year-olds had high levels of noun comprehension (approximately 82%) despite aberrant morpheme contexts. They concluded that older children were able to override sentence anomalies to complete the comprehension task. Hirsh-Pasek and Golinkoff (1996) also predicted that by age three TD children have comprehension skills that are based more upon the ability to process sentential meaning and rely less upon redundant input cues and environmental support. In summary, advanced receptive language ability is associated with increases in content word comprehension.

Productive "Is" Use Differences

One aspect of expressive language, percentage accuracy for "is" use in obligatory contexts, was found to differ significantly between groups, 41% accuracy for the SLI group and 26% for TD. This was unexpected given repeated findings that children with SLI show deficits in morphosyntactic production when compared to younger, MLU-matched, TD children (e.g., Leonard, Bortolini, et al., 1992; Leonard & Eyer, 1996; Leonard et al. 1997). Differences in subject matching procedures for this study and prior studies could explain this finding; other studies matched TD children one-to-one with children with SLI based upon MLU. Another difference lies in the age of children in this study who were younger and less linguistically advanced. Support for this conclusion comes from two reports of greater productive use of grammatical morphemes, including "is," by children with SLI compared to language-matched peers (Ingram, 1972;

Morehead & Ingram, 1973). This pattern of SLI better than TD was true only for groups at linguistic levels of MLU < 3.0 morphemes.

As for SLI subjects' verb comprehension, it is possible that increased "is" use in production reflects higher levels of knowledge for this form or for morphosyntax in general. Increased knowledge might facilitate increased verb comprehension. Percentages, however, fall well below levels of mastery. The assumption, therefore, that higher degrees of use indicate something different than lower degrees of use is not conclusive.

Summary of Group Differences

A significant difference in verb comprehension favoring children with SLI over younger TD children was found. Although groups were equivalent for expressive language stage, several group differences existed that might explain results. The most likely explanation is that children with SLI performed better because they were older. Children with SLI responded to a substantially greater number of items, both correct and incorrect, than the TD group, suggesting better overall performance for the picture selection task regardless of accuracy. Unfortunately, the simple solution of age advantage is complicated by the SLI group's advantages in age-related cognitive skills, receptive language and productive "is" use.

Children's Verb Comprehension Across Morpheme Contexts

Both subject groups, TD and SLI, showed equivalent verb comprehension for all morpheme contexts. Because performance across morpheme contexts was undifferentiated for TD children and children with SLI, discussion of factors associated with verb comprehension can be applied to both populations.

Equivalent verb comprehension across morpheme contexts does not mean that subjects were insensitive to differing function morphemes. Other researchers have demonstrated telegraphic speakers' sensitivity to varying morphemes (Gerken & McIntosh, 1993; Golinkoff et al., in press; McNamara et al., 1998; Shady, 1997). Additionally, perception of morphemes in the input is presupposed when children are demonstrating production of these same morphemes. All subjects in this investigation, except two, showed some "is" productions, and they all produced the foil morpheme "in" with mastery levels of accuracy for obligatory contexts. They also showed production abilities for weak syllables in multisyllabic words and word-final fricatives [s, z] in nonmorphophonemic contexts. Thus, it is evident that participants had the ability to process relatively small changes in phonemic and morphophonemic contexts.

Children in this study were successful comprehending target verbs despite morpheme variation. The following factors associated with children's successful verb comprehension are explored: (1) utterance position of target words, (2) verb durations, and (3) co-occurrence of morpheme -ing. The influence on verb comprehension of these three factors, separately or together, is compelling.

Utterance Position of Target Verbs

Verbs in this investigation were presented in utterance-final position (e.g., Who is pushing?). Utterance-final position is accorded special status in English and universally. The first universal operating principle proposed by Slobin in 1973 was "pay attention to ends of words," and crosslinguistic research has revealed the presence of salient cues for final syllables and words in clause-final position (Slobin, 1985). In English, words placed in utterance-final position are often marked by increased vowel durations, pauses, and changes in intonation contour. This is exaggerated in child-directed speech (CDS) (e.g., Fernald & Mazzie, 1991; Swanson & Leonard, 1994).

Evidence for the effect of word position on content word comprehension was reported recently by Shady and Gerken (1999). Shady and Gerken utilized the grammatical, ungrammatical and nonsense morpheme contexts of Gerken and McIntosh (1993) and tested an additional factor, utterance length and position of the target word. That is, half of the TD subjects heard the target noun in short utterances in utterance-final position (e.g., "Find the <u>dog</u>" and "Find was <u>bird</u>") and half heard the target noun in longer utterances in medial position (e.g., "Find the <u>dog</u> for me" and "Find gub <u>bird</u> for me"). In addition to replicating the grammaticality effect of Gerken and McIntosh, results revealed a significant effect favoring shorter utterances and utterance-final targets (69% accuracy) compared to longer utterances and medial position targets (51%). Shady and Gerken concluded that cues associated with utterance-final position play an important role in sentence comprehension for 2-year-olds.

Children in this investigation, like Shady and Gerken (1999), heard target verbs in utterance-final position, and their comprehension of target verbs probably was facilitated by utterance-final placement. Although Shady and Gerken manipulated target word position and the overall length of the utterance, they did not report manipulation of word durations in medial versus final target-word position. Utterance-final position, however, is associated with syllable lengthening. In this investigation, children's verb comprehension was supported by exaggerated durations typical of words in utterance-final position in CDS.

Verb Durations

Associated with utterance-final position are increases in duration (e.g., Klatt, 1975; Swanson & Leonard, 1994). Average duration for target verbs in this study (e.g., catching, biting) was 926 ms (range was 909 to 948 ms). Long durations of target verbs doubtless facilitated children's verb comprehension in this investigation and may explain differences compared to findings of Gerken and colleagues (Gerken & McIntosh, 1993; McNamara et al., 1998).

Although content word durations were not reported by Gerken and McIntosh (1993), Shady and Gerken (1999) measured durations for similar sentence stimuli created with DECTalk. They reported a mean duration of 283.3 ms for target content words. (It is assumed that stimuli durations reported by Shady and Gerken are consistent with stimuli durations from Gerken and McIntosh.) A large discrepancy in target word durations existed, such that children in this investigation had a distinct advantage for processing target words when compared to children in studies by Gerken and colleagues (Gerken & McIntosh, 1993; Shady & Gerken, 1999).

Fernald and McRoberts (1993) recognized the confounding influence of utterance position with duration, so they tested infants' comprehension for nouns of long and short durations positioned medially in utterances. Twenty-four 15-month-olds were shown slides of object pairs and presented target nouns in carrier phrases (e.g., "There's a dog over there;" "Look at the cookie over there"). Visual looking time to target slides was used to infer children's comprehension of nouns. Target words of short duration averaged

253 ms (e.g., "dog" = 191 ms, "cookie" > 300 ms). Long duration words averaged 584 ms (e.g., "dog" ≈ 500 ms, "shoe" = 690 ms). Fernald and McRoberts found a significant effect of word duration with increased looking time to the matching event for long duration nouns. These authors concluded that comprehension for 1-year-olds is enhanced by increased durations for target words embedded medially.

As confirmed by the investigation of Fernald and McRoberts (1993), the target verbs' long durations in this investigation are believed to have assisted children's comprehension. Target verbs in this study were longer (926 ms) than the long duration nouns (584 ms) in the study by Fernald and McRoberts. Utterance-final verb durations in this investigation were exaggerated by the co-occurrence of morpheme -ing, and morpheme -ing durations averaged 416 ms (M determined for 16 of 64 stimuli sentences). Thus, children in this investigation were presented target verbs in lengthened, utterance-final position further marked by final position morpheme, -ing. Morpheme -ing may have highlighted the verbs, not simply with increased overall durations, but because of its morphosyntactic role.

Co-occurrence of Morpheme -ing

In this investigation, co-occurrence of morpheme -ing with auxiliary "is" to encode present progressive verb tense may have been a factor affecting results. Research with 18-month-old infants has revealed infants' knowledge of the relationship between auxiliary "is" and morpheme -ing; such that, the infants showed less attention to stories in which auxiliary "is" was replaced by ungrammatical modal "can" in the present progressive tense (Santelmann & Jusczyk, 1997).

The presence of the second morpheme, -ing, could have facilitated verb comprehension regardless of experimental manipulation of "is." Evidence for the salience of -ing over "is" is found in acquisition data. Production research has established English-speaking children's early acquisition of -ing relative to other morphemes (e.g., article "the," third person present tense -s, and copula and auxiliary "is"). Crosslinguistic research of discontinuous forms such as English present progressive (i.e., forms of "be" + verb + ing) and French negative (i.e., ne + verb + pas) has revealed that children produce the second of the two elements earlier than the first (as cited in Peters, 1985). Perceptual salience is a likely factor. Increased salience for -ing is due primarily to its frequent occurrence in utterance-final position with associated lengthening, unlike "is" which most often occurs medially in its contracted form (e.g., Who's pushing?).

Subjects' -ing Production

Although speculative, production data from subjects in this investigation can help to evaluate the relationship between knowledge of -ing and verb comprehension. If subjects produced -ing more often than "is," then their knowledge of -ing might be more advanced than their knowledge of "is." And, more advanced knowledge of -ing could have supported accurate verb comprehension regardless of "is" variations. Given this possibility, subjects' -ing production was evaluated using preexperimental language sample transcripts.

Based upon production data, TD subjects' knowledge of -ing was better than their knowledge of "is." Percentage of accuracy for -ing use by TD children was approximately 54%, and it was 26% for "is." Three TD subjects had 0% use of -ing in obligatory contexts, and three had 100% use. Note that 13 of the 16 TD subjects had higher percentages of -ing production than "is."

SLI subjects' production of -ing approached mastery levels (M = 71%). No productions or obligatory contexts were found in the transcripts of 3 of the 16 subjects with SLI, so only 13 children were used for computing group mean. Range of use was 25% to 100%. Twelve of these 13 subjects with SLI showed higher -ing use than "is" production. Overall, children with SLI had higher -ing production (71%) compared to "is" (41%).

This production data supports the hypothesis that children's advanced knowledge of -ing compared to "is" facilitated verb comprehension across morpheme contexts. Interestingly, children with SLI showed higher percentages of -ing use in obligatory contexts than TD children, 71% and 54% respectively. Perhaps SLI subjects' higher -ing production was a factor in their better verb comprehension performance compared to TD subjects.

Verb Comprehension and -ing

Researchers have begun to explore young children's sensitivity to -ing. As reviewed in chapter 1, Golinkoff et al. (in press) compared verb comprehension by 18- to 20-month-olds in a preferential looking paradigm for three contexts, grammatical morpheme -ing (Which one is drinking?), ungrammatical morpheme -ly (Which one is drinkly?), and nonsense syllable -lu (Which one is drinklu?). Morpheme context was a between-subjects factor, so 48 subjects were divided into three groups. Longer visual fixation times were revealed for the matching video event in the -ing context compared to

-ly and -lu contexts. Golinkoff et al. concluded that children not yet producing -ing are sensitive to a grammatical morpheme bound to verbs.

Subjects in this study heard verbs bound to -ing regardless of "is" variations. Given findings for 1-year-olds by Golinkoff et al. (in press), it is likely that subjects were sensitive to -ing, and co-occurrence of -ing aided their verb comprehension. Furthermore, subjects showed production of -ing at higher levels of accuracy than their "is" use suggesting advanced knowledge.

Summary of Primary Factors Associated with Verb Comprehension

Three related components, taken together or viewed separately, can explain subjects' successful verb comprehension in this investigation. First, target verbs were heard in utterance-final position, a position associated with perceptual and cognitive salience. Consistent with utterance-final position and CDS, target verb durations were lengthened. Finally, verbs were bound to -ing, a highly salient, early developing morpheme. Given these factors, it is conceivable that verbs were highlighted in the stimuli, thereby promoting subjects' comprehension regardless of morpheme contexts.

Other Factors Pertaining to Verb Comprehension

Although the above three variables are believed to have facilitated subjects' verb comprehension, they may not provide sufficient explanation for equivalent performance across morpheme contexts. For example, Shady and Gerken (1999) found a significant effect of short utterances with final position targets, but they also found a main effect of morpheme grammaticality. Three additional factors in this investigation warrant discussion because they relate to theories of children's sentence processing: (1) acoustic characteristics of study stimuli, (2) phonological characteristics of morpheme contexts, and (3) contextual support for comprehension.

Acoustic Characteristics of Study Stimuli

This investigation's auditory stimuli were created to control acoustic factors while maximizing naturalness. Other comprehension studies acknowledged a trade-off in this area. Some researchers have presented sentence stimuli with varying morphemes via live voice to maintain naturalness for young subjects (Golinkoff et al., in press; Petretic & Tweney, 1977; Shipley et al., 1969). Interpretation of findings from these studies is limited by reliability of live voice presentation across contexts. Gerken and colleagues (Gerken & McIntosh, 1993; McNamara et al., 1998; Shady & Gerken, 1999) created recorded stimuli through rule-based synthesis (i.e., DECTalk). Although this controlled prosodic factors of study stimuli, rule-based synthetic speech is associated with reduced acoustic signals rather than highly redundant, acoustic-phonetic cues present in natural speech (summarized in Reynolds & Fucci, 1998). This investigation followed Gerken and McIntosh's lead by using tape-recorded, synthesized stimuli; however, auditory stimuli for this study were created using an LPC synthesis process (i.e., digital editing) with natural recordings. This likely resulted in easier processing of sentence stimuli by subjects in the present study.

Reynolds & Fucci (1998) found that children have significant increases in response latency for processing three-word sentences generated in DECTalk (i.e., DECBetty) compared to natural recordings. They hypothesized that decreased acoustic-phonetic information in the synthetic signal forces listeners to allocate additional resources to surface-level processing, including phoneme and word recognition. Meaning creation is slower and less accurate (Reynolds & Fucci, 1998). Thus, verb comprehension in this investigation was facilitated by highly natural, recorded stimuli that maintained redundant acoustic cues. Use of rule-based synthetic speech in Gerken and McIntosh's (1993) task may have increased subjects' cognitive load, such that participants were more susceptible to additional factors including the morpheme variations. It also is possible that the rule-based synthetic speech necessitated processing the sentence stimuli at more of a surface level rather than a deeper meaning-based level, and this increased focus on surface form interrupted comprehension.

Phonological Features of Study Stimuli

Segmental features of function morphemes may have assisted subjects' sentence processing. For this investigation, morpheme foils were selected to maintain phonological characteristics of function morphemes distinct from content words. That is, most function morphemes are short, unstressed syllables with null or single phoneme boundaries and unstressed central vowels. The nonsense syllable "id" and ungrammatical morpheme "in" had the same lax vowel, null onset and coronal coda as "is." Thus, "id" and "in" maintained the defining segmental features of function morphemes as a category as well as features of the target morpheme, "is."

There is evidence of children's ability to recognize segmental cues in their language as reported by Shafer, Shucard, Shucard, and Gerken (1998). They tested the ability of 10- and 11-month-old infants to differentiate a story that contained English function morphemes (e.g., the, is) from one that included nonsense function morphemes (e.g., ko, gu). In the modified story, nonsense morphemes were created using velar consonants and full vowels in order to vary typical segmental features of English function morphemes. Electrophysiological assessment using event-related potentials (ERPs) revealed significant increased attention for the modified story compared to the unmodified story by 11-month-old infants but not 10-month-olds. Authors concluded that 11-month-old infants are sensitive to phonological properties of English, specifically segmental features of function morphemes (Shafer et al., 1998).

Grosjean and Gee (1987) describe how knowledge of phonotactic features of function morphemes might contribute to effective sentence processing. They suggest that children learning language use stressed syllables to begin a lexical search while simultaneously processing unstressed syllables. Unstressed syllables can be recognized by the system as function morphemes based on phonological or distributional characteristics. If unstressed syllables are not recognized as function morphemes, then they become candidates in the lexical search. That is, the weak syllables on either side of the stressed syllable might be part of a multisyllabic content word. Grosjean and Gee conclude that word recognition and sentence processing result from the interaction between the lexical search of stressed syllables and weak syllable pattern analysis. Consistent with predictions of Grosjean and Gee, foil morphemes in this investigation (i.e., in, id), which maintained phonotactic and prosodic features of "is," did not interfere with subjects' weak syllable pattern analysis and lexical search for the stressed verb.

Contextual Support

Subjects were required to demonstrate verb comprehension in a decontextualized picture recognition task. Environmental cues, often exploited by young children during comprehension, were missing. Children, therefore, were encouraged to scan the picture display before hearing the auditory stimulus. This modified the temporal relationship between presentation of picture stimuli and auditory stimuli for this study compared to studies by Gerken and colleagues (Gerken & McIntosh, 1993; McNamara et al., 1998; Shady & Gerken, 1999). In their studies, the auditory stimulus was presented while children looked at a blank page, and picture stimuli followed the sentence. Simultaneous presentation of auditory and picture stimuli was used in this investigation to decrease overall task difficulty and to decrease confounding factors known to affect comprehension.

Carter and Gerken (1997) varied the picture context to test the effect of retention or post-access processing on TD subjects' ability to comprehend nouns across morpheme conditions. They replicated Gerken and McIntosh's (1993) test of noun comprehension using three morpheme contexts (i.e., grammatical "the," ungrammatical "was," and nonsense "gub"), but phonological and semantic distractor pictures were added. In the first experiment children selected the phonological distractors significantly more often than unrelated or semantically related pictures when making errors in all morpheme contexts. Authors concluded that children's errors were not random, rather they were built upon at least partial phonological representation of the target word. A second experiment using semantic but not phonological distractors revealed an effect of semantic distractors that interacted with the grammaticality effect. That is, children selected semantic distractors more often than unrelated pictures in the grammatical and nonsense morpheme contexts, but not in the ungrammatical context. Carter and Gerken (1987) concluded that children achieved semantic representations in grammatical and nonsense contexts but not in the ungrammatical context.

Swingley, Fernald, McRoberts, and Pinto (1996) did not find an effect on noun comprehension for grammatical "the" compared to nonsense "gef" in a preferential looking paradigm. Children in the Swingley et al. experiment had only two pictures choices, and pictures were presented simultaneous with the auditory stimulus. Investigators concluded that the number of picture choices (i.e., four versus two), the presence of picture distractors, and the temporal order of stimuli presentation are all factors that may affect children's performance in the comprehension task.

Subjects' verb comprehension in this investigation was assisted by simultaneous presentation of auditory and picture stimuli as well as picture foils that were unrelated to target content words. Although manipulating contextual aspects can help to test factors in sentence processing, additional variables (e.g., retention) are introduced. Further research is needed to tease apart relationships among phonological and semantic representations in on-line sentence processing for grammatical and ungrammatical contexts.

Summary of Factors Supporting Verb Comprehension

Children in this investigation participated in a picture selection task to test verb comprehension. Target verbs were presented in utterance-final position with exaggerated durations. Verbs were marked in all morpheme contexts by a perceptually salient, early developing morpheme, -ing, which co-occurs with auxiliary "is" in the present progressive verb tense. Furthermore, stimuli for this investigation were created through digital editing of natural recordings. In addition to controlling prosodic variables, this maximized redundant acoustic cues compared to synthetic stimuli used in prior research. Phonological features of the ungrammatical morpheme "in" and nonsense syllable "id" maintained the characteristics of function words as a class. Finally, auditory stimuli were presented with the contextual support of pictures. In this manner, children were provided a closed set of responses to compare to possible matches from their lexical search without any added memory burden. In summary, multiple factors converged in support of young children's verb comprehension. This finding is consistent with current theories in the area of comprehension development.

Implications for Theories of Language Acquisition

Discussion has focused upon individual factors related to central findings of this investigation. That is, older children with SLI outperformed younger TD children on a verb comprehension picture selection task, and experimental variation of auxiliary "is" did not result in significant verb comprehension differences for either TD or SLI subjects. Implications for theories of normal language acquisition deserve attention.

Function Morphemes Cue Morphosyntactic Categories

One impetus for this investigation was the hypothetical role of function morphemes in guiding language learners to syntactic categories such as nouns and verbs (Gerken & McIntosh, 1993; Golinkoff et al., in press; Hirsh-Pasek & Golinkoff, 1996; Maratsos & Chalkley, 1980; Morgan et al., 1996). Researchers have suggested that children might notice distributional relationships among function morphemes and content words, such as the co-occurrence of articles before nouns (e.g., a ball, the chair), auxiliaries before verbs (e.g., is jumping) and syllabic suffixes bound to verbs (e.g., crying). In this manner, function morphemes would aid novel word learning as well as syntactic category assignment.

Golinkoff, Schweisguth and Hirsh-Pasek (in preparation) conducted a study of children's novel noun and verb learning given "the" versus -ing (as cited in Golinkoff et al., in press). In this study, children either heard "Watch the fliff" or "Watch me fliffing" while an adult presented a novel object in a novel motion. Children in the noun condition showed noun learning and children in the verb condition showed verb learning. Investigators concluded that children were sensitive to "the" and -ing and that children used this information to determine the syntactic category of the nonsense word (Golinkoff et al., in press).

Interestingly, children in the above study were more successful in noun learning (81% accuracy) than verb learning (69%) given a morphosyntactic cue. Differences between noun and verb learning probably exist on many levels (see Tomasello & Merriman, 1995), but part of the difference could lie in the strength of the morphosyntactic cue. Function morphemes share many features as closed-class words in English, however they may not share the same ability to cue syntactic categories.

For this investigation, grammatical auxiliary "is" did not increase children's verb comprehension compared to ungrammatical "in" or nonsense "id" contexts. These findings differed from those of Gerken and McIntosh (1993) who found an effect of "the" on noun comprehension and Golinkoff et al. (in press) who found an effect of -ing on verb comprehension. Differences between these studies may be due to differences among the individual function morphemes. Perhaps "the" is a strong cue to nouns, and -ing is a reliable cue to verbs. In addition to segmental and suprasegmental salience, "the" and -ing are distinct forms with little variability in their semantic and syntactic functions. In contrast, auxiliary forms of "be" vary with tense and number (e.g., "am," "were"), and they occur frequently as copula forms before nouns, adjectives, and other function morphemes (e.g., That is my ball.; She was shy.) Thus, the relationship of "is" to verbs and its strength as a morphosyntactic cue may be very different from "the" for nouns and -ing with verbs.

Bootstrapping Proposals

Bootstrapping theorists presume cues in the input that are perceived and utilized by children during early stages of language acquisition. Syntactic bootstrapping theory is built upon the idea that syntactic cues, including function morphemes and word order, aid in developing word meanings and syntactic categories. The purpose of this study was to vary the morpheme "is" in sentences to test the impact of this morphosyntactic cue upon verb comprehension. Subjects showed equivalent verb comprehension performance across varying morpheme contexts, so the role of auxiliary "is" as a cue to verb comprehension remains ambiguous. Morpheme -ing was not manipulated experimentally, yet findings from this investigation are consistent with the deduction that -ing was a morphosyntactic cue benefitting subjects' verb comprehension.

Although a morphosyntactic element was investigated, several prosodic and phonological factors probably contributed to subjects' verb comprehension. In this study, children's comprehension of target words was maximally supported by suprasegmental and segmental characteristics of sentence stimuli. Verbs were presented with exaggerated durations in utterance-final position. Additionally, the relationship of the stressed verb root word in the penultimate position bound to the unstressed final -ing might form a salient combination (Peters, 1985).

Morpheme contexts in this investigation were foil morphemes that maintained the unstressed and phonotactic features of "is." In contrast, segmental variation may have contributed to Gerken and McIntosh's (1993) findings of a grammaticality effect. Their foils, nonsense syllable "gub" and ungrammatical morpheme "was," did not retain segmental similarities to article "the" other than the vowel. "Gub" and "was" are both CVC syllables and begin with consonants common to content words. Furthermore, the prevocalic, interdental fricative [ð] differentiates "the" from "was" or "gub." This phoneme only occurs in the prevocalic position in English determiners (e.g., the, these, this), not content words. Thus, [ð] is highly marked in the language and provides a consistent segmental cue for nouns. Grosjean and Gee (1987) point out that, "The system also knows that no polysyllabic word starts with [ðə] and that it is therefore most probably the definite article 'the'." (p. 147).

This discussion of segmental and suprasegmental cues associated with function morphemes leads to the question of whether young telegraphic speakers are sensitive to morphosyntax or whether they are sensitive to prosodic and phonotactic features of their language. Children may not know morpheme -ing as a verb inflection coding present progressive verb tense, but they might be aware of its relationship as an affix to lexical items. Their knowledge of -ing no doubt stems from its stable form and utterance-final lengthening. Likewise, children may not understand article "the," but they may be cued by the salient [ð] and they may have learned the distributional relationship between [ð] and nouns. The morphosyntactic functions of "is" would take longer to sort out because of its variability in the input. Initially children might process only the unstressed, minimal nature of "is" as they complete their lexical search for stressed syllables in the input.

Therefore, the suprasegmental and segmental features of auxiliary "is" might be sufficient cues to assist in the lexical search of the verb regardless of children's knowledge of the morphosyntactic relationship of "is" to verbs.

Prosodic Structure Theory

Prosodic features of input are known to play a role in children's language development. For this reason, care was taken by the investigator to maintain the trochaic (i.e., strong - weak) syllable pattern characteristic of English during stimuli creation. However, relationships among syllables in clitic groups were not considered. In the present progressive tense, function morphemes "is" and -ing have similar semantic and syntactic functions, yet their relationship to verbs is distinctive as described by prosodic structure theory.

Proponents of prosodic structure theory propose that sentences have a hierarchically organized prosodic structure (e.g., Dresher, 1996; Selkirk, 1996). The prosodic structure of sentences is realized phonologically, and it theoretically arises separately from morphosyntactic structure. According to prosodic structure theory, function words generally occur in clitics with content words, but do not stand alone. Clitics are function morphemes that can be phonologically joined to content words, and a clitic group (or prosodic word) consists of a content word and all adjacent clitics (Gerken, Jusczyk, & Mandel, 1994; Selkirk, 1996). In this manner, -ing is joined to verbs in clitic groups (e.g., eating, riding). The auxiliary "is," however, is atypical because it is cliticized to the preceding word despite its syntactic relationship with the succeeding verb (Selkirk, 1996). Specifically, "is" in the study stimuli occurred in a clitic group with "who," because of the possible phonological realization, "who's."

One consequence of this theory is an explanation for the lack of difference between subjects' verb comprehension in "is" and omitted contexts. Children frequently hear auxiliary "is" in its contracted form (e.g., Who's jumping?), and the omitted context has the same stress pattern (e.g., Who ɸ pushing?).

More importantly, it is possible that syllables joined prosodically in clitic groups are processed differently than syllables that occur in separate clitic groups. Production research has examined the role of prosodic structure theory, but comprehension studies have not been conducted. Peters (1985) predicted that clitics in a language are perceived as a part of the content word during early phases of language segmentation. If so, then -ing would be closely associated with verbs, but "is" would be merged with sentence subjects. Furthermore, if clitic groups are perceptually available to listeners, then aberrant morphology joined to a content word in a clitic group might result in decreased comprehension for the content word. Thus, verb comprehension would be vulnerable to foils for morpheme -ing, as in the study by Golinkoff et al. (in press). In contrast, aberrant morphemes for auxiliary "is" in this investigation were not in clitic groups with target verbs (e.g., Who in / pushing? or Who id / jumping?), so the clitic group of verb plus -ing was maintained in all morpheme contexts. Perhaps verb comprehension was not disrupted because morpheme changes were not in clitic groups with target content words.

Coalition-of-Cues Model of Language Comprehension

Review of research studies testing children's comprehension leads to the conclusion that an interaction among input cues must exist. In fact, researchers have begun to demonstrate children's use of combined cues from different domains for language learning (Gerken & McIntosh, 1993; Morgan & Saffran, 1995; Shady &

Gerken, 1999). One broad perspective on the interaction of cues in the input and their relationship to children's comprehension is offered by the coalition-of-cues model of language comprehension (Hirsh-Pasek & Golinkoff, 1996). Hirsh-Pasek and Golinkoff outlined a process of comprehension development beginning in infancy with extraction of acoustic information from the speech stream and rapidly progressing to sentence-level syntactic analysis by 3-year-olds.

Hirsh-Pasek and Golinkoff (1996) proposed that two interacting variables, syntactic complexity and the level of correlated input cues, affect children's comprehension. Children who lack adult-like linguistic processing skills demonstrate comprehension when syntactic complexity is low and cueing is high, regardless of their productive abilities. These same children show decreased comprehension, which may even lag behind production, when syntactic forms are complex or cues insufficient. Hirsh-Pasek and Golinkoff's predictions provide a workable interpretation of findings from this investigation as well as other researchers.

Input Cues and Child Factors Interact to Affect Comprehension

Figure 2 is a modified representation of Hirsh-Pasek and Golinkoff's (1996) coalition-of-cues model of language comprehension. Comprehension occurs in the interaction of the child's cognitive resources and linguistic knowledge and the message's properties from multiple sources. Elements of the message are differentially weighted depending on the child's shifting focus and skill (Hirsh-Pasek & Golinkoff, 1996). For example, infants seem to be highly tuned to prosodic and acoustic aspects of speech

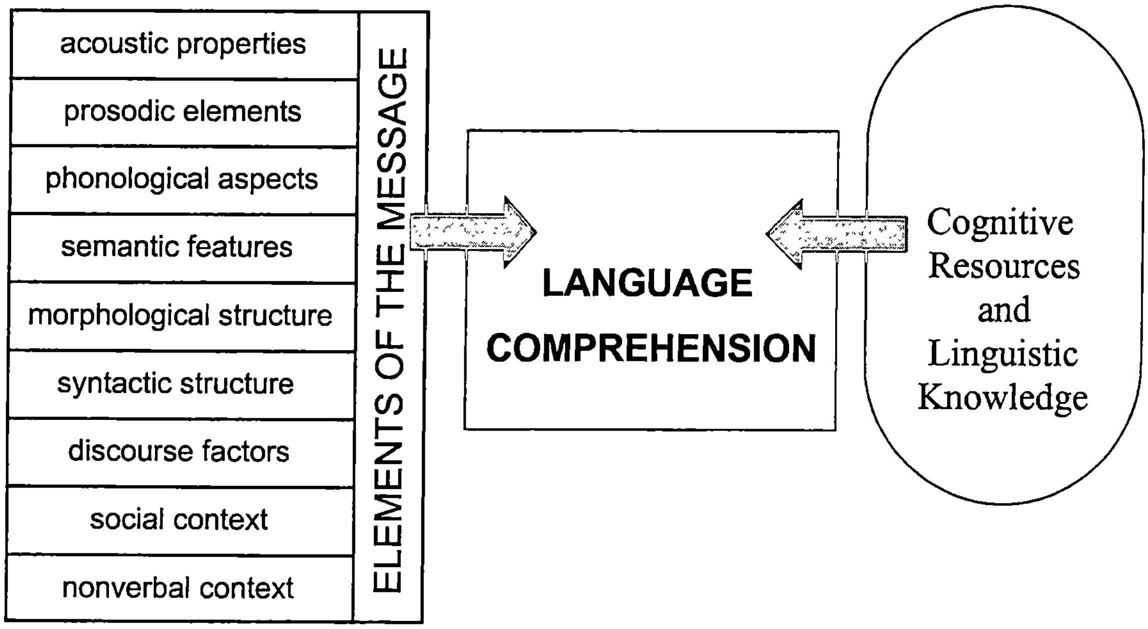

Figure 2. Model of language comprehension as an interaction between multiple input cues, developing linguistic knowledge, and limited cognitive resources.

input, but 3-year-olds are capable of comprehending increasingly complex forms regarding remote events. In the model of comprehension illustrated by Figure 2, relative weights for elements of the message also are dependent upon the cues themselves. In other words, cues in the message can contribute to or interfere with comprehension. For example, a facial frown is a nonverbal element that facilitates the listener's comprehension of the speaker's utterance, "I had a rough weekend," but interferes with comprehension of "I had a good weekend." These patterns of correlated and/or conflicting cues impact the listener's comprehension.

This model assumes that language comprehension will be quicker and more accurate when cognitive resources are plentiful and linguistic load is light. Conversely, comprehension will suffer when cognitive resources are limited or linguistic knowledge strained. The presence of redundant cues for experimental tasks in this investigation and studies by Gerken and colleagues (Gerken & McIntosh, 1993; McNamara et al., 1998; Shady & Gerken, 1999) can be examined and an understanding of conflicting results can be gained.

Comprehension Processes Across Research Studies

The proposed comprehension model lends clarity to research results that support or undermine the hypothesis of a grammaticality effect. Table 13 is a comparison of message elements in the experimental tasks of this investigation and Gerken and McIntosh (1993). The purpose of comparison is to view study findings as a function of interacting input cues. As message elements are compared, bear in mind the hypothesis that toddlers will demonstrate comprehension when these input cues are redundant, highly correlated with one another, and closely associated with intended meaning.

Table 13

Comparison of Input Cues From Two Comprehension Research Studies

Message Elements	Beverly, 1999	Gerken & McIntosh, 1993
acoustic properties	near natural speech (digitally edited)	synthetic speech (DECTalk)
prosodic elements	child-directed prosody long verb durations utterance-final verbs "is" in clitic group separate from verb	prosody of DECTalk short noun durations utterance-medial nouns "the" + noun form clitic group
phonological aspects	"is," "in," "id"	"the," "was," "gub" marked [ð] absent in foils
semantic features	early verbs	early nouns
morphological structure	4 varied auxiliary "is" contexts morpheme -ing also present	4 varied article "the" contexts
syntactic structure	present progressive verb tense simple "Who" interrogative	article + noun phrase 3 different imperatives
discourse factors	interrogative = request for response	imperative = request for action
social context	picture selection task tangible rewards	picture selection task tangible rewards
nonverbal context	1 target and 3 foil pictures simultaneous with linguistic stimulus	1 target and 3 foil pictures followed linguistic stimulus

Several elements of the message in Gerken and McIntosh's (1993) task provided straightforward input cues consistent with meaning. Stimulus words were early developing nouns, and a simple syntactic structure requiring a response was utilized (e.g., Show the chair to me.). Prosodic factors, including use of a female voice with varied intonation and focal stress on content words, were cues facilitating subjects' comprehension. Other elements, however, were associated with decreased input cues. A picture selection task for comprehension is decontextualized and relies on greater linguistic knowledge by the child. Because presentation of picture stimuli followed introduction of the auditory stimulus, contextual cues were low and a memory component was added. Acoustic-phonetic properties of the stimulus may have been affected by the use of rule-based synthetic speech. Finally, target words were embedded in utterance-medial position, and foils used in the ungrammatical and nonsense morpheme contexts varied key segmental features of grammatical morpheme "the."

For this investigation, stimuli vocabulary and sentence form were rudimentary, except for the inherent difficulty of verb comprehension in a decontextualized picture selection task. Children, however, had exaggerated acoustic, prosodic, and phonological cues. Advantages for subjects in this investigation included presence of -ing in all contexts and utterance-final position of lengthened target words. Only one sentence frame (i.e., "Who is...?") was used for all stimuli items, whereas Gerken and McIntosh (1993) used three (i.e., "Find the...;" "Show the...; Point to the..."). Contextual cues were enhanced because of simultaneous presentation of picture and linguistic stimuli.

When viewed within a dynamic, multidimensional model of comprehension, conflicting results from the two studies can be reconciled as variations of the same comprehension process. Comprehension is built upon trade-offs among input cues and child factors. Some aspects of the input increase the likelihood of successful comprehension and others interfere with processing. Because of this complexity, many questions remain. Perhaps morpheme grammaticality has little effect on content word comprehension, but instead atypical segmental properties of function morphemes may disrupt comprehension processes (Shady, 1997, pp. 18-28; Shafer et al., 1998). Perhaps children are only sensitive to morpheme grammaticality when acoustic elements of the signal are attenuated. It also is possible that comprehension remains intact when a minor number of message elements are inconsistent or reduced. However, when a critical number of cues are insufficient to support comprehension, breakdown occurs. The hypothetical number of cues required to support comprehension is unknown, and it probably varies with the cues themselves as well as the child's age and stage of language development. Results from this investigation, rather than detracting from previous reports of a grammaticality effect, may point to other important aspects of comprehension development in language acquisition.

SLI Subjects' Sensitivity to Morpheme Contexts

Factors affecting verb comprehension across morpheme contexts by all subjects, TD and SLI, have been proposed, and implications of study findings for theories of normal language acquisition have been examined. Before extending this discussion to theories of SLI, it is necessary to review the question of SLI subjects' sensitivity to morpheme variations.

It is conceivable that children with SLI were sensitive to morpheme foils, but were able to accurately identify verbs regardless of morphosyntactic context. Like TD children, subjects with SLI had at least emerging productions for "is" and foil "in" productions suggesting the ability to perceive and acquire knowledge of these morphemes from the input. They produced weak syllables in multisyllabic words and final position fricatives [s, z] in nonmorphophonemic contexts. Children with SLI, therefore, have the ability to perceive and process signals from the input. However, the question of SLI children's perception of morpheme variations is complicated by research that suggests that children with SLI have deficits in perceiving rapid acoustic changes (e.g., Leonard et al., 1992; Tallal & Stark, 1981) as well as research suggesting that SLI is a general processing limitation (summarized in Leonard, 1998). For these reasons, three possibilities regarding SLI subjects' sensitivity to morpheme contexts and verb comprehension are explored:

1. Subjects with SLI did not perceive morpheme variations, therefore they could not use these cues in verb comprehension;
2. Subjects with SLI perceived variations in the morpheme contexts but did not process the differing morphosyntactic functions, consequently this was not a factor in their verb comprehension;
3. Subjects with SLI perceived and processed the morpheme variations, but they used other cues to achieve successful verb comprehension.

The first two of these possibilities are what led to the a priori research hypothesis that subjects with SLI would perform more poorly than younger TD subjects in this investigation. That is, children with SLI are known to have difficulty with morphosyntax which could be based on perceptual or processing weaknesses. Yet, Shady (1997) demonstrated that TD children as young as 16 months of age have knowledge of the distributional relationships of noun-related and verb-related morphology in spoken passages.

The first proposition is that subjects with SLI did not perceive morpheme variations. Research has shown that children with SLI have difficulty compared to their language-matched peers in perception of speech stimuli of shorter duration relative to adjacent portions with longer durations (e.g., Leonard et al., 1992; Tallal & Stark, 1981). If children with SLI have difficulty with verbal stimuli of relatively brief duration, then perception of morpheme differences may have been problematic. Differences among grammatical morphemes, "is," "in," and "id," were encoded by postvocalic consonants with durations approximately 45 to 70 ms. Perhaps SLI subjects' perceived and processed only the vowel, [I], in all contexts. Information critical to perceiving morpheme variations in this study occurred at a rate known to be difficult for children with SLI, and this brief transitional information occurred between a vowel and a focally stressed verb. If subjects with SLI did not perceive morpheme variations, then "is" and its variations could not be a factor in their verb comprehension.

The second possibility is that subjects with SLI perceived variations but did not process the morphosyntactic functions of "is" versus "in" and nonsense "id." Leonard et al. (1992) pointed out that findings of auditory perceptual deficits related to SLI are complicated by additional processing demands inherent to tasks testing perceptual skills. Tasks that reveal relative auditory weaknesses require more than just perception, because children must retain the target stimulus, process the discrimination (e.g., same or different; or comparison to foils), and give a physical response to matches. Leonard et al. concluded "...that when a difficult but achievable discrimination is involved, any additional operations that must be performed make it vulnerable to loss." (p. 1082). Children with SLI are known to have significant morphosyntactic deficits. General morphosyntactic deficits or particular weaknesses for auxiliary "is" might preclude the ability to process morpheme variations. Or, children with SLI might have knowledge of morphosyntactic functions, yet be unable to apply that knowledge in a task involving additional processing steps. Content word comprehension is more complicated than perception of morpheme contrasts; several added linguistic processes and task demands are required. Thus, it is possible that children with SLI were unable to process "is" and its variants, and consequently this was not a factor in their verb comprehension.

Lastly, children with SLI may have perceived and processed morpheme contexts, but morphosyntactic knowledge including distributional properties of morphemes may not have been an important cue for successful verb comprehension in this task. SLI subjects' verb comprehension may have been influenced by the same factors as TD subjects' performance (i.e., verb durations, utterance-final position, -ing, etc.). It also is possible that different factors contributed to SLI subjects' comprehension. Various theories regarding the nature of SLI attempt to explain patterns of relative strengths and weaknesses seen in children with SLI, and findings from this investigation can be viewed within these frameworks.

Implications for Theories of SLI

Successful verb comprehension across morpheme contexts by subjects with SLI in this investigation together with counter findings of a grammaticality effect by McNamara et al. (1998) can be viewed within the context of theories of SLI. Most pertinent to this line of research are three theories regarding the nature of SLI: (1) general processing capacity limitations, (2) the surface account of morphosyntactic deficits, and (3) memory weaknesses.

General Processing Capacity Limitations and SLI

Leonard has proposed that SLI is the result of general processing capacity limitations (e.g., Leonard, 1989; 1998; Leonard et al., 1992). Theoretically, processing limitations could be due to limited space, limited resources, limited time, or a combination of these (Leonard, 1998). It remains unclear whether processing limitations stem from one underlying source, multiple sources, or specific mechanisms (e.g., the auditory processing deficit account and the phonological memory deficit account).

The comprehension model depicted in Figure 2 demonstrates the interaction of child factors and input variables assumed to affect comprehension. Child factors are conceptualized broadly as cognitive and linguistic knowledge and all aspects of the processing system. Thus, successful content word comprehension can be viewed as the end result of adequate cognitive and linguistic resources for the task, whatever the task variables. Children who have limited processing capacity, whether due to young age or SLI, can successfully comprehend messages when elements are redundant and related to meaning. Breakdown occurs when children have inadequate resources and when elements of the message are difficult or cues reduced.

In the comprehension model (Figure 2), elements of the message were differentially weighted by their effect upon accurate comprehension. Some aspects of the input facilitate comprehension while others interfere with processing. Given an understanding of these variables, a limited capacity model can be applied readily to findings for SLI subjects in this investigation and the study of McNamara et al. (1998).

In this investigation, three elements of the message increased the processing load. First, comprehension in a picture selection task is more difficult than when environmental cues to meaning are present. Second, comprehension for verbs presents a unique challenge to language learners (Tomasello & Merriman, 1995) and especially children with SLI (Rice et al., 1994). Lastly, morphosyntactic cueing of "is" before target verbs was manipulated in ways that were not grammatical. There were, however, several advantages that outweighted challenges. Verbs occurred in utterance-final position with exaggerated durations and marked by -ing. Given their high levels of accuracy, subjects with SLI clearly had adequate resources to meet the needs of this verb comprehension task.

In McNamara et al. (1998), which used the task of Gerken and McIntosh (1993), elements of the message might have overloaded children's processing capacity (see Table 13). For example, target nouns were positioned medially and their durations were characteristic of adult-directed speech. It is also possible that neither segmental nor grammatical deviations would affect noun comprehension independent of other processes in the comprehension task such as a retention factor.

Although findings from this investigation cannot prove or disprove theories of limited processing capacity and SLI, discrepancies between this investigation and that of

McNamara et al. (1998) correspond with assumptions of a general processing limitation. A related but somewhat different theory of SLI, the surface account, proposes that morphosyntactic weaknesses for children with SLI are the result of a general processing limitation combined with the unique characteristics of English morphosyntax (e.g., Leonard, 1989; 1998; Leonard et al., 1992).

Surface Account

Leonard claims that SLI is characterized by a general processing limitation that is particularly vulnerable to English morphophonemic properties (e.g., Leonard, 1989; 1998; Leonard et al., 1992). That is, grammatical morphology in English is distinguished by brief, unstressed sounds and syllables which are more difficult to perceive than other elements in the input. Children with SLI are assumed to be capable of perceiving these elements, however the added strain of sentential processing can affect perception, processing, or retention of English function morphemes.

If the surface account's assumptions regarding the input and children with SLI are accurate, then children with SLI might be expected to be less sensitive to low phonetic substance aspects of the input, like "is" and "the." However, findings by McNamara et al. (1998) suggested that children with SLI are sensitive to morphosyntactic elements within sentences. In their study, children with SLI showed significantly higher noun comprehension for grammatical "the" than in the context of ungrammatical "was." They concluded that children with SLI have adequate morphosyntactic knowledge, despite production limitations, to use morpheme cues when comprehending nouns.

One limitation of McNamara et al.'s (1998) report of a grammaticality effect lies in generalizing findings from "the" and noun comprehension to whole classes, either function morphemes or content words. For example, the present study did not extend their finding of a grammaticality effect to verb comprehension given auxiliary "is" variations. The solution may rest with differences between "the" and "is" or between noun learning and verb learning. Recent research has revealed differences between TD and SLI children's production of noun-related morphology, including "the," and verb-related morphology, including "is" (Leonard et al., 1997; Leonard, Miller, & Gerber, 1999).

Differences in learning verb-related morphology and noun-related morphology are compatible with the surface account, although primary assumptions of the surface account do not address this. That is, verb-related morphology as a class may require additional processes in paradigm formation than noun-related morphology, leading to a relative delay in acquisition of the former. Findings from the present study did not determine whether children with SLI use morphosyntactic cues, specifically those related to verbs, to assist in determining word meanings or identifying syntactic categories. Results from this investigation are consistent with the hypotheses of the surface account, however, the question of SLI children's ability to use morphosyntactic cues remains.

Memory Limitations

Various aspects of memory, including short-term or working memory, the phonological trace, and long-term memory and storage, have been implicated as causes of SLI. Rice et al. (1994) proposed that phonological memory and aspects of verb morphology interact to interfere with one another. Specifically, the complexity of distributional relationships between verbs and morphology may weaken associative strength and impact long-term memory and verb learning (Rice et al., 1994).

Montgomery (1995) found poorer nonsense word repetition and poorer sentence comprehension for longer utterances for children with SLI compared to younger, language-matched peers. Likewise, Shady and Gerken (1999) reported a significant effect of utterance length and target word position for TD children. In their study, long utterances were five to six words, like those in McNamara et al. (1998), and short utterances were three words, as in this investigation. Thus, utterance length in this investigation may have supported TD and SLI children's successful comprehension. The relationship between utterance length and memory is not straightforward; although, Montgomery concluded that negative effects of sentence length on SLI children's comprehension reflected limitations in phonological memory.

McNamara et al. (1998) also concluded that children with SLI have limitations in memory that affect comprehension. Like Carter and Gerken (1997), McNamara et al. utilized picture distractors to evaluate whether the grammaticality effect for subjects with SLI was the result of problems retaining semantic representations given the delay in picture presentation following the linguistic stimulus. Subjects with SLI selected the semantic distractors significantly more often than unrelated distractors when making errors. McNamara et al. concluded that children with SLI are able to process sentences and form semantic representations, but they are unable to retain target words for correct responding.

Summary of Research Findings and Theories of SLI

It is important to evaluate present results from subjects with SLI in light of what is known about the population's primary deficits as well as the supposed nature of SLI. Findings of successful verb comprehension by children with SLI are consistent with SLI theories that propose general processing capacity limitations. Subjects with SLI have adequate cognitive and linguistic resources to comprehend verbs in this relatively easy picture selection task, but they show decreased content word comprehension when their processing capacity is overburdened. Limited processing capacity could account for the disparate results of this study and the investigation by McNamara et al. (1998), because their task was comparatively more difficult.

Alternative proposals regarding SLI, surface account or memory limitations, cannot be ruled out. In keeping with the surface account, findings from the present study suggest that children with SLI do not process low phonetic substance, verb-related morphology (i.e., auxiliary "is") as a cue when comprehending verbs. Regarding theories of memory deficits, this investigation reduced memory load in two ways, through the use of shorter utterances and by eliminating a retention factor. Again, these changes might account for differences between this study and that of McNamara et al. (1998).

Research Limitations

Questions regarding the role of input cues in children's sentence processing remain. This investigation identified a picture selection task and a set of stimuli associated with overall success in verb comprehension. Other studies, however, have found decreased noun comprehension secondary to variation in morpheme contexts. Differences in findings from this study and previous research highlight the complexity of the processing task. Until specific factors associated with the input can be manipulated experimentally with demonstrated effects for children's comprehension, our knowledge of input cues and comprehension development is limited.

This investigation utilized target words of long duration consistent with CDS. Durations of content words in this study were more than three times greater than the content words in studies that have revealed a grammaticality effect of morpheme context. In this manner, an additional variable that likely affected verb comprehension was introduced. Furthermore, the long target word durations did not occur in isolation. Target word lengthening also was associated with utterance-final position. Thus, it is not clear whether long durations or the salient utterance-final position or a combination of these factors supports verb comprehension. Further research is needed to sort out the relationship among these factors.

Another limitation was the co-occurrence of morpheme -ing with verbs. This salient and early emerging grammatical morpheme might have cued children to target verbs regardless of "is" manipulation. Although researchers have begun to address children's sensitivity to morpheme -ing (Golinkoff et al., in press; Santelmann & Jusczyk, 1997), it is not known whether this morpheme facilitated children's verb comprehension in this task.

Lastly, if morphemes such as "the," -ing, or "is" provide cues that facilitate children's lexical and grammatical learning, they may cue content words in unique ways. That is, function morphemes as a group are associated with a correlated set of cues or minimalness, but critical cues for "the" might be different from critical cues for -ing or auxiliary "is." Research regarding morphosyntactic cues to content word comprehension is limited by assumptions regarding significant features of these morphemes and how they are utilized by language learners.

Future Research

Studies like this one and others are beginning to clarify the enigmatic event that is comprehension. Yet, the investigation of significant factors and relationships is ongoing. Research from diverse sources - including picture selection tasks and the preferential looking paradigm, production studies, crosslinguistic research, and ERP studies - will contribute to understanding in this area. Studies that systematically vary individual input factors are needed. Although factors are isolated for experimental manipulation, comprehension is no doubt a multifaceted event. With this in mind, other aspects of the input must be carefully controlled or manipulated to reduce the effect of confounding variables. In this investigation, children were found to be generally successful for verb comprehension despite auxiliary "is" anomalies. Utilizing aspects of this task in future research, sources of redundancy or input cues can be tested.

Morphosyntactic Cue of -ing and Verb Duration

The role of morpheme -ing as a morphosyntactic cue to verb comprehension calls for additional investigation. Because TD children develop -ing production early, subjects' need to be 1 to 2 years old with MLUs of approximately 1.0 to 2.0 morphemes. To test subjects' sensitivity to -ing manipulation, a preferential looking task could be used with the following four morpheme contexts: (1) grammatical -ing (Who is push<u>ing</u>?); (2) omitted (Who is push<u>ϕ</u>?); (3) ungrammatical morpheme (Who is push<u>est</u>?); and (4) nonsense (Who is push<u>il</u>?). All foils are consistent with phonotactic features of morpheme -ing, and stimuli would be created through digital editing to enhance naturalness and control.

In addition to the within-subjects factor of grammaticality, a between-subjects factor of duration is needed to test the role of exaggerated duration in verb comprehension. One group of subjects (n = 16 to 20) would hear target sentences created with verb durations in utterance-final position similar to adult-directed speech (i.e., approximately 300 to 350 ms), and an equal number of subjects (n = 16 to 20) would hear the same stimuli with verb durations typical of CDS and utterance-final position (i.e., approximately 700 to 750 ms). Although verb durations would be manipulated, -ing durations for both groups would be the same (i.e., approximately 150 ms).

A grammaticality effect is predicted given findings of Golinkoff et al. (in press). Additionally, subjects hearing exaggerated verb durations typical of CDS are expected to outperform subjects hearing shorter duration verbs. An a priori hypothesis regarding interaction between grammaticality and verb duration is not established. Verb duration and -ing are expected to reveal significant main effects with or without an interaction effect. If verb duration is a key cue for comprehension, then children exposed to long durations might demonstrate verb comprehension regardless of morpheme context. Given shorter durations, however, children might rely upon the morphosyntactic cue and show a grammaticality effect of -ing for verb comprehension.

Effect of Utterance-Final Position

The role of utterance-final position in children's comprehension can also be tested using this model (see Shady & Gerken, 1999). Findings regarding sensitivity to -ing variation and effects of verb duration would impact decisions regarding study design to test utterance-final positions. Verb durations and the length of utterance would be controlled, and target word position would be varied from medial to final. The key would be to create meaningful, syntactic utterances that place the same verbs in utterance-medial (e.g., Who is over there pushing? and Who is happily playing?) and utterance-final positions (e.g., Who is pushing over there? and Who is playing happily?). It is predicted that utterance-final position would result in increased verb comprehension performance for TD 2-year-olds.

Distinctive Cueing by Individual Function Morphemes

Once investigations of factors such as content word duration, utterance position and -ing are undertaken, research to determine the distinct role of different English function morphemes can be conducted. Understanding of these factors will clear the way for additional investigation manipulating auxiliary "is." Study of the unique features of "is" might be probed in a content word comprehension task using the copula form (e.g., Which one is baby?; Which one in baby?). Replication of the grammaticality effect of "the" could be further examined using similar stimuli and a between-groups design (e.g., Which one's the baby?; Which one's was baby?). Or, "the" and "is" could be contrasted in a noun comprehension task along with a nonsense syllable that violates the phonotactic features of function morphemes as follows: (1) grammatical "the" (Find the bird for me); (2) ungrammatical "is" (Find is bird for me); and (3) nonsense "ko" (Find ko bird for me). In addition to the proposed studies, care giver input and production data would help to complete the developmental picture.

Morphosyntactic Cues to Verb Comprehension and SLI

As investigators discover factors relevant to children's comprehension development, future research must continue to include a subject group of children with SLI. Factors associated with SLI can be systematically manipulated and SLI subjects' performance can be compared to age-level and language-matched peers. Specifically, SLI children's perception of sentence variations must be tested. After a clear picture of perception is gained, additional investigations of morphosyntactic knowledge can proceed. An investigation into children's, TD and SLI, sensitivity to several function morphemes presented in both grammatical and ungrammatical contexts could help to evaluate the surface account. For example, perhaps both TD children and children with SLI display sensitivity to "the" and -ing in comprehension tasks, but only TD children are sensitive to auxiliary "is." McNamara et al.'s (1998) post-access hypothesis and the role of retention must also be pursued in future investigations.

Chapter VI

Summary and Conclusion

Summary

Research has provided evidence that young children who produce telegraphic utterances can use function morphemes to segment the speech stream, to begin to determine word meanings, and to label syntactic categories (Gerken & McIntosh, 1993; Gelman & Taylor, 1984; Golinkoff et al., in press; Katz et al., 1974; Naigles, 1990). The purpose of this investigation was to examine the effect of morphosyntactic cues on verb comprehension for two groups of telegraphic speakers, typically developing (TD) toddlers and preschoolers with specific language impairment (SLI). Of primary interest was whether telegraphic speakers would show increased verb comprehension for interrogatives containing a grammatical auxiliary (Who is pushing?) compared with interrogatives containing no auxiliary (Who ϕ pushing?), an ungrammatical function morpheme (Who in pushing?), or a nonsense syllable (Who id pushing?). The second research question asked whether groups of MLU-equivalent, telegraphic speakers would show similar verb comprehension performance.

Thirty-two children participated, 16 TD children (mean age = 26 months) and 16 children with SLI (mean age = 48 months). Groups were equivalent for MLU, 2.87 and 2.91 morphemes for TD and SLI groups, respectively. All subjects had productive "is" use at or below 60% accuracy, however percentage of occurrence in obligatory contexts was significantly higher for the SLI group (41%) than the TD group (26%). All subjects produced unstressed syllables and final position fricatives spontaneously in nonmorphophonemic contexts.

A picture selection task with four morpheme contexts, similar to the method of Gerken and McIntosh (1993), was used to test verb comprehension. Experimental stimuli included a picture book with 16 pages, four picture choices per page and 64 digitally edited sentences divided into four lists of 16. Each child heard four tokens in each of the four morpheme contexts (i.e., "is," omit, "in," and "id") for a total of 16 possible items. General Estimating Equations (GEE), an analysis of binomial variance, was used to test for significant differences in verb comprehension between groups, TD and SLI, and among morpheme contexts.

Contrary to previous reports of a grammaticality effect, there was no significant difference in children's verb comprehension across morpheme contexts. TD subjects and subjects with SLI were generally successful comprehending the verb despite morpheme variation. There was a main effect for group. Children with SLI showed significantly higher verb comprehension (80% accuracy) than the younger TD children (64% accuracy). This was evident for three of the four morpheme contexts (i.e., "is," omit, "id"), however context by group interaction was not statistically significant.

Several factors in this investigation probably contributed to TD and SLI subjects' successful verb comprehension. Target verbs were presented in utterance-final position with exaggerated durations. Verbs were marked in all morpheme contexts by a perceptually salient, early developing morpheme, -ing, which co-occurs with auxiliary "is" in the present progressive verb tense. Auditory stimuli were created through digital editing of natural recordings increasing the presence of optimal acoustic and phonetic cues. Phonological features of the ungrammatical morpheme "in" and nonsense syllable "id" maintained the characteristics of function words as a class. Lastly, auditory stimuli were presented with the contextual support of pictures.

Although groups showed no differences in performance across morpheme conditions, the SLI group showed greater verb comprehension accuracy compared to the MLU-equivalent TD group. The most likely explanation for this is that subjects with SLI were older than TD subjects. Accompanying this age advantage were age-related cognitive advantages, a receptive language advantage, and higher productive "is" use. Additionally, if the co-occurrence of -ing was an important cue in children's verb comprehension, then SLI subjects' higher -ing production compared to TD subjects could be a factor in group differences.

Conclusion

Young telegraphic children are capable of verb comprehension in a picture selection task despite variation of auxiliary "is." Successful comprehension occurred for content words presented in lengthened utterance-final position with redundant input cues closely correlated with meaning. Findings from this investigation, although not able to determine the role of auxiliary "is" as a morphosyntactic cue, highlight important cues in the input as well as the complex nature of comprehension development.

Previous research reporting the use of function morphemes by young children has found that co-occurring input cues aided content word comprehension. Factors have included environmental support from object and picture contexts (Carter & Gerken, 1997; Gelman & Taylor, 1984; Katz et al., 1974; Swingley et al., 1996; Taylor & Gelman,

1988) and phonological and prosodic features of stimuli (Gerken & McIntosh, 1993; Shady, 1997; Shady & Gerken, 1999; Shafer et al., 1998). Results from this study also suggest the importance of multiple factors in children's comprehension. The role of utterance-final position with exaggerated duration should not be underestimated, and acoustic and phonological properties may be critical to comprehension. Environmental cues, in this case the presence of picture stimuli, and a reduction on memory load are also probable contributors toward successful comprehension.

Bootstrapping theories have suggested that young language learners use function morphemes in the discovery of syntactic categories such as nouns and verbs; however, the present study did not find a grammaticality effect of "is" on verb comprehension. It is possible that auxiliaries, such as "is" or "was," do not play the same role as input cues as other function morphemes, such as "the" and -ing. That is, language learners are able to differentiate individual function morphemes based upon phonological and prosodic cues. Children may attend to the distinctive phonological relationship between [ð] and nouns when learning "the," and they may be aware of -ing in lengthened utterance-final position associated with verbs. Use of morphosyntactic cues may be built upon unique properties of function morphemes, not just within-class features.

Investigation of comprehension and the role of morphosyntactic cues provides a foundation for exploring theories of SLI children's relative weaknesses in morphosyntactic production. One ongoing question is whether children with SLI perceive variation in function morphemes embedded in utterances (Leonard et al., 1992; Tallal & Stark, 1981). It is possible that children with SLI have difficulty perceiving morpheme variations, therefore they cannot use morphosyntactic cues to determine syntactic categories or word meanings. If children with SLI have a general processing limitation, they might perceive low phonetic substance morphemes but be slow to learn their morphosyntactic functions. Again, this type of deficit would restrict the use of function morphemes as cues. It also is possible that children with SLI perceive morphemes and process morphosyntactic functions, but they are unable to use these cues in comprehension tasks, especially when an additional variable like memory is added.

Because of the complexity inherent in comprehension development for TD children and children with SLI, many questions remain. Research in this area has been constrained by techniques for testing comprehension in young children as well as limitations in our knowledge base. Future research promises to yield a deeper understanding of comprehension processes and language acquisition for typically developing learners as well as children with specific language impairment.

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Appendices

Appendix A

Child and Family History Questionnaire

Please complete this questionnaire as accurately as possible. All of the information is confidential. Results will be summarized as group data and no identifiers will be used when the research is reported in the final document.

Child's Name: ____

Date of Birth: ___________________________ Age: __________________

Parent/s Names: ____

Address: ____

Home Phone: _____________________ Work Phone: _________________

I. MOTOR DEVELOPMENT

At what age did your child: roll over ______________;

sit alone ______________; walk _________________

Compared to other children, how would you describe your child's motor skills?

____

II. COMMUNICATION DEVELOPMENT

At what age did your child: babble ______________;

say single words____________; say 2-word phrases__________

Is your child's speech understandable to you? _________________

Is your child's speech understandable to others? _______________

If no to either of these, please describe: _________________________________

____

Compared to other children, how much talking does your child do?

____

Appendix A continues

Appendix A continued

III. BIRTH AND MEDICAL HISTORY

Did you experience any difficulties during pregnancy, labor, and/or delivery?____

If yes, please describe: ____

Did the baby have problems after birth? ____ If yes, please describe:___________

____

Does your child have a history of ear infections? ____ If yes, please describe:____

____

Does your child have other health or medical concerns? _____ If yes, please

describe: ____

____

IV. SOCIAL HISTORY

List the names and ages of all your children:

Name ____________________________________ Age _______________

Name ____________________________________ Age _______________

Name ____________________________________ Age _______________

Name ____________________________________ Age _______________

How does your child play with other children? ____________________________

____

Do you have any concerns about your child's behavior? ____ If yes, please

describe: ____

Appendix A continues

Appendix A continued

V. FAMILY HISTORY

Have any family members experienced speech, language, and/or learning difficulties? ____________________

What is the primary language spoken in your home? ____________________

Are there any other languages spoken in your home on a regular basis?

____

Please list your occupation and job title:

Mother: ____________________

Father: ____________________

Please circle the last year of school completed and list any degree/s earned:

Mother: 1 2 3 4 5 6 7 8 9 10 11 12

Post High School: 1 2 3 4 5 6 7 8 9 10

Degree(s)____________________, ____________________

Father: 1 2 3 4 5 6 7 8 9 10 11 12

Post High School: 1 2 3 4 5 6 7 8 9 10

Degree(s)____________________, ____________________

Appendix B

Acoustic Parameters of Stimulus Sentences

Note. Total duration is measured in seconds, but other durations are reported in milliseconds. FM = function morpheme. Amp = amplitude in decibels. F_o = fundamental frequency in Hertz.

List	Stimulus Sentence	Total Duration	Who + FM Duration	Verb Duration	Who Amp	Verb Amp	Who F_o	Verb F_o
BENCHMARK SENTENCE Who is pushing?		1.349	335	928	76.21	78.26	323	253
1	Who *is* pushing?	1.348	338	911	76.55	76.55	339	278
2	Who ϕ pushing?	1.279	230	912	75.55	77.44	345	260
3	Who *in* pushing?	1.334	324	942	74.21	76.86	345	294
4	Who *id* pushing?	1.368	329	925	78.63	78.89	339	278
4	Who *is* crying?	1.366	335	944	77.15	78.63	370	238
1	Who ϕ crying?	1.296	219	940	77.04	75.49	328	274
2	Who *in* crying?	1.331	334	909	76.78	77.29	345	259
3	Who *id* crying?	1.385	318	946	78.40	77.61	328	208
3	Who *is* cutting?	1.374	342	943	77.94	77.62	385	202
4	Who ϕ cutting?	1.286	228	937	75.35	76.50	299	225
1	Who *in* cutting?	1.323	341	915	75.46	75.86	323	232
2	Who *id* cutting?	1.344	324	932	76.28	78.04	328	236
2	Who *is* biting?	1.376	335	937	77.34	75.75	346	200
3	Who ϕ biting?	1.309	224	916	76.30	76.38	370	248
4	Who *in* biting?	1.338	347	937	79.19	76.43	333	225
1	Who *id* biting?	1.354	332	919	76.21	76.89	377	187
1	Who *is* climbing?	1.367	337	937	78.48	76.48	303	194

Appendix B continues

Appendix B continued

List	Stimulus Sentence	Total Duration	Who + FM Duration	Verb Duration	Who Amp	Verb Amp	Who F_0	Verb F_0
BENCHMARK SENTENCE Who is pushing?		1.349	335	928	76.21	78.26	323	253
2	Who ϕ climbing?	1.280	238	941	78.98	76.83	339	263
3	Who *in* climbing?	1.337	342	942	74.44	75.86	308	211
4	Who *id* climbing?	1.400	355	917	77.36	75.33	339	253
4	Who *is* playing?	1.353	346	920	77.07	76.82	333	211
1	Who ϕ playing?	1.226	211	924	76.10	78.85	345	270
2	Who *in* playing?	1.344	324	920	78.04	76.71	385	308
3	Who *id* playing?	1.380	323	934	78.23	77.79	328	271
3	Who *is* blowing?	1.409	346	938	78.59	79.45	338	213
4	Who ϕ blowing?	1.294	231	911	76.04	78.01	317	223
1	Who *in* blowing?	1.344	352	926	77.62	78.11	364	225
2	Who *id* blowing?	1.397	351	910	78.70	80.06	364	217
2	Who *is* cooking?	1.376	327	939	77.43	77.61	344	260
3	Who ϕ cooking?	1.304	232	930	77.33	78.01	344	241
4	Who *in* cooking?	1.322	333	916	74.82	75.98	308	385
1	Who *id* cooking?	1.372	334	915	78.51	79.11	364	256
1	Who *is* clapping?	1.358	328	924	77.98	76.58	364	213
2	Who ϕ clapping?	1.267	234	923	78.92	76.84	330	206
3	Who *in* clapping?	1.365	329	919	78.78	79.96	345	278
4	Who *id* clapping?	1.388	331	934	74.83	75.76	333	220
4	Who *is* painting?	1.368	353	917	77.85	76.82	323	235
1	Who ϕ painting?	1.269	219	910	76.51	76.40	339	247

Appendix B continues

Appendix B continued

List	Stimulus Sentence	Total Duration	Who + FM Duration	Verb Duration	Who Amp	Verb Amp	Who F_o	Verb F_o
BENCHMARK SENTENCE Who is pushing?		1.349	335	928	76.21	78.26	323	253
2	Who *in* painting?	1.340	342	915	78.58	78.43	344	253
3	Who *id* painting?	1.383	339	917	76.77	78.11	323	293
3	Who *is* catching?	1.330	338	918	76.49	76.01	323	345
4	Who ϕ catching?	1.276	219	929	76.65	76.32	400	244
1	Who *in* catching?	1.349	353	931	75.01	75.42	328	345
2	Who *id* catching?	1.368	331	936	76.69	75.52	323	308
2	Who *is* pouring?	1.378	344	925	78.16	78.14	317	290
3	Who ϕ pouring?	1.295	205	916	76.76	81.09	323	247
4	Who *in* pouring?	1.328	350	919	75.55	77.71	339	236
1	Who *id* pouring?	1.408	336	924	77.56	79.79	333	256
1	Who *is* kissing?	1.338	345	910	78.37	78.78	370	263
2	Who ϕ kissing?	1.254	232	915	75.11	75.53	340	476
3	Who *in* kissing?	1.353	334	948	76.93	78.52	344	238
4	Who *id* kissing?	1.414	325	940	76.13	76.73	346	230
4	Who *is* jumping?	1.331	320	909	75.44	73.69	345	227
1	Who ϕ jumping?	1.272	233	941	78.65	75.55	328	244
2	Who *in* jumping?	1.341	336	945	75.44	76.28	339	267
3	Who *id* jumping?	1.389	329	932	76.63	78.27	345	235
3	Who *is* building?	1.375	320	935	77.93	77.42	313	193
4	Who ϕ building?	1.276	209	916	76.96	77.23	408	225
1	Who *in* building?	1.325	348	922	76.20	77.10	328	220

Appendix B continues

Appendix B continued

List	Stimulus Sentence	Total Duration	Who + FM Duration	Verb Duration	Who Amp	Verb Amp	Who F_o	Verb F_o
BENCHMARK SENTENCE Who is pushing?		1.349	335	928	76.21	78.26	323	253
2	Who *id* building?	1.412	335	942	75.37	76.64	323	210
2	Who *is* kicking?	1.367	345	931	74.72	77.41	328	250
3	Who ϕ kicking?	1.305	237	916	76.13	76.01	370	285
4	Who *in* kicking?	1.361	325	912	75.31	77.54	377	328
1	Who *id* kicking?	1.347	320	912	75.37	75.47	317	270

Appendix C

Guidelines for Use of CSL for Acoustic Measurement of Stimulus Sentences

Measuring

To measure, double click the left hand button on the mouse, being very careful not to move the mouse, til you see the "delta" time (Δ) in the A window (represented with a triangle). Record this number.

1. Measurement 1 - Duration of "who + the target word": Place the cursor on the onset of [w] for "who." Locate the onset by the appearance of the second formant with the first formant on the spectrogram. (Use the left hand button on the mouse to activate cursors and to mark on the window. Be careful, a double click on the right hand button will erase all cursors already placed. You can pick up already placed marks one at a time by clicking directly on the mark and moving the mouse.) To locate the offset: (a) [Iz] locate the offset at the end of the dark turbulence for the [z]; (b) [Id] locate the offset at the middle of the release burst for the [d]; (c) [In] locate the offset at the middle of the last + in the first/second formants on the green formant tracing; (d) For "who" + omitted target word locate the offset at the end of the second formant of the vowel [u].

2. Measurement 2 - Duration of the entire utterance: Leave the cursor mark for the onset of "who" from the prior measurement in place. Move the cursor from the offset of the target word to the offset of the utterance. Locate the offset for the "ng" by placing the cursor in the middle of the last + of the first and second formants in the green formant tracing. Again, use the delta time for the duration measurement as seen in the A window.

3. Measurement 3 - Duration of the verb+ing: This time leave the cursor mark on the offset of the utterance and move the cursor from the onset of "who" to the onset of the verb. Locate this onset at the burst, or slightly to the left of the burst of the stop consonant. (Some of these will be faint and broken.) Note the delta time by double clicking and record this number.

4. Measurement 4 - Peak amplitude for "who": Note that when the cursors are moved in B window across the amplitude curve, the number in the < > at the top of the window on the far right indicates the changing amplitude measurements. Using the curve and checking these numbers, find the peak amplitude. (Note that the highest reading will sometimes appear to the right of the visual peak.) Also, make sure not to select a reading in the [I] vowel of the target word. Do select peak readings which are to the left of the initial visible segmentation of "who." Record the amplitude in the < >.

Appendix C continues

Appendix C continued

5. Measurement 5 - Peak amplitude for the vocalic portion of the first syllable of the verb: This is completed as in measurement 4 above. Be careful not to select a peak associated with the initial or a medial stop consonant. Some peaks are located on the [n] or [l] within verbs (e.g., build), not the vowel.

6. Measurement 6 - Peak F_0 for "who": Before beginning measurements 6 and 7, select "View" from the pulldown menu and change the Pen Color to blue. Then select "Analyze" and Pitch Extraction, and pitch all. Blue +'s will appear intermittently on the B window. Do not select Pitch before completing the amplitude measurements, because selecting this analysis changes the y-axis and corresponding readings in the < > portion of the window. Now use the cursors to sweep across the blue +'s and note the changing readings of the fundamental frequency in the < > part of the screen (top, right). Select the highest F_0 for "who" being careful to avoid [I] but using any part of "who" even if it is to the left of the initial visible segmentation. Record the F_0 from the < >.

7. Measurement 7 - Peak F_0 for the vocalic portion of the first syllable of the verb: Same as step 6, but again be careful (as in step 5) to avoid the stop consonants when selecting the peak.

After checking to make certain you've recorded all seven measurements, purge the screen using F2, click on A window and purge it with F2 also. The 7 measurements on one sentence are comlete, start at Step 3 under setup to begin another sentence.

Appendix D

Target and Foil Verbs Associated with Experimental Task Pages

Note. Page positions for the target verbs are designated by numbers and are as follows: 1 = top left corner, 2 = top right, 3 = bottom left, and 4 = bottom right corner.

Page	Target Verb	Page Position	Foil Verbs
1	pushing	2	walking, falling, kicking
2	crying	2	reading, painting, talking
3	cutting	3	drinking, washing, building
4	biting	3	writing, sitting, cooking
5	climbing	1	dancing, running, skating
6	playing	1	clapping, sleeping, biting
7	blowing	4	sleeping, sitting, writing
8	cooking	3	riding, swinging, hammering
9	clapping	3	playing, blowing, pouring
10	painting	2	reading, cutting, washing
11	catching	2	falling, sweeping, swimming
12	pouring	4	jumping, sweeping, walking
13	kissing	1	crawling, swimming, drumming
14	jumping	4	waving, swinging, jumping
15	building	4	splashing, cooking, crying
16	kicking	1	waving, skating, riding

Appendix E

Guidelines for Language Sample Transcription

Note. The guidelines for the computer software, Systematic Analysis of Language Transcripts (SALT) (Miller & Chapman, 1986), were the primary source for determining procedures for language sample transcription. All SALT punctuation and morpheme designating procedures were followed for accurate calculation of MLU by the SALT program. These additional guidelines were generated to establish reliable procedures for transcription decisions not otherwise specified by SALT.

Utterance-level Decisions:

1. Transcription begins at the start of the play on the audiotape and proceeds until a minimum of 100 spontaneous, complete and intelligible utterances are produced. Breaks in transcription due to interruptions by parents, changing toy sets or other distractions are possible.

2. Only child utterances are transcribed. However, context notes are included throughout the transcript to avoid the need to return to the audiotape for later interpretation.

3. All imitative utterances are placed in parentheses so that SALT will not include these utterances in the analysis.

4. Indicate long unintelligible strings using punctuation for context notes. Shorter unintelligible utterances are indicated with X for each unintelligible syllable. SALT does not include these utterances in the analysis.

5. Child utterances that are a repetition of prior utterances, regardless of adult input between utterances or the child's use of the repetition for emphasis, are placed in parentheses and not included in the analysis.

6. Yes/no utterances in the form of "yes," "no," "yup," "yeah," "nah," in response to adult yes/no questions are included in the transcript. Forms of yes/no such as "uhhuh" or "unhunh" are placed in parentheses and not included in the analysis.

Adult: Do you want the chicken in the wagon?
Child: yes.

Appendix E continues

Appendix E continued

7. Yes/no utterances that are in response to an adult repetition of the child's utterance are placed in parentheses and not included in the analysis.

> Child: chicken in wagon.
> Adult: The chicken's in the wagon?
> Child: (yes).

8. Nonwords such as "uhoh" or noises and exclamations (well, hey, oh) are placed in parentheses and not included in the analysis.

<u>Morpheme Segmentation Decisions</u>:

Generally, decisions regarding morpheme segmentation are based on procedures developed by Brown and cited in Miller (1981). The following additional decisions are specified.

1. The early developing negative contractions, "can't" and "don't" are always counted as one morpheme, not two.

2. Compound words are typed as one word so that they will be counted as one morpheme (e.g., byebye, nightnight, choochoo).

Appendix F

Subjects' Performance on Preexperimental Language Measures

Note. TD = typically developing group; SLI = specifically language impaired group; CA = chronological age in months; Rec SS and Exp SS = standard scores on the receptive language subtest and the expressive language subtest of the PLS-3; Rec LA and Exp LA = language age-equivalent scores on the receptive and expressive subtests of the PLS-3; MLU = mean length of utterance in morphemes; Is Use = percentage of occurrence in obligatory contexts.

Subject	Group	CA	Rec SS	Rec LA	Exp SS	Exp LA	MLU	Is Use
1	TD	24	105	27	109	29	2.00	0%
2	TD	26	127	35	117	32	3.27	27%
3	TD	27	105	27	113	30	2.74	45%
4	TD	23	137	33	134	33	2.69	38%
5	TD	25	115	30	139	41	3.21	38%
6	TD	27	118	31	121	33	3.68	39%
7	TD	27	109	28	121	33	2.83	36%
8	TD	28	127	35	130	37	3.73	5%
9	TD	27	118	31	117	32	2.32	0%
10	TD	31	102	33	98	32	3.09	6%
11	TD	26	121	33	117	32	2.19	24%
12	TD	25	131	36	130	37	3.04	25%
13	TD	22	123	28	130	32	2.53	31%
14	TD	29	112	29	133	38	3.10	27%
15	TD	24	93	23	121	33	2.53	32%
16	TD	29	115	30	117	32	2.97	38%

Appendix F continues

Appendix F continued

Subject	Group	CA	Rec SS	Rec LA	Exp SS	Exp LA	MLU	Is Use
17	SLI	58	57	31	66	38	2.56	58%
18	SLI	42	96*	43*	81*	35*	2.74	50%
19	SLI	57	82	48	75	43	3.45	55%
20	SLI	53	70	34	73	34	2.89	60%
21	SLI	42	76	30	81	33	2.45	41%
22	SLI	54	67	37	68	40	3.63	45%
23	SLI	44	76	30	73	28	2.21	54%
24	SLI	55	77	44	75	43	2.95	50%
25	SLI	42	80	33	75	29	2.33	31%
26	SLI	50	90	46	79	38	3.21	21%
27	SLI	44	78	31	77	30	3.09	30%
28	SLI	56	77	44	70	41	3.75	21%
29	SLI	42	86	36	79	32	2.45	36%
30	SLI	47	73	29	77	30	2.20	14%
31	SLI	42	78	31	83	34	3.70	48%
32	SLI	44	88	37	83	34	2.93	38%

* score based on CELF-P results, not PLS-3

Appendix G

Guidelines for Scoring the Experimental Task via Videotape

Note. These procedures were developed for accurate scoring of the experimental task, specifically for videotape viewing. Although all subjects' performances for the experimental task were scored during the experimental session, all videotapes were rescored by the investigator for final data analysis. Furthermore, 50% of the videotapes were rescored during reliability procedures.

1. From left to right, top to bottom, pictures for each item are considered #1 - #4. Children's responses are scored with the picture number selected and a + or - indicating correct or incorrect selection of the target verb. Comments regarding delays, hesitations, verbal output can be written on the score form.

2. Self-corrections by the child are allowed. However, if the child touches more than one picture without a verbal indication that he/she is self-correcting, this is considered an ambiguous response and it is not counted. A repetition may be given. If the self-correction appears in any way to have been prompted by the examiner, the first response is counted.

3. If the child points to more than one picture, count it as no response. Repetitions may be given by the examiner for these items.

4. If the examiner administers an item using "live voice" rather than the audiotaped stimulus, the response cannot be counted.

5. Responses to repetitions of stimulus items can be counted if the child clearly did not respond or responded ambiguously to the initial presentation. If repetitions were given simply because the child responded in error on the initial presentation, the response following the repetition cannot be counted.

Appendix H

Subjects' Results for Experimental Task

Subject	Group	Age	Sex	List	Verb Comprehension Is	Omit	In	Id
1	TD	24	M	1	4/4	3/4	3/4	2/4
2	TD	26	M	2	2/4	3/4	4/4	3/4
3	TD	27	F	3	0/1	0/0	2/3	2/3
4	TD	23	F	4	3/4	2/4	3/4	3/4
5	TD	25	F	1	2/4	2/4	2/4	3/4
6	TD	27	F	2	3/3	0/2	2/3	2/2
7	TD	27	M	3	2/3	0/2	2/4	0/2
8	TD	28	M	4	3/4	2/3	2/3	3/4
9	TD	27	F	1	0/4	3/4	3/4	3/4
10	TD	31	F	2	3/4	4/4	4/4	4/4
11	TD	26	F	3	3/4	3/4	3/4	1/4
12	TD	25	M	4	2/4	2/4	3/4	3/4
13	TD	22	M	1	1/4	3/4	3/4	0/4
14	TD	29	M	2	3/4	4/4	3/4	2/4
15	TD	24	F	3	2/4	0/4	1/4	2/4
16	TD	29	M	4	4/4	3/4	3/4	3/4
17	SLI	58	M	1	3/4	3/4	2/4	4/4
18	SLI	42	M	2	4/4	4/4	3/4	4/4
19	SLI	57	F	3	3/3	4/4	3/4	3/4
20	SLI	54	M	4	2/3	2/4	3/4	3/4

Appendix H continues

Appendix H continued

Subject	Group	Age	Sex	List	Verb Comprehension			
					Is	Omit	In	Id
21	SLI	43	M	1	3/4	4/4	3/4	3/4
22	SLI	54	F	2	4/4	4/4	4/4	3/4
23	SLI	44	M	3	1/4	3/4	3/4	3/4
24	SLI	55	M	4	3/4	3/4	0/4	4/4
25	SLI	42	M	1	4/4	4/4	4/4	4/4
26	SLI	50	F	2	4/4	4/4	4/4	4/4
27	SLI	44	M	3	1/4	2/4	3/4	4/4
28	SLI	56	M	4	4/4	2/4	3/4	3/4
29	SLI	42	M	1	3/4	4/4	3/4	2/4
30	SLI	47	M	2	4/4	4/4	0/4	4/4
31	SLI	42	M	3	3/4	2/4	3/4	3/4
32	SLI	44	M	4	4/4	4/4	4/4	3/4

Vita

Brenda L. Beverly was born in Baltimore, Maryland and raised in Reading, Pennsylvania. She earned her B.S. Ed. in Communication Disorders and her M.S. in Speech-Language Pathology from Bloomsburg University in Bloomsburg, Pennsylvania. Brenda was awarded her Certificate of Clinical Competence in Speech-Language Pathology from the American Speech-Language-Hearing Association in 1987. She worked in Florence, South Carolina for the Pee Dee Speech and Hearing Center and later for The Learning Center, affiliated with Bruce Hospital and the Carolinas Hospital System. In 1992, Brenda took a position as a clinical supervisor with The University of Tennessee Hearing and Speech Center. Clinically, her work has focused on evaluation and treatment of pediatric language and phonological impairments as well as fluency disorders in individuals of all ages. Brenda entered the doctoral program at The University of Tennessee, Knoxville as a part-time student in January 1994. Her degree will be conferred in December 1999.

Since August 1998, Brenda has been with the faculty of the department of Speech Pathology and Audiology at the University of South Alabama in Mobile, Alabama. There, she will continue to teach and conduct research in the areas of child language development and language impairment.