In presenting this thesis in partial fulfilment of the requirements for an advanced
degree at the University of British Columbia, I agree that the Library shall make it
freely available for reference and study. I further agree that permission for extensive
copying of this thesis for scholarly purposes may be granted by the head of my
department or by his or her representatives. It is understood that copying or
publication of this thesis for financial gain shall not be allowed without my written
permission.

Department of Graduate Studies - School of
The University of British Columbia
Vancouver, Canada

Date April 24/01

DE-6 (2/88)
ABSTRACT

Current explanations for lexical processing difficulties in children with SLI were evaluated using an online picture-naming task. The twenty-seven participants included a group of school age children with language impairment (SLI), and two groups of typically developing children, one matched for language level (LM) and one matched for age (AM). Participants named familiar line drawings from a computer screen while hearing semantically related or unrelated nouns through headphones. These words occurred at three points relative to the pictures: -300ms, 0ms, +300ms. Reaction times and accuracy were recorded. The SLI group resembled age peers in overall response patterns and speed, though some slowing was noted. The SLI group showed semantic priming in the first two Time conditions, but at +300ms, the priming pattern was reversed. Findings are seen to point to processing asynchronies and generalized slowing rather than representational deficit accounts.
# Table of Contents

ABSTRACT ................................................................. ii

TABLE OF CONTENTS ......................................................... iii

LIST OF TABLES AND FIGURES ........................................ vi

ACKNOWLEDGMENTS ......................................................... vii

CHAPTER ONE: INTRODUCTION ............................................ 1
  Lexical processing difficulties in SLI. ................................ 1
  Literature Review ....................................................... 2
    Normal development of lexical processing ........................ 2
    Reorganization of phonological underlying representations ... 3
    Improved lexical-semantic organization .......................... 4
    General increased speed of processing ........................... 6
  Summary of accounts of lexical processing development .......... 7
  Account 1: Specific deficits in phonological-lexical processing or representation. ... 7
    Evidence for the phonological processing account from offline research. .... 9
      Tip-of-the-tongue evidence ....................................... 9
      Non-word repetition studies ................................. 10
    Evidence for the phonological processing account from on-line research. .. 11
      The auditory lexical decision task ............................ 11
      Gating tasks ................................................... 12
    Evaluation of evidence for phonological processing deficit. .... 14
  Account 2: Specific deficits in lexical-semantic representation or processing. .. 14
    Off-line Evidence for a specific-lexical semantic deficit ....... 14
    Evidence from semantic priming studies ......................... 15
    Evaluation of evidence for specific lexical-semantic processing deficit .. 16
  Account 3: General processing constraints: slowness ............... 16
    Evidence for the generalized slowing account .................. 17
    Evaluation of the generalized slowing account ................ 20
  Evaluation of current literature on lexical processing in SLI ... 21
  Areas in need of further investigation ............................ 22
  The Current Study .................................................... 24
    Purpose ......................................................... 24
    The picture naming interference paradigm ...................... 24
    The semantic inhibition effect in adults ....................... 25
    Picture-Naming paradigm used with typical children .......... 27
    Usefulness of a picture naming paradigm used with language impaired children. .... 29
  Research Questions .................................................. 30
CHAPTER TWO: METHODS
Overview...34
Participants...34
Grouping procedures...35
Language impaired and typically developing groups...35
Age matched and language matched groups...36
Apparatus...38
Stimuli...38
Description of stimuli...38
Stimulus parameters...39
Frequency of use...39
Age of acquisition...39
Semantic properties...40
Phonological properties...41
Standardized line drawings...41
Inclusion of Distractor items...42
Creation of auditory stimuli...44
Design and Presentation...44
Overview of experiment...44
Experimental design...44
Experimental procedures...45
Data management...46

CHAPTER THREE: RESULTS
Overview...48
Results of Analysis...48
Reaction time analysis...48
Main effect for group...50
Main effect for relatedness...50
Main effect for time...50
Interaction of group and time...50
Summary of Findings...52

CHAPTER FOUR: DISCUSSION
Overview...54
Lexical Processing in Typical Development...54
Developmental differences in lexical processing...54
Development in general speed of processing...57
LIST OF TABLES AND FIGURES

Table 1: Mean and standard deviations for group defining measures. .....................37
Table 2: Stimulus List. .........................................................................................42
Table 3: Mean and standard deviation reaction times for LI, LM, and AM groups. ........48
Table 4: Mean and standard deviation naming errors for all groups. .......................52
Figure 1: Interaction of Group and Time. ...............................................................50
ACKNOWLEDGMENTS

In completing this project I relied on the time, expertise, and support of many individuals. I wish to formally acknowledge the contributions of these people here.

The principals, teachers, speech-language pathologists, and particularly the students from school districts in Maple Ridge, Coquitlam, and Surrey donated considerable time to my study. My final clinical educator, Betty-Ann Waddington, assisted in my search for student participants. She was also instrumental in promoting my clinical confidence while demonstrating high standards of practice in a school setting.

The two members of my thesis committee, Jeff Small and Judith Johnston, have both made extraordinary contributions of time and expertise to this project. For endless hours, Jeff Small helped me to work through the technological aspects of creating the experiment, even on evenings and weekends! The comments he provided during the editing process were also thought-provoking and useful.

Judith Johnston, my thesis advisor, patiently guided me through virtually every element of this project and I am grateful for the rich academic experience I gained working with her. During the writing process I appreciated her knack for identifying the often elusive areas of potential within my work and for helping me to organize them more eloquently.

On a personal level, I would like to acknowledge the immense assistance I have received from my companion, Rodney Smelser. His many contributions ranged from the technical, such as providing computer expertise, to the domestic, such as doing my laundry when I was too busy.

Finally, for their contribution of funding, I wish to thank the British Columbia Medical Services Foundation for their summer research scholarship. I am especially grateful to my father, John Howarth, who generously funded my entire nine years of post-secondary education and who encouraged me to pursue a degree in speech-language pathology in the first place.
CHAPTER ONE: INTRODUCTION

Lexical processing difficulties in SLI.

The purpose of this study is to examine lexical processing in typical and language impaired children. From an early age, children with specific language impairment (SLI) often demonstrate difficulties in lexical development beyond the difficulties observed in same-age peers or younger children at similar language levels. For example, children with SLI generally acquire their first words later than typically developing children (Leonard, 1998). Analysis of utterances produced by young preschoolers demonstrates less lexical diversity in children with language impairments compared to both their age-peers and MLU matched peers (Watkins, Rice, & Moltz, 1993; Watkins, Kelly, Harbers, & Hollis, 1995). Older children with SLI name pictures less quickly and less accurately than their same-age peers (Leonard, Nippold, Kail, & Hale, 1983; Lahey & Edwards, 1996, 1999; Wiig, Semel, & Nystrom, 1982).

The cause of lexical difficulties in children with SLI is currently an unresolved area of investigation. Deficits in lexical processing have been implicated in the atypical lexical development described above, however it is not yet clear what the exact nature of these deficits are, and whether they constitute a specific area of deficit for language impaired children, or whether they are actually consistent with the typical processing of children at the same language level.

Several theories about the nature of lexical processing in children with language impairments exist. The three most prominent of these theories are based on theories of typical development in lexical processing and fall into two general categories: (1) those implicating specific processing or representational deficits in the lexicon, and (2) those implicating general processing constraints.
Some current evidence points towards specific phonological processing or representational constraints, such as poorly defined and organized phonological underlying representations in the lexicon (Dollaghan, 1998; Edwards and Lahey, 1996). A specific semantic processing deficit is another possible cause of lexical difficulties in children with SLI, although it is one not yet documented in detail. Other evidence suggests a general processing constraint, such as slowness of processing, in children with SLI (Lahey and Edwards, 1996).

Throughout this chapter, these three theories are first reviewed briefly in the context of typical development in lexical processing. Then, the current literature on three parallel accounts of lexical processing difficulties in children with SLI is reviewed. Limitations in this literature are then identified and the purpose and experimental technique of the current study are introduced.

Literature Review

Normal development of lexical processing

To understand the nature of lexical processing in language impaired children we must first understand how a typical child's lexical processing changes from birth to adulthood. Many inherent challenges exist in developing a mature lexical system; children must first identify spoken words from a continuous, acoustically variable speech stream and then map these words onto a meaning or concept (Church & Fisher, 1998). A growing body of literature has investigated how infants begin to create these initial lexical entries (see Church & Fisher, 1998 for review) to begin learning words. However, relatively less is known about the transformation from the early preschool lexical processing system to the mature adult lexical processing system. In this context, lexical processing is defined as a set of processes which encompass the manipulation of both the lexical representations of phonological form and syntactic-semantic
representations in the lexicon (Bock & Levelt, 1994).

The proposed areas of lexical processing development to date parallel the areas of proposed weakness in SLI, including reorganization of the phonological underlying representation in the lexicon, improved lexical-semantic organization, and increased speed of general processing; each of these three ideas will be reviewed briefly here.

Reorganization of phonological underlying representations.

One difference in the lexical systems of children and adults appears to be in the level of phonological detail available in the underlying representations. Current models of lexical development suggest that the phonological underlying representations in typically developing children move from being undetailed, or "holistic" to being more fine-grained as the size of the lexicon grows (Garlock, 1998; Metsala, 1997; Walley, 1993). Specifically, underlying lexical representations are restructured from being detailed to the level of the syllable to being detailed at the level of the phoneme as more phonetic overlap occurs in the growing lexicon (Garlock, 1998).

One piece of evidence for the undetailed lexical representations in children compared to adults comes from gating studies. In one gating task, kindergarten children required more of the auditory signals to reach an isolation point and a total acceptance point than did older, grade one children and adults (Walley, Michela, & Wood, 1995). The finding that younger children require more of a signal to recognize a word could be consistent with a lexical system where words are stored without distinct phonemic onset details, but rather by larger word units such as the syllable. As the children mature and their vocabularies grow, they become better able to identify words based on the phonemic onset (Walley, 1993).

Further evidence for phonological underlying representation restructuring comes from a phonological priming study using a cross-modal picture-naming paradigm with children ages 4 to
11 (Brooks & MacWhinney, 2000). In this paradigm, children were asked to name pictures while listening to interfering words which were phonologically related by onset, or rhyme, or were phonologically unrelated. In younger children, the strongest phonological priming effects were reported when the target and interfering stimulus shared a common rhyme. This rhyme priming was not significant in the older children, but rather, the older children were only primed by stimuli sharing the same onset. These results would be consistent with a lexicon which is restructured from a global representation to a more detailed and efficient representation organized by word onset (Brooks & MacWhinney, 2000).

**Improved lexical-semantic organization.**

The production of overextended or underextended naming errors in early language development is a phenomenon which suggests that children do not start out with adult-like organization in the semantic network. In light of the evidence for holistic phonological underlying representations in young children's lexicons, there is also the possibility of impoverished, or poorly organized and connected semantic representations in young children. While some evidence exists for differences in lexical semantic processing in children and adults, this evidence is far from conclusive.

In the analysis of word-finding errors produced by typically developing preschoolers in naming and story telling tasks, mistakes were most frequently semantic in nature, where a semantically related word of the target was given (McGregor, 1997). This is a finding that suggests difficulties in lexical-semantic processing in typical children. Unfortunately, our knowledge about lexical semantic processing in young children has been historically limited by methodological flaws, such as comparing semantic priming in young children and adults when stimuli are presented in a written format (Powell, Wulfeck, Bates & Liu, 1997). Recent use of
auditory online paradigms, such as cued shadowing, and the picture-naming interference task have attempted to address such limitations. Cued shadowing is an online, auditory task where subjects listen to words or sentences and repeat a target word which is signaled by voice shift (Bates & Liu, 1996). This procedure has revealed robust semantic priming effects in children as young as 7 (Powell, Wulfeck, Bates & Liu, 1998; Liu, Bates, Powell, & Wulfeck, 1997). In these studies, apart from overall slower reaction times in the younger children, the older and younger children demonstrated equivalent semantic priming effects suggesting that children as young as 7 have well organized and detailed semantic underlying representations. In another study using the picture-naming interference task, where Japanese 6-year-old children named pictures while hearing a semantically related or an unrelated word presented at different time conditions, significant effects of semantic relatedness in one of the seven time conditions was reported (Tazume, 1997). However, the findings of these few studies do not rule out the possibility of differences in lexical-semantic organization in children and adults. One reason for the similar semantic priming effects in young children and adults on these online tasks could be the nature of the semantic relations evaluated. The word pairs used in the cued shadowing tasks, as well as in the picture-naming interference task, were related by strong semantic association rather than by semantic category. For example, “airplane” and “fly” were used as a related pair, rather than a more categorical pair like “airplane” and “bus”. This point is not a trivial one, considering findings that adults demonstrate significantly different semantic priming effects when stimuli are related by either semantic association or by semantic category (LaHeij, Dirkx, Kramer, 1990). Typical 10 year old children have demonstrated robust semantic priming effects with both category and association type semantic relations (Nation & Snowling, 1999). However, it is possible that younger children would not exhibit semantic priming in both types of stimulus
pairs. Some researchers believe that younger children organize the words in their lexicon by
function, or semantic association until they eventually adopt the categorical organization seen in
adults and older children (Nation & Snowling, 1999). In support of this notion, at least one
picture naming study has demonstrated priming effects with words related by semantic category
in grade two children but not in kindergarten children (McCauley, Weil, & Sperber, 1976).
Clearly more research is needed in the area of developmental lexical-semantics; however, in the
meantime it remains possible that the organization of the lexicon is transformed as children
develop and learn more words.

General increased speed of processing.

Overall processing speed is another postulated area of difference between lexical
processing in children and adults. Children perform slower than adults on a variety of both
lexical and non-lexical tasks (Kail, 1991; Edwards & Lahey, 1993; Liu, Bates, Powell, &
Wulfeck, 1997), and speed of processing is found to increase consistently into adulthood (Kail,
1991). In a study of auditory lexical decisions in 6 to 9 year olds and adults reaction time
decreased with age; this difference in speed during the auditory lexical decision task was
equivalent to the difference in verbal response time for a tone detection task, therefore the
authors attribute lexical slowness to a general response slowness in children (Edwards & Lahey,
1993). According to Edwards and Lahey, whether this speed reduction is caused by neuromotor
immaturity or a limited information processing system remains to be seen. Whatever the cause,
typically developing children seem to have a generally slower processing system than adults; this
slowness influences, but is not restricted to lexical processing.

Although there appears to be evidence for an increase in processing speed with age, the
generalized slowing hypothesis falls short as a comprehensive account for lexical development as
a result of its general scope. This account alone could not account for the specific developmental differences in lexical-semantics and phonological underlying representations previously discussed. Additionally, research which investigates the speed of processing in specific tasks and task components is still required to validate the model by reducing the possibility of slowness in specific processes. Online tasks are particularly applicable to this line of research because they permit specific processes to be isolated and manipulated experimentally. For example, the auditory gating task, serves to isolate the acoustic-phonetic word identification processes (Grosjean, 1996).

**Summary of accounts of lexical processing development.**

The nature of typical lexical processing development remains an area where significant investigation is warranted. Preliminary evidence exists for the holistic phonological underlying representation model, but evidence and intuition also support the notions of lexical-semantic reorganization, and increased speed or efficiency of processing with age. Further studies are required to evaluate each of these accounts in detail with both typical children, and language impaired children. At this point, the discussion will delve further into the research in the three areas of proposed lexical processing development in language impaired children.

**Account 1: Specific deficits in phonological-lexical processing or representation.**

In models of word production, lexical-phonological processing serves to transform a semantic-syntactic underlying representation to a phonological underlying representation which permits phonological encoding, or the assembly of the sounds and intonation of a word (Levelt, 1999). In lexical perception, phonological processing serves to map an acoustic-phonetic representation to a phonological representation useful in generating a cohort of possible lexical entries for use in word recognition (Tyler, 1992). Because in the real world, word production
and lexical perception usually occur within sentence processing. Phonological working memory is also a significant factor in lexical processing. The phonological working memory is the system responsible for short-term holding of verbal material by rehearsal while higher-level processing occurs (Montgomery, 1995a). Since lexical-phonological processing must occur quickly in real-time, and the acoustic quality of average speech is often jeopardized by background noise, contextual variability and short durations of segments, it would not be surprising if lexical-phonological processing was a vulnerable system (Church & Fisher, 1998). Breakdowns in either phonological working memory or lexical-phonological processing would limit the ability of children to process all of the phonological details in words that they heard, which in turn would yield overall poorly defined or inaccurate underlying phonological representations in the lexicon. Phonological representational deficits could limit the speaker's ability to effectively retrieve words from the lexicon because there would not be enough detail to differentiate similar words by form.

Current literature around lexical processing in SLI lends support to both limited phonological representational and phonological processing accounts for reduced lexical knowledge and skills in children with SLI. The representational account points to poorly detailed or organized underlying representations in the lexicon while the specific processing account refers to inefficient processes in the access to phonological form within the lexicon. These two accounts are clearly distinct from one another, however, studies designed to differentiate between them are not yet available. Thus, for the purposes of this paper, specific representational or processing accounts are discussed together as a phonological processing account.

The phonological processing deficit account is an appealing one because it is consistent
with the growing literature reporting a wide variety of perceptual and productive phonological
difficulties in children with SLI. For example, studies have demonstrated that language impaired
children demonstrate fragile speech discrimination abilities where perception of rapid acoustic
transitions are highly vulnerable to breakdowns (Leonard, McGregor, & Allen, 1992;
Montgomery, 1999). Additionally, the analysis of naturalistic speech samples produced by
young preschoolers reveals delayed articulation and phonological skills with reduced
intelligibility of speech in preschool children with SLI compared to their age-peers (Roberts,
Rescorla, Giroux, & Stevens, 1998). Finally, preschool and school-age children with language
impairments have been reported to perform poorly on phonological awareness tasks, such as
rhyme and alliteration production, compared to their age-match and language-match peers
(Fazio, 1997; Joffe, 1998). Considering these areas of weakness, a finding of either poorly
defined phonological representations or limited phonological processing skills in children with
SLI would be no surprise. The results of several off-line and on-line experiments are, in fact,
consistent with the phonological processing account for lexical deficits in SLI and these studies
will now be reviewed in detail.

Evidence for the phonological processing account from offline research.

Tip-of-the-tongue evidence.

The tip-of-the-tongue phenomenon (TOT) occurs when a speaker is unable to produce a
specific lexical item while reportedly knowing the meaning and form of that specific word
(Faust, Dimitrosvsky, & Davidi, 1997). The TOT phenomenon often provides additional
evidence for models of the lexicon; Bock and Levelt, for example, claim that a TOT state is
evidence of a separation of the “lemma” and the “lexeme” (Bock and Levelt, 1994). One study
elicited the TOT phenomenon in a naming task with language impaired children and their
typically developing classmates (Faust et al., 1997). The language impaired children named
significantly fewer items, and reported the TOT state more often than their peers. During the
TOT state, all of the children were able to provide appropriate semantic information about the
target words. However, the children with language impairment provided less, and less accurate
information about the phonological form of the target word than their peers suggesting a
processing breakdown at the level of the phonological underlying representation.

Non-word repetition studies.

Non-word repetition tasks, which have been found to predict lexical knowledge with both
children and adults in many different studies, usually require subjects to repeat multi-syllable
nonsense words (Edwards & Lahey, 1998). Although not without controversy, non-word
repetition tasks have often been used to assess phonological working memory in adults and
children (Adams & Gathercole, 1995). Many researchers argue that the nonword repetition task
is more pure a measure of phonological working memory than tasks which use real words
because success on the nonword repetition task requires the use of phonological processes such
as perception and encoding, in the absence of higher level lexical knowledge (Montgomery,
1995b). This claim is called into question by Dollaghan, Biber and Campbell (1995), who
demonstrate that performance on non-word repetition tasks can be influenced by long-term
memory and lexical knowledge. However, the nonword repetition task does involve phonological
processing and phonological working memory; and a deficit in these areas clearly would yield
difficulties on that task.

Typical preschool children who perform well on nonword repetition tasks and other
measures of phonological working memory have been found to use more complex grammar and
a greater vocabulary than children who do not perform as well (Adams & Gathercole, 1995).
Children with language impairments do not perform as well on non-word repetition tasks as their peers (Dollaghan & Campbell, 1998; Edwards & Lahey, 1998; Montgomery, 1995a). Results of the non-word repetition task using stimuli controlled for phonetic complexity and resemblance to other English words, were found to be "extremely powerful predictors of language status" because they differentiated between language impaired children and typically developing children with a high degree of accuracy (Dollaghan & Campbell, 1998). Such findings lend support to the phonological processing account for lexical difficulties in children with SLI.

Evidence for the phonological processing account from on-line research.

The auditory lexical decision task.

The auditory lexical decision task, where subjects respond "yes" to real words or "no" to nonwords as quickly as possible, was administered to a group of children with SLI and a group of age-matched typically developing peers (Edwards and Lahey, 1996). Children with SLI were both slower and less accurate than same age peers at making auditory lexical decisions. Two possible interpretations of these results are offered by Edwards and Lahey: first, children with SLI may have generally slower processing abilities, and especially slow decision making skills. This explanation would account for the finding that children with SLI were slower at the task, however, it would not adequately explain the higher number of inaccurate responses. The second possibility is that children with SLI have difficulty with the lexical processes used to access a word by phonological form and moreover, have access to only "holistic" or undetailed underlying phonetic representations. The auditory lexical decision task would pose difficulties for children with SLI because searching for word entries by form through holistic lexical representations would be inefficient and ineffective; both the slowness of response and the higher number of inaccuracies could be explained by this phonological processing account. As the study
lacks a language-matched control group, Edwards and Lahey were unable to comment on whether the proposed slowness and phonological processing deficits are related to developmental language level or whether they are specifically impaired in children with SLI.

Windsor and Hwang (1999a) addressed this limitation by conducting the auditory lexical decision task with language impaired children, their chronological age-match peers and language-age match peers. Compared to both groups of peers, the children with language impairments responded more slowly and less accurately to morphologically derived words with less phonological transparency. In other words, language impaired children had more difficulty than their age and language matched peers in judging words if the phonological form of the base word was different than that of the derived form as in the pair “major/majority”, where the primary stress is shifted and the initial vowel is centralized during the derivation. In the SLI group alone, performance was significantly worse in processing the phonologically opaque derivatives than the phonologically transparent derivatives, such as “dark/darkness”. Presumably the additional cost of the phonological opacity caused the reduced performance in the children with SLI because of limited processing abilities. Although intended to evaluate a general processing limitation account, the results of this study could also be consistent with a specific phonological processing account in children with SLI.

Gating tasks

More compelling evidence for specifically weak phonological processing in children with SLI comes from an experiment which employed the gating task. Spoken word recognition with auditory time gating, requires subjects to identify words based on the presentation of increasingly longer segments of the word (Grosjean, 1996). Gating studies provide insight into lexical access processes because they evaluate the amount of word stimulus required for word isolation
In a recent study, Dollaghan compared the word recognition performance of children with SLI, and their typically developing age-matched peers (Dollaghan, 1998). Stimulus words were in three groups: unfamiliar nonsense words (beal) which were taught to the subjects, familiar words related to the nonsense words phonologically (bead), and familiar unrelated words (boat). Children with SLI could identify familiar, phonologically unrelated words as quickly as their peers. However, they required more acoustic signal to identify the words from the other two stimulus groups. In addition, many of their midterm guesses did not even belong to the same word-initial cohort for familiar and unfamiliar words. The results suggest that children with SLI have weak phonological processing; the representations for new lexical entries are not quickly and accurately distinguishable from similar existing entries. However, without a language-matched control group, whether such a deficit is an area of particular weakness for children with SLI, or a factor tied to language ability is unknown.

Fortunately, in a more recent study Montgomery used highly familiar words in an auditory time gating experiment with language impaired children, their age-matched peers and their vocabulary-matched younger peers (Montgomery, 1999). Montgomery evaluated the amount of acoustic information required by the subjects to reach various points in auditory lexical processing, including the phoneme identification point where a subject can identify the first phoneme of the word, the cohort point, where a subject first produces a word from the cohort of possibilities, and the isolation point, where the target word is first identified. Results from this study indicated that children with SLI reached each of these lexical processing stages in the gating task with the same amount of auditory information as both their age-peers and their vocabulary-peers. One possibility for the difference between Montgomery’s findings and those of Dollaghan is that Montgomery’s task, which used highly familiar words, was not sensitive
enough to identify developmental distinctions in processing. When processing highly familiar words, language impaired children did not have difficulty in acoustic-phonetic processing, however, difficulties in lexical phonological processing at the sentence level, or processing of more recently acquired words were not ruled out by this investigation.

**Evaluation of evidence for phonological processing deficit.**

Strong evidence exists for an account attributing lexical processing difficulties to weak underlying phonological representation and limited phonological-lexical processing skills in children with SLI. However, as will be shown in the following sections, the specific focus of this account poses a problem in light of findings which can not explained by phonological processing deficits alone.

**Account 2: Specific deficits in lexical-semantic representation or processing.**

A second explanation for some of the lexical difficulties exhibited by children with language impairments posits specific deficits in lexical-semantic processing. Such a deficit could involve deficiencies in the underlying semantic representation, or breakdowns in lexical-semantic processing because of poor connections between lexical entries in the semantic network.

**Off-line Evidence for a specific-lexical semantic deficit.**

Off-line productive data, such as error analysis, suggest that like the phonological representations, the semantic representations in children with SLI might be flawed. One recent study categorized and analyzed naming errors in children with and without SLI (Lahey and Edwards, 1999). Children with SLI and a group of age-matched peers were asked to rapidly name a series of line drawings. The resulting naming errors were classified according to a list of subcategories. Analysis revealed that the children with SLI made more naming errors than NLI
peers. The largest difference between control and SLI groups in error distribution was that children with SLI had a greater proportion of "semantic-associated" errors, such as saying "key" for "lock" or "dust" for "broom". This finding suggests that children with SLI may have poorly defined and poorly organized semantic representations, or they may have difficulty with lexical-semantic processes such as lexical selection.

Evidence from semantic priming studies.

An additional means of assessing the lexical-semantic system is through semantic priming. Semantic priming occurs when the presentation of a stimulus causes an improvement in reaction time or accuracy of a response to another related stimulus. Priming studies can reveal the nature of the relationship between lexical stimuli and are therefore useful in the study of the organization of the lexicon. Very little work on priming in children with SLI is available; however, evidence from priming studies in children with word-finding difficulties or reading impairments suggest semantic deficits. One study investigated the effects of semantic priming in preschool children with word-finding difficulties (McGregor and Windsor, 1996). In this naming exercise, the accuracy of children with word finding difficulties increased in the presence of semantic primes which were synonyms of the target words (e.g. walking-stick/cane, road/highway, wallet/pocketbook). However, the improved accuracy of children with word finding difficulties was significantly less than the increased accuracy of the control groups.

Semantic priming was also used in a recent study of lexical decisions in good and poor reading comprehenders (Nation and Snowling, 1999). Both groups demonstrated robust priming effects for words that were highly associated such as "shampoo" and "hair". Unlike their peers, children with reading comprehension difficulties did not present with priming effects in "non-associated category coordinate pairs", such as "bottle", and "jar". These findings suggest that
children with reading comprehension difficulties may have difficulty with the construction of categorical semantic relationships in the lexicon.

**Evaluation of evidence for specific lexical-semantic processing deficit.**

In light of the finding that children with SLI produce more semantic-associated naming errors than their peers (Lahey and Edwards, 1999) and the results of the two priming studies with other populations of language-challenged children, it seems plausible that children with SLI also have some representational, or process-related deficits of a semantic nature. However, because processing difficulties seem likely in both phonological and semantic lexical processing, the possibility of a general processing constraint at the root of both specific processing breakdowns deserves further consideration. The final theoretical account discussed in this review will thus be the generalized slowing hypothesis.

**Account 3: General processing constraints: slowness**

The generalized slowing account suggests that symptoms of language impairment arise because of general limitations in information processing and storage due to a reduced rate of processing in children with SLI (Windsor & Hwang, 1999a). The general slowing account basically postulates that children with SLI are slow to perform lexical tasks because of generally slow processing which is not specific to linguistic processing. By this account, the observed specifically linguistic deficits in children with SLI could be explained within a generalized slowing account by the time-dependent nature of language (Miller, Kail, & Leonard, 1998). The areas of language which are specifically vulnerable in children with SLI, such as grammatical morphology in English, are particularly dependent on timely processing because of the relatively short durations involved (Leonard, McGregor, & Allen, 1992). While this account has been questioned because of its broad scope and failure to permit sufficient explanatory power
regarding various spared abilities in children with SLI (Johnston, 1994), it has also received considerable attention because it seems to account for many of the deficits exhibited, and is appealing to intuition (Windsor & Hwang, 1999a).

Evidence for the generalized slowing account

Evidence for the generalized slowing account comes from numerous studies where children with SLI are slower than their peers on a variety of processing tasks, both linguistic and non-linguistic in nature (Kail et al., 1994). For example, children with SLI are slower than same-age peers at performing lexical tasks like naming pictures (Leonard et al., 1983; Lahey and Edwards, 1996), and making auditory lexical decisions (Edwards and Lahey, 1996). They are also slower at performing non-linguistic tasks such as searching for a visual match to a target from five choices (Miller, Kail, & Leonard, 1998).

In an attempt to quantify the slowness in processing by children with SLI, a number of researchers have evaluated models which mathematically predict the reaction times of language impaired children on a variety of tasks from previously published research studies (Kail, 1994; Windsor & Hwang, 1999b; Miller et al., 1998). Kail (1994) and Miller and colleagues (1998) reported a linear relationship between mean reaction times in a group of language impaired children and their peers on a variety of tasks such as picture naming, and digit scanning. The language impaired group of children was found to respond with reaction times one fifth (Windsor & Hwang, 1999b) or one third (Kail, 1994) greater than their age-peers without language impairments regardless of task. Although these studies appear to support the generalized slowing hypothesis, this support is questionable; since the specific processing demands of each task were not examined or controlled for, we cannot rule out the possibility that a specific type of process contributes to the slowness more than another process. As Windsor and Hwang (1999b) point
out, the difficulty of tasks used to demonstrate generalized slowing has not yet been sufficiently investigated. They predict that generalized slowing in children with SLI would be more obvious in difficult lexical tasks, such as the auditory decision task with opaque derivatives used in Windsor and Hwang's study (1999a), than in the more simple picture naming and auditory lexical decision tasks typically used to evaluate the generalized slowing hypothesis.

One recent study used a variety of on-line naming conditions in an attempt to tease apart the relative contributions of lexical processes, perceptual processes and non-linguistic processes to slowness in naming by children with SLI (Lahey and Edwards, 1996). The first condition evaluated the speed of lexical processing. Reaction times were measured as subjects named line drawings after pauses of specific durations between picture presentation and response signal; children with SLI were significantly slower than their age-matched peers at all pause durations, but there was no group by pause duration interaction. This finding was interpreted as indicating that slowness of lexical processing does not contribute to slowness of naming in children with SLI because the children with SLI did not especially benefit from the extra lexical processing time provided by the longer pauses. The second condition focused on perceptual encoding of the stimulus. Subjects were given identical prime pictures or unrelated prime pictures prior the presentation of the picture to be named. The primes were presented for three different durations: 25ms, 75 ms, and 125 ms. If the children with SLI were slower at perceptually encoding the pictures, there should be less difference between the groups at the longer durations of the identical primes because more encoding time would be permitted. Since no group by prime duration by prime type interaction effects were found in the analysis, it was assumed that perceptual encoding slowness did not contribute to the differences in naming slowness between the two groups.
As slower perceptual encoding of pictures was not found to contribute to slowness in naming in the children with SLI compared to their peers, the third task evaluated the possibility that slower post-lexical verbal response production, or the process of articulating a word once lexical selection is complete, could account for most of the difference in naming speeds between the two groups. In the third condition, subjects completed auditory and visual detection tasks where they were asked to respond to a tone or a circle with the verbal response “yes”. Although this “yes” is a verbal response, the authors claimed that it required minimal lexical processing because it was used repeatedly throughout the task, and did not carry any contextual meaning. The “yes” response was considered to be an estimate of post-lexical verbal response time, or the time required to articulate a spoken word when no lexical selection processing was required. Children with SLI were significantly slower than the control group on both the auditory detection and visual detection tasks. The difference in speed between the two groups on these tasks was close to the difference in naming speeds, therefore Lahey and Edwards claimed that most of the difference in naming speed could be accounted for by the slower post-lexical verbal response time in the language impaired group. Although handy, and seemingly logical, this interpretation of the third experiment does not entirely hold up under closer scrutiny. The differences in speed for responding “yes” to a stimulus are not necessarily related to post-lexical verbal production; many other processing systems, such as attention or memory could be involved. Also, this task did not rule out the possibility that the processing demands of detecting the signal were more vulnerable in language-impaired children rather than the demands of uttering the response word.

Lahey and Edwards considered their findings as support for a generalized slowing account of naming slowness, where the children with SLI have a limited rate of processing which is not specific to language or perceptual processes. While this slowing is general in that it
applies to non-linguistic processing, it is not general across different tasks. If the slowness influences post-lexical processing but not lexical or perceptual processing, a generalized slowness account falls short. A reduction in the rate of processing in specific components of a task is not a generalized constraint.

Although Lahey and Edwards's results are not conclusive, they are useful in that they cast doubt on the generalized slowing hypothesis' ability to account for naming difficulties in SLI when component processes are teased apart. Further investigation into the speed of processing specific components of tasks, with consideration for the relative difficulty of those tasks, is clearly warranted.

Evaluation of the generalized slowing account.

The generalized slowing account for lexical difficulties in specific language impairment seems to account for the many findings where children with SLI perform relatively slower than their typically developing peers on a variety of tasks. However, in and of itself the generalized slowing account would not account for all of the lexical data available in the SLI literature. The production of relatively higher naming errors in children with SLI (Leonard, Nippold, Kail, & Hale, 1983; Lahey & Edwards, 1996) would not be fully explained by generalized slowing because a slow but otherwise intact lexical system could still produce accurate words, especially in a naming task without time limitations. Also, findings where language impaired children perform as quickly as their peers would not be explained by the generalized slowing account alone (Miller, Kail, & Leonard, 1998). One means of saving the generalized slowing hypothesis is to adopt a hybrid account which takes into account such factors as task demands and knowledge base to predict performance on language tasks (Johnston, 1999). This adapted account where generalized slowing interacts with the specific task requirements and the
knowledge available for completing a task has promise and requires further investigation.

As is obvious from the preceding sections, the generalized slowing theory is only one of many areas in the lexical processing literature which require more attention. The discussion will thus move to a comparative evaluation of the current literature in lexical processing in language impaired children, and to the important areas requiring further exploration.

Evaluation of current literature on lexical processing in SLI.

Preliminary evidence exists for the specific phonological and semantic processing accounts as well as the generalized slowing account of lexical difficulties in SLI. However, none of these accounts alone could account for all of the evidence described in previous sections. For example, a phonological processing deficit could not account for the abundance of semantic errors in a naming task. A semantic processing deficit, on the other hand, could not fully account for the difficulties exhibited by children with language impairments on gating tasks and nonword repetition tasks. The generalized slowing account may be able to account for all of these phenomena, but it would fall short in accounting for those few tasks on which language impaired children performed as quickly as their peers (see Miller, Kail, & Leonard, 1998). Finally, it is implausible that all types of processing tasks would be equally slow in children with language impairments. To create a useful account of lexical processing deficits, the interaction of slowness, task difficulty, knowledge and available processing resources must be considered as an expansion to the generalized slowing account. It is clear that with the evidence presently available, none of these three accounts can stand above the others; it is even possible that all three play some role. The nature of lexical processing difficulties in language impaired children will remain elusive until several significant issues are addressed by empirical means.
Areas in need of further investigation.

One significant issue which remains to be addressed is whether children with SLI have a series of isolated, or specific lexical processing deficits, for example, phonological and semantic, or whether, they have a more global processing deficit, such as generalized slowing, which creates difficulties in lexical processing. This issue is not only theoretically interesting, but of clinical importance as well; understanding where processing breakdowns occur is highly critical to designing intervention for language impaired populations. To improve our knowledge of lexical processing in children with language impairments, expansion in the two areas of investigation described in the next sections are essential.

The first area which requires more investigation in language impaired children is lexical-semantic processing. Although evidence from error analysis and off-line semantic priming studies implies a deficit in lexical-semantic processing in children with language or reading difficulties, there is not yet enough reliable evidence for lexical-semantic processing deficits in children with language impairments. It seems possible that children with SLI have specific difficulties in the lexical-semantic representation, or in the component lexical-semantic processes in lexical access, but further evidence is needed to confirm this point.

The second area requiring further investigation is the nature of processing slowness in children with SLI. Although we know that children with SLI are consistently slower to respond to many tasks than their chronological age-matched peers, we still do not fully understand the scope of this slowness. Evidence from Lahey and Edwards (1996) suggests that slowness may only affect specific non-linguistic processes in lexical tasks. Research comparing processing speeds in different components of tasks is required in order to further assess the generalized slowing hypothesis. Whether slowing in language impairment is general or process specific has
significance because of the different implications for predicted sources of breakdowns within a language processing model. While generalized slowing of all processes would yield some detrimental effects, slowness of specific processes could also create breakdowns by hindering coordination among interdependent language processes (Johnston, 1999). The speed in different types of processing tasks is highly significant in the study of language processing, where coordination of processes is essential. One single faulty or slow process could wreak havoc on other dependent language processes.

Even if more studies about lexical-semantic processing and the speed of processing in specific tasks in children with language impairments are conducted, one important question would still remain. Do children with language impairments have a specific deficit in lexical processing, or do they have typical lexical processing skills for their language level? To answer this question, an important methodological adjustment must be made to future research studies. Very few studies of lexical processing in children with SLI have used a language matched control group to investigate the possibility that lexical processing deficits in children with SLI are related to language level. Because most studies include only an age-matched control group, the issue of whether processing constraints in lexical tasks are related to overall language ability, or are an area of particular weakness for children with SLI remains to be addressed. Since both slowness of processing (Chi and Gallagher, 1982), and holistic lexical representations (Levelt, Roelofs, & Meyer, 1999) are known to be consistent with typical language development, it is possible that children with SLI are processing lexical items in the same fashion as younger children with the same language skills. Distinguishing between a lexical processing delay and a specific lexical processing deficit in children with SLI is not yet entirely possible because of the important gaps in our knowledge about typical lexical development.
The Current Study

Purpose.

The purpose of this study is to investigate on-line lexical processing in language impaired children, addressing the important issues highlighted in the previous section. Specifically, the nature of lexical-semantic processing, and the relative speed of different types of lexical processes will be evaluated to determine how children with language impairments process words compared to their same-age, and same-language level typically developing peers. To address these issues, the experimental technique must provide a time line factor in order to consider the temporal effects of speed of processing and must permit the evaluation of lexical-semantic representations. Finally, the task must be appropriate for young children so stimuli must be auditory or pictures. The picture-naming interference paradigm (Schriefers et al., 1990), a variant on the classic Stroop processing paradigm, was selected since it lent itself well to these criteria.

The picture-naming interference paradigm

The picture-naming paradigm is a recent variant of the classic Stroop experiments where interference between the printed words for colour names and the actual colours of the ink used to print those words was observed (see Macleod, 1991 for a history and review). In the picture-naming interference paradigm, subjects are presented with a picture and an interfering stimulus (IS) such as a spoken word (Schriefers et al., 1990). The subject must name the picture as quickly as possible while ignoring the interfering stimulus. Two features of the interfering stimuli are manipulated for experiments. First, the type of relation between the IS and the target is manipulated: the interfering stimuli can be semantic relatives, phonological relatives, or unrelated to the target picture name. Second, the relative timing of presentation is manipulated;
the IS can be presented prior to, simultaneous with, or after the presentation of the target picture. The reaction time for naming the picture is then measured.

**The semantic inhibition effect in adults.**

Previous experiments on typical adults have demonstrated a robust semantic inhibition effect in slightly early presentations (pre-presentations), and phonological priming in later presentations (simultaneous, or post-presentations) of the interfering stimulus (Schriefers et al., 1990; Levelt et al., 1991).

To account for the semantic inhibition effect, the processes involved in picture naming and word recognition must be considered. For the purposes of this proposal, the model of Levelt and his colleagues has been adopted as a basic framework; however, the model is not covered in full detail here (Levelt, Roelofs, & Meyer, 1999; Bock and Levelt, 1994; Levelt, 1999).

The first component of the picture-naming interference task is picture naming. In picture naming, at least three groups of processes are essential; identification of the picture and concept, selection of the name from the lexicon, and production of the selected name (Johnson, Paivio, & Clark, 1996). Some models of lexical selection, the second of these three processes, suggest that the name selection process consists of two distinct levels: activation of the "lemma", or semantic-syntactic underlying representation, and the "lexeme" or underlying representation which includes sound form specification (Bock and Levelt, 1994).

The second component of the picture-naming interference task is the perception of the word presented auditorily. The general processes involved in the perception of a word must provide: acoustic-phonetic interpretation of sounds, phonological interpretation of sounds, activation of phonological representation in the lexicon, activation of semantic underlying representation, activation of conceptual representation. The revised version of the cohort model
described by Montgomery (1999) and Tyler (1992) are employed as a theoretical framework for lexical recognition for the purposes of this discussion. Within this model, word recognition from an auditory stimulus begins with processes for lexical mapping of the acoustic form, where a "cohort" of possible words is activated based on acoustic analysis of the word onset (Montgomery, 1999). After lexical mapping has occurred, subsequent stages include lexical access, lexical selection and lexical recognition. While the revised cohort model consists of serial stages of processing, it is considered an interactive model because information from "later" stages of processing, such as sentential or semantic context, can also influence the lexical mapping phase (Montgomery, 1999).

In the picture-naming interference paradigm, semantic inhibition occurs when the two components, naming the picture and perceiving the auditory word, co-occur such that the activation of the semantic representation for the picture is simultaneous with the activation of the semantic representation for a semantically-related, interfering word (IS). According to Levelt, when a lexical concept such as "sheep" is activated, activation will normally spread to all related concepts in the semantic network, such as "goat" and "llama" (Levelt, 1999). The lemma for "sheep" is not selected until activation reaches levels that are sufficient to rule out all of the related items. When a related word, such as "goat" is presented during the picture-naming interference task, the same set of terms is further activated. Semantic inhibition occurs because activation of the lemma for "sheep" is delayed by the increased competing activation from the word "goat". Semantic inhibition would not occur upon the presentation of an unrelated word, like "tree" because the set of items activated by the word "tree" would not overlap and compete with the set of items activated by the word "sheep" (Levelt, 1999). Semantically related words present more significant competition with the target name because they are already activated as
semantic relatives of the target.

In summary, semantic inhibition will only occur when the series of processes involved in naming the picture reaches the semantic level just as the series of word recognition processes involved in hearing the related word also reaches the semantic level. The picture naming interference task is an example of a language task which requires considerable coordination in different processes to achieve a specific effect.

**Picture-Naming paradigm used with typical children.**

Although the picture-naming interference task would be appropriate for young children, it has not yet enjoyed widespread use with typical children. In one study, 6 year old children completed the picture naming-interference paradigm (Tazume, 1997). This study investigated semantic inhibition effects with the presentation of three types of interfering stimuli: same stimulus words, words from the same semantic category, and words from a different semantic category. Interfering stimuli were presented in 7 time conditions: -300 ms, -150ms, -50ms, 0ms, +50ms, +150ms, +300ms. Rather than finding the semantic interference effects observed in adults, Tazume observed the strongest interference effects when either a related or unrelated interfering stimulus was presented simultaneously with the picture. In all 7 time conditions, the mean response times in semantically related conditions were longer than in semantically unrelated conditions, however, this trend was not statistically significant except at -300ms. In the adult group, an early (-50ms SOA) presentation semantic inhibition effect consistent with Schriefers et al. (1990) was reported.

Although Tazume's study was useful as a preliminary application of the picture-naming interference task with young children, the credibility of the results presented by Tazume is questionable in light of several methodological issues. For example, the stimuli used in that
study consisted of only 6 items: dog, cat, apple, orange, ship, and truck. Using a small number of target pictures has been shown to reduce the magnitude of the semantic inhibition effects significantly (Caramazza & Costa, 2000). Furthermore, the possibility of extraneous repetition priming effects, or item-specific facilitation, for these items is high considering they were each repeated at least 7 times and the pictures depicted the exact same items. Repetition priming effects reduce reaction times in naming and these effects can persist for up to 6 weeks (Johnson et al., 1996). In Tazume’s experiment, the semantic inhibition or priming effects in the children could conceivably be washed out by repetition priming effects. Also, these stimulus words seem to be highly associated to one another, rather than related by semantic category alone. La Heij and colleagues (1990) reported significantly different findings when either associated or related words were used in the picture naming paradigm. Because of these methodological issues, Tazume’s findings can not be taken as definitive; improved studies for the replication of the results are essential.

Although Tazume’s results are limited by methodological problems, these findings do provide preliminary evidence for considerable developmental differences between lexical processing in adults and children. The significant difference between naming reaction times in related and unrelated conditions at the -300ms presentation time implies that even young children have an emerging network organization in their lexical-semantic underlying representations. The inhibition effect at simultaneous presentation of target and interfering stimulus in Tazume’s study was not related to semantic condition and is consistent with findings from earlier studies that report a general interference in young children that declines with development (Ehri, 1976; Rosinski et al, 1975). Theoretical explanations for this effect have posited a developmental change in the inhibitory mechanisms and in the hierarchical organization of the lexicon (Johnson
et al., 1996). By this account younger children possess less fine-tuned inhibition of lexical competitors; thus, both related and unrelated words are inhibited during lexical selection. With development, only the words sharing a superordinate category are inhibited during lexical selection. Another possible interpretation of the non-specific interference at simultaneous presentation of word and picture is that children have an overall poor ability to initiate two different forms of lexical processing simultaneously. Some aspect of the task of initiating both word recognition and picture naming simultaneously exceeds the processing limits of the younger children. Our understanding of lexical processing development in children would clearly be enriched by a greater understanding of whether the overall inhibition effect decreases as a result of lexical processing development, or as a result of more general information processing development.

Usefulness of a picture naming paradigm used with language impaired children.

In a picture-written word interference task comparing strong and poor grade 2 readers, only the strong readers exhibited semantic inhibition when incongruent words were presented with a picture (Ehri, 1976). This finding was interpreted to suggest that the poor readers did not demonstrate semantic inhibition because their print interpretation skills were significantly slower than their ability to retrieve a picture label.

A study which employed this naming-interference technique with language impaired children could examine effects of general or specific speed of processing, as well as the semantic nature of the lexical representations or processes in this population. In adults, and children, the interference effect only occurs when the processes of word production and word perception are coordinated in a fashion that interferes with one another. Because of this necessary coordination of the two different processes, the interference effect provides us with an indirect means of
evaluating the speed of two component processes within a single task. Results of this paradigm can thus indicate whether one or more of the component processes are slower than the others. Studies of this kind are essential for piecing together a "processing profile" for children with language impairment; the processing profile "provides a detailed picture both of where the [individual] performs normally and of where his or her performance is disrupted" (Tyler, 1992).

Research Questions

Review of statement of purpose and outline of experiment.

This study was designed to evaluate the lexical processing of language impaired children compared to their chronological-age and language level-matched peers. More precisely, the specific phonological and semantic processing deficit accounts, as well as the generalized slowing account of lexical processing difficulties in language impaired children were investigated.

Participants in the experiment named pictures while listening to related or unrelated words presented at 3 different time intervals. Reaction times were measured and effects of relatedness and time on naming speed were evaluated. The results were analyzed to permit response to the following four research questions.

Research questions and hypotheses.

Research questions for the comparison of typically developing children and those with SLI.

1. Is there evidence for differences in semantic processing ability between language impaired and normally developing children in the picture-naming interference paradigm?

A finding of no group effects of semantic relatedness or time condition between SLI and age-matched groups would be compatible with the theory that children with SLI have lexical-
semantic processing skills which are typical for their age. A finding of no group effects of semantic relatedness or time condition between SLI and language-matched groups would be consistent with the idea that children with SLI have lexical-semantic processing skills which are typical for their language ability, if not for their age.

A finding of a group effect for semantic relatedness at any condition, with deficiencies in the SLI group could be attributed to weak connections between the target words and the related words in the lexicons of children with SLI. Such a finding could be due to incomplete representations and would be evidence for representational deficits in the lexicon.

2. Is there evidence for a process-specific slowness in either the lexical selection process required for naming the picture, or the lexical access process required for perceiving the word?

A group difference for time of presentation in the absence of a group effect for semantic relatedness would suggest a specific processing constraint account of SLI where there is atypical processing speeds in one of two different types of processes: the word recognition processes involved in hearing a word (speech perception, phonological interpretation, phonological lexical access) and/or the naming processes involved in identifying a picture (visual perceptual encoding, picture identification, concept activation). Either of these two sets of processes could be slower in children with SLI.

If the picture naming processes are slower than the word recognition processes, then semantic inhibition could only occur when the picture stimulus is presented before the interfering stimulus. This would allow the non-verbal processes involved in identifying the picture extra time to reach the point of semantic activation by the time the point of semantic activation is reached for the interfering stimulus. In this case, semantic inhibition would peak at a later SOA time for children with SLI than for the control group.
If the word recognition processes are slower than the picture naming processes, then semantic inhibition could only occur when the interfering stimulus was presented prior to the picture stimulus. This early presentation of the word would permit the verbal processes a head start so that the conditions for semantic inhibition could still be reached in time for interference to occur.

3. Is there evidence for a generalized slowing hypothesis of lexical processing?

A result where children with SLI have longer response times than the control groups without any group effects of presentation time or semantic relatedness, would support the generalized slowing hypothesis. In this case, all of the processes involved in naming the picture and hearing the word would be executed more slowly in children with SLI than in their language-matched peers.

Research question for comparison between younger and older typically developing children.

Although the primary goal of this study was to compare lexical processing in language impaired children and typically developing children, the availability of a younger language-level matched control group and a older age-matched control group provides an opportunity to investigate typical development in lexical processing. Therefore, the results of this study will also contribute to the sparse literature on typical lexical processing development.

4. Is there evidence for developmental trends in lexical processing through comparison of the younger and older typically developing children?

Using the same analysis techniques described above, the processing speed of component lexical processes and the nature of the semantic representation of the children at two ages will be evaluated. If younger children have the poorly defined, or “holistic” underlying lexical
representations postulated by current researchers such as Metsala (1997) and Garlock (1998),
then we would expect to find a group by relatedness interaction in the analysis. If the younger
children, have specific processing deficits in either word perception or word production, then we
should find a group by time interaction in the statistical analysis. If the younger children are
generally slower but have otherwise intact processing, as is be predicted by the developmental
findings of Kail (1991), we would expect to find slower responses and similar effects of time and
relatedness.
CHAPTER TWO: METHODS

Overview

Language impaired and typical language school-aged subjects participated in an on-line picture naming task with semantically related and unrelated auditory interfering stimuli presented at three time conditions (-300ms, 0 ms, and +300 ms). Reaction times and accuracy of naming were recorded using a Macintosh computer, the Psyscope Program and a CMU button box.

Participants

Participants in this study were 42 elementary school students between the ages of 6 and 10 years. Of the 42 students, 39 were recruited during the school year by school principals and speech-language pathologists who delivered parental consent letters to typically developing children and language impaired children respectively. The remaining 3 students were recruited during the summer; they were typically developing relatives of speech-language pathologists or audiologists. All students in the study passed a hearing screening of 1000 Hz, 2000 Hz and 4000 Hz at 25dB. The participants also performed within the average range on the Test of Nonverbal Intelligence- Third Edition (Brown, Sherbenou, & Johnsen, 1997). Specific information about the participants can be found in Appendix 1.

Each participant in the study completed three subtests of the Clinical Evaluation of Language Fundamentals- Third Edition (Semel, Wiig, & Secord, 1995)), or CELF-3, : Formulated Sentences, Concepts and Directions and Recalling Sentences. The CELF-3 was selected as the language assessment tool for this project because it provides normative data for children ages 6 and older, and was therefore appropriate for even the youngest participants. These three particular subtests were selected because of all the CELF-3 subtests, their processing
demands were judged to be the least similar to those of the on-line naming experimental task since they involve sentence level processing, such as following complex directions, and off-line lexical processing, such as using a given word to describe a picture.

**Grouping procedures**

From the results from the CELF-3 subtests, three groups were formed: children with language impairment, typical children matched to the language impaired children for chronological age, and typical children matched for language level.

**Language impaired and typically developing groups.**

All students were initially divided into two categories: those with language impairments and those with typical language skills. Of the original 42 children, 9 children were excluded; two of these children were excluded because they had been identified as typical children yet their performance was below the cutoff for an average score on one or more CELF-3 subtest. The other 7 children were excluded because they had been identified as language impaired, yet their CELF-scores did not fall below the average range in more than one subtest. An additional 3 students were used in a pilot study and were therefore excluded from further analysis as well. From the remaining 30 students, 9 students, all initially identified by a school speech-language pathologist, formed the group of children with language impairments, called the “LI group” hereafter. Each student in the LI group obtained a standard score below the average range cutoff score of 7 on at least two of the three CELF-3 subtests. The group of 21 students with normal language skills, the “NL group”, were initially identified by the school principal or speech-language pathologist as average students. The NL students performed within the average range on all three subtests of the CELF-3.
Age matched and language matched groups.

Two groups of typically developing children were created for comparison to each other and the LI group: a language match (LM) group and a chronological age group (AM). For the language level comparison group, 9 participants from the NL pool were selected on the basis of raw scores on the Formulated Sentences subtest of the CELF-3. The Formulated Sentences subtest was employed as the matching measure because it was considered a reasonable estimate of overall language abilities, and of all the subtests administered, it was considered the least similar to the experimental task in that it does not require as much time dependent, or on-line processing. Children matched on this task could potentially show differences on the experimental task. A t-test indicated that the difference in mean raw scores on the Formulated Sentences subtest for the LI and LM groups was not statistically significant $M(14.2, 18.0)$, $t= -1.25, (16), p>.05$ however, the LI group was significantly older than the LM group $M(105, 82.6)$, $t= 5.6, (16), p<.05$. For the chronological age match group (AM), 9 children were selected whose ages most closely corresponded to those of the children in the LI group. Statistical tests indicated no significant difference in the mean age of the AM and LI groups, $M(103.2, 105.0)$, $t= .33, (16), p>.05$. The three students not yet accounted for were excluded because their age or language scores were not close enough to the scores of children in the LI group for matching purposes. By the end of the matching process, 27 children remained in three groups of 9 each.

Although the primary purpose of the two NL groups was to permit a comparison between language impaired children and peers with equivalent ages or language scores, the two NL groups will also provide the opportunity for a developmental comparison between younger and older typically developing children. The LM and AM groups can be compared as the younger and older groups, respectively. In general, the 6 and 7 year olds were placed in the LM group.
and the 8, 9, and 10 year olds were placed in the AM group.

A summary of the mean ages and standardized testing results used for group matching purposes are presented in Table 1. A table presenting individual scores for all children is presented Appendix 1.

Table 1: Mean and standard deviations for group defining measures.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Experimental Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LI</td>
</tr>
<tr>
<td>Age in months</td>
<td>105.0 (11.0)</td>
</tr>
<tr>
<td>Quotient Score, TONI-3</td>
<td>99.0 (14.0)</td>
</tr>
<tr>
<td>Standard Score, CELF-3, FS</td>
<td>5.1 (1.8)</td>
</tr>
<tr>
<td>Standard Score, CELF-3, CD</td>
<td>5.3 (1.4)</td>
</tr>
<tr>
<td>Standard Score, CELF-3, RS</td>
<td>5.7 (1.6)</td>
</tr>
<tr>
<td>Raw Score on CELF-3, FS</td>
<td>14.2 (7.3)</td>
</tr>
</tbody>
</table>

Notes: LI refers to the language-impaired group, LM to the language matched group, and AM to the age-matched group. TONI-3 refers to the Test of Nonverbal Intelligence-3, and the CELF-3, refers to the Clinical Evaluation of Language Fundamentals-3. FS, RS, and CD stand for Formulated Sentences, Recalling Sentences and Concepts and Directions respectively.
Apparatus

The experimental task was administered using a Macintosh computer with a 12-inch VGA monitor and the Psycscope program, which is an “integrated environment for designing and running psychology experiments on Macintosh computers” (Cohen, MacWhinney, Flatt, & Provost, 1993). Participants sat a comfortable distance from the monitor, wearing headphones for the auditory stimuli, as well as a microphone headset to record their responses. The microphone headset was connected to the Carnegie Mellon University (CMU) Button Box which in turn was connected to the Macintosh computer, recording voice activated reaction times with a potential temporal resolution for accuracy of 1 millisecond (Cohen, et al., 1993). The experimenter was seated directly beside the participant with the Button Box accessible and the monitor clearly visible. Accuracy of participant responses was recorded by the experimenter using the three keys on the Button Box.

Participants were seen for two sessions each. The first session consisted of the hearing screening, and standardized test administration. The second session consisted of the experimental task and completion of remaining test administration if required. Twenty-five participants were seen in a private, quiet room in their schools, and the remaining 5 participants were seen at home, in a quiet, private room with a table.

Stimuli

Description of stimuli

Stimuli were words, presented auditorily, and pictures. The words and the expected labels, i.e. target names intended for each picture, were designed as a single integrated set of stimuli.

Stimuli consisted of 18 word-picture pairs; each of nine pictures was paired with both a
related and unrelated word. For example, a picture of a lion was presented in one trial with the related word “fox” and in a separate trial with the unrelated word “van”. The intended picture labels and the words were controlled and matched according to several variables including: frequency of use by children, age-of-acquisition, semantic category level, word-association in children, phonological structure and availability of a standardized line drawing.

**Stimulus parameters**

**Frequency of use.**

All picture labels and words were controlled for frequency of use by young children using Kolson’s 1961 database of words spoken by kindergarten children. More recent alternative measures of word frequency were employed to verify the trends reported in Kolson’s database; however, these measures were generally based on written or adult word frequency measures and were therefore not considered as relevant as Kolson’s database (Zeno, Ivens, Millard, & Duvvuri 1995; Morrison, Chappell & Ellis, 1997). Only items with a mid to high frequency of use were selected. Intended labels for pictures and words were matched together based on their relative frequencies. The quantitative descriptor “mid to high” frequency of use was based on the definitions used in Garlock’s dissertation on the development of spoken word recognition and phonemic awareness (Garlock, 1998). That study described words occurring less than 10 times per million as “low” frequency and words occurring greater than 40 times per million as “high” frequency. In the current study, words with mid frequencies of 10-40 times per million were paired together, and words with high frequencies of over 40 times per million were paired together. Words with frequencies lower than 10 times per million were avoided.

**Age of acquisition.**

Since naming speed in adults is influenced by age of acquisition, in addition to the effects
of frequency of use (Barry, Morrison, & Ellis, 1997; Ellis & Morrison, 1998), the age of acquisition was considered in the selection of stimuli. All words and picture labels used in this study were reported to be acquired by children prior to the age of 5 years (Morrison, Chappell, & Ellis, 1997). Therefore, the words selected were assumed to be familiar to all of the children who participated in this study.

**Semantic properties.**

Words and picture labels were controlled for their semantic nature in two ways. First, all items included in the stimuli list were considered to be members of the same "basic level" within the semantic taxonomy described by Rosch in her study of natural categories (Rosch, 1975). Neither superordinate terms such as "musical instrument" nor subordinate terms such as "kettle drum" were used, rather basic level items "piano", "guitar" and "drum" were selected.

Second, all items in the related condition were related primarily by semantic category rather than by semantic association. In a previous comparable study different priming effects were reported depending on whether the stimuli were related by semantic association, for example, cat and dog, or by semantic category, for example, cat and fox (La Heij, Dirkx, & Kramer, 1990). To reduce these opposing semantic effects, the word-picture pairs used in this study were limited to those related by category only.

Where possible, weak semantic associations between words were verified using normative data in children's word associations (Palmero, and Jenkins, 1964; Entwisle, 1966). No pairs of words were used if either one of the words appeared anywhere in the list of associated words provided for the other word. Associative information in children was available for only 4 of the 27 target words and labels. Of the 23 remaining words and labels, 17 were verified using normative data available for adults (Marshall, & Cofer, 1970; Keppel, & Strand,
1970). The remaining 6 items without data (van, rabbit, grapes, airplane, boat, bus) were not considered to be strongly associated by the experimenter.

**Phonological properties.**

Previous similar studies have demonstrated phonological priming effects when the picture labels and words shared phonological form (Shriefers, Meyer, & Levelt, 1990). Therefore, similar consonant onsets and vowels were not permitted within picture-word pairs to reduce any such effects of phonological priming. Where possible the picture-word pairs were matched for syllable length to reduce differences in lexical processing times between the two stimuli. However, in half of the stimulus this was not possible due to all the other stimulus matching constraints, and the word was different from the picture label in syllable length. In the 9 stimuli where the picture label and word were different syllable lengths, there was a 1 syllable difference in 7 pairs and a 2 syllable difference in 2 pairs. The picture label was the longer item in 6 cases and the word was longer than the picture label in 3. As the majority of these length asymmetries involved longer picture labels, and these same picture labels were used in both the related and unrelated conditions, it was assumed that the asymmetrical trials would not bias the overall results.

**Standardized line drawings.**

All of the words selected for the picture list were available within a published database of standardized line drawings, and thus they could be easily depicted (Cycowicz, Friedman, & Rothstein, 1997). Because of the poor line quality of the copied drawings presented in the Cycowicz et al. article, the nine pictures were re-created from the line drawing database by an artist, who was instructed to replicate the line drawings as closely as possible. These new clearer drawings were digitized using a scanner and photo editing software.
Inclusion of Distractor items

One possible concern regarding the relatively small number of stimulus items used in this study is the washing out of effects by repetition priming. Repetition priming refers to the trend where response times decrease when stimuli are shown multiple times (Logan, 1990; Johnson, Paivio, & Clark 1996). If lexical items are activated in a task, that activation remains for up to several weeks (Johnson et al., 1996). If a small set of items is presented repeatedly in a single task, we might expect repetition priming to occur. As a means of counteracting the effects of repetition priming, a set of 12 distractor items were included in the stimuli list. These items, were controlled for age of acquisition so that they were all acquired prior to age 6 (Morrison et al., 1997), and they were also designed to be visually, semantically, and phonologically different from the target stimuli. The distractor items were included to diffuse the overall lexical activation during the task thereby decreasing the relative activation of the target items. All of the items selected as target stimuli and distractor items are presented in the following Table 2.

Table 2: Stimulus List

<table>
<thead>
<tr>
<th>Picture Stimulus</th>
<th>Word presented for each Relatedness Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Related</td>
</tr>
<tr>
<td>Target Stimuli</td>
<td></td>
</tr>
<tr>
<td>cow</td>
<td>dog</td>
</tr>
<tr>
<td>lion</td>
<td>fox</td>
</tr>
<tr>
<td>banana</td>
<td>lemon</td>
</tr>
<tr>
<td>grapes</td>
<td>orange</td>
</tr>
<tr>
<td>sock</td>
<td>shirt</td>
</tr>
<tr>
<td>dress</td>
<td>hat</td>
</tr>
<tr>
<td>--------</td>
<td>-----</td>
</tr>
<tr>
<td>car</td>
<td>train</td>
</tr>
<tr>
<td>plane</td>
<td>boat</td>
</tr>
<tr>
<td>piano</td>
<td>drum</td>
</tr>
</tbody>
</table>

**Training Stimuli**

<table>
<thead>
<tr>
<th>snake</th>
<th>frog</th>
</tr>
</thead>
<tbody>
<tr>
<td>tree</td>
<td>fork</td>
</tr>
<tr>
<td>bed</td>
<td>carrot</td>
</tr>
<tr>
<td>pumpkin</td>
<td>mushroom</td>
</tr>
<tr>
<td>hammer</td>
<td>chair</td>
</tr>
<tr>
<td>butterfly</td>
<td>house</td>
</tr>
</tbody>
</table>

**Distractor Stimuli**

<table>
<thead>
<tr>
<th>balloon</th>
<th>glasses</th>
</tr>
</thead>
<tbody>
<tr>
<td>snake</td>
<td>house</td>
</tr>
<tr>
<td>bed</td>
<td>frog</td>
</tr>
<tr>
<td>butterfly</td>
<td>mushroom</td>
</tr>
<tr>
<td>pumpkin</td>
<td>fork</td>
</tr>
<tr>
<td>tree</td>
<td>carrot</td>
</tr>
<tr>
<td>foot</td>
<td>chair</td>
</tr>
<tr>
<td>kite</td>
<td>flower</td>
</tr>
<tr>
<td>bread</td>
<td>window</td>
</tr>
<tr>
<td>scissors</td>
<td>door</td>
</tr>
<tr>
<td>hammer</td>
<td>pencil</td>
</tr>
</tbody>
</table>
Creation of auditory stimuli

The 18 words were recorded in a sound booth, spoken by a male adult native speaker of English. For each individual word the speaker was asked to visualize a picture of the word and speak as if to name the picture. The words were recorded at least two times each directly to the computer using a MacRecorder device and Sound Edit software. Extraneous portions of the signals were removed using Sound Edit software leaving only the target word from acoustic onset to acoustic offset; care was taken during segmentation to avoid creating abrupt transitions in the signal. For each signal, Cool Edit software was used to measure the root mean square (rms) amplitude, an indicator of average amplitude of a signal. Using rms amplitude values, one of the two original signals for each word was selected, minimizing differences in amplitude so that all auditory stimuli fell within an amplitude range of 7dB.

Design and Presentation

Overview of experiment

Individual trials required participants to name a picture while a word was presented auditorily at one of three times relative to the onset of presentation of the picture. The experimental design included three within subject time conditions: -300ms, 0ms, and +300 ms stimulus onset asynchrony, and two semantic relatedness conditions: related and unrelated. In total, each subject named 105 pictures which included: 15 training items, 27 unrelated target pictures, 27 related target pictures and 36 filler pictures.

Experimental design

The three time conditions (-300ms, 0ms, and +300 ms) were presented to each participant in three separate blocks using a counterbalanced order of block presentation. One of the 6 possible block presentation orders was assigned to each participant at the beginning of the
session. Each block consisted of 30 trials; 9 pictures presented with related words, the same 9 pictures presented with unrelated words, and 12 filler pictures also presented with unrelated words. These 30 trials were presented in a fixed-random order, this same order being used for each of the three blocks. The only restriction on the randomization of the trials within the block was a constraint against presenting the same picture twice within a set of three consecutive trials.

**Experimental procedures**

At the beginning of each session the apparatus was demonstrated and explained to the participant to reduce any apprehensions. The microphone headset and headphones were placed onto the participant and a test of the Button Box voice activation device was conducted.

Participants were instructed to name each picture as quickly as they could because the game was "a race" to see how fast children could name the pictures flashed on the screen. The participants were told that during the game they would hear a man saying different words and that they should ignore the man and try not to let him confuse them. Each of the three blocks of trials commenced with 5 training items. Participants were given feedback during the training items and reminded to respond quickly and accurately. Any necessary adjustments of the apparatus were made between these training items.

For each of the experimental and filler trials, the following events occurred in sequence:

1. An asterisk appeared in the middle of the screen for 1 second to alert the participant.
2. The picture to be named and the auditory presentation of the related or unrelated word were presented in order according to the stimulus onset asynchrony condition. During the +300 ms SOA block, the picture was seen for 300 ms before the word was presented. During the 0ms SOA block, both picture and word were presented simultaneously. During the -300 SOA block, the picture was not presented until 300 ms after the onset of the word.
3. When the participant named the picture, the voice activation device recorded the reaction time from the onset of the stimulus and caused the picture to disappear from the screen. When encouragement or specific feedback was required it was provided at this time.

4. The experimenter judged the response as accurate, false start, or inaccurate and pressed a button accordingly. The trial was completed with this experimenter button-push; therefore the pace of presentation was controlled by the experimenter.

Data management

The 3 time conditions and 2 relatedness conditions implicated 6 response time data cells for each subject. A mean response time was calculated for each participant for each of these 6 experimental conditions. A maximum of 9 reaction times were available per subject to yield the mean reaction time value. Because of the typically high variability of reaction time data in children, and numerous false starts caused by the voice activation technology further processing of the data was required prior to analysis.

To reduce the possibility that priming effects would be washed out, the data used included only trials where the correct label was spoken, and no false starts were produced. All reaction time values judged by the experimenter to be errors, where the picture was incorrectly named, or false starts, where the participant audibly exhaled, sighed, uttered "um", or used a carrier phrase to respond as in "it's called a..." were removed from the analysis. Furthermore, any response time greater than 3 standard deviations from the group mean reaction time for each condition were considered outliers and removed from further analysis. Three subjects produced fewer than three accurate responses in a particular condition; the group mean was used instead of the subject's means for these three instances. In total, 344 false starts, 88 errors, and 54 outliers were removed from analysis. These removed trials accounted for 33% of the data so that 67% of
the data was retained for further analysis. Compared to similar studies in adults where less than 5% of the data was removed because of errors or false starts (Glaser & Dangelhoff, 1984), the data loss in the current study appears high. However, in a timed naming study including children, only 76% of data was retained for the children with SLI and 85% for the typically developing children (Lahey & Edwards, 1996). Therefore, 67% of the data kept in this study is not out of line especially considering the use of an interfering stimulus in the current study. As will be demonstrated in Chapter 3, there was no statistically significant difference in the number of responses kept for the LI, AM and LM groups.
CHAPTER THREE: RESULTS

Overview

Language-impaired, age-matched and language matched groups of children named pictures while hearing semantically related or unrelated interfering stimuli (IS) in three different time conditions, -300 ms, 0ms, and +300 ms. Mean reaction times for naming pictures in each of the resulting 6 conditions were computed for each participant. Results of a mixed model analysis of variance were used to respond to the research questions posed in the introduction. The analysis focused on whether there were differences in mean response times between the language impaired and typical children, and the young and old typical children associated with the stimulus onset asynchrony (SOA) time and the relatedness conditions.

Results of Analysis

Reaction time analysis

Group means and standard deviations for reaction times in the 6 experimental conditions are presented in milliseconds in the Table 3 below.

Reaction times were analyzed in a mixed model Analysis of Variance (ANOVA) with a between subjects factor of Group (3 levels: LI, AM, LM) and two within subjects factors, Time (3 levels: -300ms, 0ms, +300 ms) and Relatedness (2 levels: related, unrelated).
Table 3: Mean and standard deviation reaction times for LI, LM, and AM groups.

<table>
<thead>
<tr>
<th>Relatedness</th>
<th>SOA condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-300ms</td>
</tr>
<tr>
<td>Language Impaired Group</td>
<td></td>
</tr>
<tr>
<td>Related</td>
<td>M (SD)</td>
</tr>
<tr>
<td></td>
<td>847 (135)</td>
</tr>
<tr>
<td>Unrelated</td>
<td>M (SD)</td>
</tr>
<tr>
<td></td>
<td>952 (207)</td>
</tr>
<tr>
<td>Language Matched Group</td>
<td></td>
</tr>
<tr>
<td>Related</td>
<td>M (SD)</td>
</tr>
<tr>
<td></td>
<td>1014 (144)</td>
</tr>
<tr>
<td>Unrelated</td>
<td>M (SD)</td>
</tr>
<tr>
<td></td>
<td>1181 (232)</td>
</tr>
<tr>
<td>Age Matched Group</td>
<td></td>
</tr>
<tr>
<td>Related</td>
<td>M (SD)</td>
</tr>
<tr>
<td></td>
<td>754 (71)</td>
</tr>
<tr>
<td>Unrelated</td>
<td>M (SD)</td>
</tr>
<tr>
<td></td>
<td>837 (239)</td>
</tr>
</tbody>
</table>

Note: all values are in milliseconds, values were rounded to the millisecond since this is the reported accuracy of the button box.

The ANOVA resulted in significant main effects for Group, $F(2, 24) = 23.40, p < .05$, Relatedness, $F(1, 24) = 4.57, p < .05$, and Time, $F(2, 48) = 13.13, p < .05$. The ANOVA also yielded
a two way interaction of Group by Time F(4, 48) = 3.89, p<.05. The following sections will analyze each significant finding in more detail.

**Main effect for group.**

The AM group had the shortest mean reaction times (M: 836 ms), the LM group had the longest mean reaction times (M: 1375), and the LI group reaction times fell between the two other groups (M: 1000). A posthoc Tukey Honest Significant Difference (HSD) test revealed that the difference between mean reaction time for the LM group and the other two groups, LI and AM, was significant (p<.05) but the difference between the LI and AM groups was not.

**Main effect for relatedness.**

Across Group and Time conditions, the semantically related conditions (M: 1038 ms) yielded significantly shorter mean reaction times than the semantically unrelated conditions (M: 1108 ms), (p< .05). Only one of the 9 comparisons reversed this trend. At +300 ms SOA the LI group responded more quickly on average, when a semantically unrelated IS was presented.

**Main effect for time.**

The mean reaction times across Groups were shorter in the -300 SOA condition (M: 930.9 ms) than in the 0 SOA (M: 1170.7 ms) and +300 SOA (M: 1117 ms) conditions. A posthoc Tukey HSD test (p<.05) indicated a significant difference between mean reaction times for -300 SOA, and the other two, but not between 0 SOA and +300 SOA. Furthermore, as the examination of the interaction effect for Group and Time indicates, the results from the LM group account for the lack of overall differences between the 0ms and +300ms conditions.

**Interaction of group and time.**

The significant Group by Time interaction is presented graphically in Figure 1.
Figure 1: Interaction of Group & Time

![Graph showing interaction of group and time](image)

Essentially the difference in reaction times between the LI and AM groups remains constant in all Time conditions, however, the difference between these two groups and the AM group increases from left to right, reaching the greatest value in the +300 ms SOA condition.

**Error analysis**

In addition to the analysis of mean reaction times, an analysis of numbers of correct and incorrect naming trials was also conducted. Mean and standard deviation number of errors are presented in Table 4 on page 52. This analysis was used to investigate the possibility that the interfering stimuli in the 6 experimental conditions could have an influence on the accuracy of responses over and above the effects on reaction time alone. For example, if a stimulus caused enough of an interference, an error, or a false start could be produced rather than simply a delay. An observation consistent with this possibility is that in several trials children were observed to incorrectly repeat the interfering stimulus rather than name the picture at hand. Some of the children commented that the interfering stimulus was "tricking" them. This observation suggests interference in naming, thus an analysis of response accuracy was conducted. Since each trial
had been judged as either correct, false start, or incorrect, data concerning the accuracy of responses was available. Analysis included four separate 3-way mixed model ANOVA, Group (LI, LM, AM) by Time (-300, 0, +300) by Relatedness(related, unrelated), with response type (correct responses, false starts, errors, and outliers) as the four dependent variables. The ANOVA yielded no significant effects for number of correct responses, false starts, or outliers. There was, however, a marginally significant main effect of Relatedness in the analysis of number of errors, F(1, 24)=3.73, p<.06. Across all groups and conditions, there were fewer errors produced on unrelated trials than in trials where the interfering stimulus was related to the target.

Summary of Findings

The ANOVA resulted in the significant main effects summarized below:

1. Group: the older children, in the AM and LI groups responded more quickly than the younger children in the LM group.

2. Relatedness: Children responded more quickly in the related IS condition. They also responded with more errors in this condition suggesting a speed-accuracy trade-off.

3. Time: Overall, children responded more quickly in the -300 ms time condition. There was an interaction of Time and Group which in part reflects the performance of the LM group who responded relatively more slowly in the 0ms and +300ms conditions than the other two groups.
Table 4: Mean and standard deviation number of naming errors

<table>
<thead>
<tr>
<th>Relatedness</th>
<th>SOA condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-300ms</td>
</tr>
<tr>
<td>Related</td>
<td>LI Group</td>
</tr>
<tr>
<td>M (SD)</td>
<td>.7 (.5)</td>
</tr>
<tr>
<td>Unrelated</td>
<td>LM Group</td>
</tr>
<tr>
<td>M (SD)</td>
<td>.7 (.9)</td>
</tr>
<tr>
<td>Related</td>
<td>AM Group</td>
</tr>
<tr>
<td>M (SD)</td>
<td>.6 (1.0)</td>
</tr>
<tr>
<td>Unrelated</td>
<td>AM Group</td>
</tr>
<tr>
<td>M (SD)</td>
<td>.1 (.3)</td>
</tr>
</tbody>
</table>

Note: Values represent mean number of errors per condition, i.e. total possible was 9.
CHAPTER FOUR: DISCUSSION

Overview

This study compared the performance of language impaired children with that of their chronological-age and language level-matched peers on the picture naming interference task. The specific phonological and semantic processing deficit accounts, as well as the generalized slowing account of lexical processing difficulties in language impaired children were investigated. The findings are useful in providing preliminary responses to the four research questions discussed in Chapter 1. In the following discussion the research question on typical lexical processing development, and each of the three research questions about lexical processing in language impaired children will be addressed in turn. Ultimately, the implications of these findings for future research endeavors and clinical practice will be discussed.

Lexical Processing in Typical Development

Analysis of the mean reaction times and response accuracy for the younger children (ages 6-8), in the LM group, and those for the older children (ages 8-10), in the AM group, in the 3 Time conditions and 2 Relatedness conditions reveals the nature of typical development in the areas of (1) general lexical processing speed, (2) lexical-semantic representations, and (3) specific lexical processing efficiency. The following section commences with a detailed description of group differences in lexical processing followed by further discussion of the findings in the three identified areas of typical lexical processing development.

Developmental differences in lexical processing.

Close investigation of the significant results and non-significant trends for the young and the old children at each of the three Time conditions reveal several developmental differences in lexical processing.
**-300ms Condition**: At the first presentation time, -300ms, children heard the IS word 300 ms prior to seeing the picture stimulus. As is implicit in the main effect for Relatedness, both the young (LM) and the old (AM) groups responded with semantic priming effects in this condition; the reaction times were shorter when a semantically related word was presented than when a semantically unrelated word was presented. Again reflecting the main effect for Group, the LM groups responded with reaction times longer than the AM group.

**0ms Condition**: In the second time condition, 0ms, the subjects heard the IS word and saw the picture stimulus simultaneously. Reaction times were significantly longer across groups than in the first condition, and the relative increase was higher for the LM children than for the AM. Additionally, there was a trend of increased number of naming errors produced in the 0 ms Time condition compared to the other conditions. Together, these findings are consistent with an interference effect. Moreover, because these trends occur across Relatedness conditions, this interference effect is probably not entirely semantic in nature. The finding of the "general" interference at simultaneous presentations would be consistent with the general interference effect at 0ms reported by Tazume (1997).

**+300ms Condition**: In the final condition, +300ms, the subjects had been presented with the picture stimulus for 300ms prior to the presentation of the auditory IS. The younger children in the LM group exhibited even longer overall reaction times than in the second condition, while the AM group exhibited reaction times equivalent to those in the first time condition. Both groups exhibited a semantic priming effect in this condition; this is a finding that raises questions because theoretically, with 300 ms of processing time already permitted, the selection of the target word should have been nearly completed by the time the IS was presented, therefore it is surprising that the related word could still prime picture naming.
One possible explanation for the priming in the final time condition, especially in the young LM group, is differences in task strategy. The similar reaction times in the +300ms and -300 ms condition, and the smaller degree of semantic priming observed in the -300ms condition in the AM group would be consistent with the assumption that many of the older children had indeed already begun naming the picture by +300ms. By this argument the presentation of the IS yielded a small semantic priming effect in the AM group because most of the lexical processing had already been completed before the IS was presented. On the other hand, the younger children may have adopted a strategy of waiting to hear the IS before responding, hence the longer reaction times and somewhat stronger degree of semantic priming exhibited in the +300ms condition. The observation that the reaction times are longer in the +300ms condition than in the other two conditions for the younger LM group, would be consistent with their waiting the 300 ms until the IS was presented before processing the picture. Further compelling evidence for the difference in task strategy comes from anecdotal comments recorded by the examiner. For example, during several testing sessions with the younger children the examiner noticed participants consistently responding after the IS was delivered. In one case a 7 year old child was observed to shake his head after each IS to indicate that the voice had incorrectly named the picture. During a pause between trials these children were asked whether they were waiting for the voice, or whether they were trying to name the pictures as quickly as possible. If the children confirmed that they were waiting for the voice prior to responding; they were reminded of the initial directions to name the picture as quickly as possible. Considering the reaction time results and this anecdotal evidence, differences in task strategy, or ability to follow task directions, are plausible accounts for the differences between the older and younger children in the +300ms SOA condition and no further discussion will be dedicated to this issue. Instead,
the discussion will turn once again towards the original research questions.

**Development in general speed of processing.**

The finding of increased response speed across conditions in the older group of children is consistent with the theory that children become generally faster in lexical processing as they become older.

**Development in lexical-semantic representation and processing.**

One of the proposed areas of development in typical lexical processing is in underlying semantic representations. In the current experiment, both younger and older children responded more quickly in the related IS conditions than in the unrelated conditions. The related words consistently primed their responses, while unrelated words did not, suggesting that even the youngest children had detailed and well organized semantic representations developed for the categorically related words. Such a finding is consistent with the priming effects in children aged 7-11 for highly associated words presented by Powell, Wulfeck, Bates & Liu (1998). The results add to the literature on semantic priming in children by demonstrating significant priming effects in children as young as 6 for minimally associated, categorically related word pairs.

**Development in specific lexical processes.**

Considering that the effects of semantic relatedness were not significantly different across the two age groups and three time conditions, the current study does not provide clear evidence for a specific processing change in lexical development. However, two findings in the current study suggest subtle but theoretically significant differences in lexical processing between typical children and adults, for both general information processing and specific auditory processing of words.

The first difference between adult subjects and the child participants in the current study
is the findings of a general interference effect at 0ms SOA in both LM and AM groups of children when no such interference has been reported in adult subjects. The finding of general interference, which is consistent with Tazume's (1997) findings, suggests that the simultaneous presentation of target stimulus and IS caused processing difficulty for most of the children. As there was no interaction of Time by Relatedness, this developmental trend likely reflects general limitations in information processing in children; perhaps these children were less capable of processing two stimuli simultaneously than adults.

Another developmental finding of particular interest, was that the typical children in this study exhibited reversed priming effects compared to the effects described in the literature. In the subsequent discussion, “semantic priming” refers to conditions where reaction times are significantly shorter upon presentation of the related interfering stimulus compared to the unrelated IS. “Semantic inhibition” refers to conditions where reaction times are shorter in the unrelated condition. In contrast, “general interference” is used to describe a general increase in reaction times in both Relatedness conditions. The current study found significant semantic priming effects in all Time conditions with categorically related words and a general interference effect in the 0ms condition. In contrast, the children in Tazume’s study responded with semantic inhibition effects at the -300 SOA condition with highly associated words (Tazume, 1997). Furthermore, adults consistently respond with semantic inhibition effects at 0 ms SOA (Schriefers et al, 1990). Two possible accounts of lexical development are proposed to provide reconciliation of these three apparently contrasting findings.

One means of reconciling the adult findings and the findings of the current study would be to propose separate lexical mechanisms for semantic priming and semantic inhibition. Theoretically these two separate mechanisms could develop at different ages, thereby accounting
for the differences reported in children and adults. By some accounts in the adult literature, semantic priming and semantic inhibition arise from two distinct lexical processing mechanisms which differ depending on the nature of the semantic relation in the IS as well as the value of the SOA for the task. The first of these processes, semantic inhibition, is a rapid inhibitory process designed to prevent naming errors among category members (La Heij, Dirkx, and Kramer, 1990), which possess overlapping featural descriptions (Thompson-Schill, Kurtz, Gabrieli, 1998). Semantic priming, the second distinct process, is a slow excitatory process which yields associative priming to aid in sentence processing (La Heij, Dirkx, and Kramer, 1990) because the associative relationships reflects the use of words, rather than the meaning of words (Thompson-Schill, Kurtz, Gabrieli, 1998). Evidence for these different mechanisms comes from a series of picture naming experiments in adults which manipulated semantic relation type (categorical or associated) and Time condition. For example, a categorically related IS yielded semantic inhibition at SOAs close to 0ms, or after 0ms, but there was no effect at -400ms (La Heij, Dirkx, and Kramer, 1990). Furthermore, semantic priming only occurred when the IS was a highly associated word presented at -400ms. The priming diminished at 0ms, and associative inhibition was observed at +75 and +150ms.

One possible means of reconciling the literature on semantic priming and inhibition in children and adults would be to propose that children already possess the lexical mechanism responsible for priming, however, they do not yet possess the separate semantic inhibitory mechanisms. Assuming that the Tazume's (1997) finding of semantic inhibition in young children was possibly compromised by methodological limitations already discussed, the current findings of semantic priming with categorically related words in children, and findings of semantic inhibition in adults (La Heij, Dirkx, and Kramer, 1990) could support this dual
mechanism approach. Perhaps the children already possess the slower excitatory semantic priming mechanism described by La Heij et al., (1990) because this mechanism is useful in early language acquisition. They do not develop the fast, or automatic lexical processing required to produce the semantic inhibition effect until later ages when they have larger vocabularies. Only after more language use, when children have more complex lexicons do they require the fast acting lexical inhibition mechanism. Previous studies have demonstrated that even typically developing children aged 7-11 produce robust semantic priming effects associated words (Liu, Bates, Powell & Wulfeck, 1997) and children aged 10 are primed by both associated and categorical semantic relations (Nation & Snowling, 1999). These findings would be consistent with the two-lexical mechanisms account.

Although the notion of two separate lexical mechanisms shows some promise in reconciling the current findings and the adult literature, much more developmental research in this area would be essential in determining when the inhibitory mechanism was acquired and how it interacted with the priming mechanism. A further issue which requires attention within the two separate mechanism approach presented here is that of the relationship between processing semantic associations and categorical semantic relations. If the two separate processing mechanisms are as described (La Heij, Dirkx, and Kramer, 1990), then the nature of the semantic relationship used in each experiment is highly significant. Conceivably, the discrepancies between the direction of the semantic effects in the adult study, Tazume’s study, and the current study could be attributed to insufficient available data for controlling the degree of semantic association in children. The semantic association in Tazume’s study may not have been controlled at all. In the current study, controlling measures included primarily adult association norms because such norms for children were unavailable for the majority of the
stimuli words. However, there is very little discrepancy between the associative norms for children and adults in the studies available (Palmero & Jenkins, 1964; Marshall & Cofer, 1970; Entwisle, 1966). Clearly the type of semantic relation employed in a study must be considered to fully evaluate the two separate mechanisms account further. Such precise research will not be possible unless more comprehensive word association and categorization data for children becomes available.

The dual-mechanism account is not consistent with all of the adult literature. For example, Thompson-Schill, Kurtz, and Gabrieli (1998) used a “backwards priming” technique to demonstrate that when semantic association and relatedness are carefully controlled, experimental results suggest that only semantic relatedness is required to yield semantic priming; semantic associations are actually not essential for priming. The backwards priming technique involves pairs of words with asymmetrical associative relationships (e.g., Dog and Flea) to demonstrate this point. In these asymmetrically associated pairs, there is a constant degree of semantic relatedness within the pair; however, only one of the words is semantically associated to the other. For example, “flea” is strongly associated with “dog”, but “dog” is not necessarily strongly associated with “flea” but rather with “cat”. Using these types of pairs, the authors demonstrated that the magnitude of semantic priming observed in an auditory lexical decision task was related only to semantic relatedness and not to the semantic association between the words used (Thompson-Schill, Kurtz, and Gabrieli, 1998). In summary, the connection demonstrated between semantic relatedness and semantic priming in the absence of semantic associations, contradicts models attributing semantic priming to word associations. Therefore, the findings of Thompson-Schill, Kurtz, and Gabrieli (1998) casts doubt on the description of separate associative priming and semantic inhibition previously discussed.
Further doubt is cast on this model when both the reaction time and naming error results of the current study are considered together. The children demonstrated semantic priming in all Time conditions, however, they also demonstrated a higher number of errors in Related conditions than in Unrelated conditions. The most obvious description of this situation would be a “speed-accuracy trade-off”, where on Related items, children responded more quickly than on the Unrelated items but with more errors. Still, the question of why the speed-accuracy trade-off is found only in the Related condition remains. While semantic inhibition based on reaction time values was not observed in the Related conditions, some form of interference was occurring in the form of a semantically based speed-accuracy trade-off. A naming error indicates that the search for the target word was disrupted. Therefore, errors occurring more frequently in Related conditions could be considered the result of unrecoverable semantic inhibition. Thus it would seem that forms of both semantic inhibition and semantic priming is observed in the same group of children. This finding would not be compatible with a model which proposed two separate mechanisms for priming and inhibition, especially if the proposal suggested that the children had not yet acquired inhibitory processes.

A possible alternative to the two separate lexical mechanisms account is an explanation which attributes developmental differences in priming results to processing differences within an integrated lexical system. In this approach, semantic priming and inhibition are merely different outcomes arising from a single lexical system; the specific end result depends primarily on the timing and process coordination in that system. Rather than being a distinct process, semantic inhibition is characterized as the result of activation within a group of semantic relatives of the target word, which creates interference in the selection of the target word. Semantic priming is likewise seen as a pattern of interaction among semantic relatives that ultimately leads to faster
reaction times on the target form. If this is the case, differences in the timing of various sub-components of lexical processing in children and adults could yield drastically different results in response time outcomes. Specifically, the discrepancies observed between the children in this study, and those in Tazume's study, or in adults could rest in the high degree of coordination in processing required to produce the semantic inhibition effect within a single lexical processing mechanism. With the close link of highly coordinated processes in mind, it seems possible that the semantic priming observed in the current study was not the associative priming described by La Heij, Dirkx & Kramer (1990) but merely the outcome of visual and auditory activation processes coordinated in a certain fashion.

In the picture-naming interference task, semantic inhibition is the end result of a trial only when the target and semantic relatives are both equally activated for an extended period of time during the selection of the target word. Apparently in adults this pattern of activation occurs around 0ms SOA, when the target and IS are presented simultaneously. Semantic priming, on the other hand, occurs when the activation of a semantic relative does not compete with the activation of a target word, but rather, hastens the activation of the target word, usually in early IS presentations, such as -400 ms.

From the single process viewpoint, the semantic inhibition at seen in adults at 0ms SOA could be attained in two ways: by changing the timing of the IS presentation, or the relative processing speed of either the auditory processing or the picture naming processing. For example, if the IS was changed to +100SOA, ie. the word is presented 100 ms after the target picture, the target would have already received some activation by the time the IS was processed, and semantic priming could conceivably result because the overall activation of the target word would be boosted by the processing of the IS. Alternatively, if the processing of the auditory IS
was relatively slower than seen in the adult system, processing of the IS would be delayed until
the target word had already received significant activation again leading to an overall priming
effect.

By this logic, the children in the current study may have demonstrated semantic priming
at 0 SOA rather than semantic inhibition because their auditory processing was slightly slower
than that of adults. The delay in auditory processing would clearly be less than 300 milliseconds,
otherwise semantic inhibition could have been observed at the -300 ms SOA condition. The
auditory processing differences between the children and the adults would be only subtle ones by
this account. However, as has been discussed, such subtle differences could yield the seemingly
opposite effects of semantic priming or inhibition.

One strong argument against this account of subtle timing distinctions between semantic
priming and inhibition comes from the adult literature around semantic inhibition. In a survey of
studies which employed the picture-naming interference task to investigate semantic inhibition at
many different SOAs, ie. -800 ms, -400 ms, -300 ms, -200 ms, -150 ms, -100 ms, -50 ms, 0
ms, +50 ms, +100 ms, +150 ms, +200 ms, +300 ms, +400 ms, (Glaser & Dungelhoff, 1984;
Tazume, 1997; Schriefers, Meyer, & Levelt, 1990), semantic priming is reported in only one
study at -200 and -800 ms SOA (La Heij, Dirkx, & Kramer, 1990), yet the findings of semantic
inhibition between -100 ms, and +100ms are robust in all studies. The virtual lack of early
priming effects is difficult to reconcile with the single process account. While it is clear that in
adults the processes of semantic inhibition and semantic priming are distinct enough to yield
predictable results across a number of studies, the possibility of less distinct differences in
children remains in need of further investigation.
Summary of developmental trends in lexical processing.

Based on the findings of the current study, as children develop, they perform lexical processing tasks more quickly. There was no evidence for specific processing breakdowns, or weaknesses in either group, however this possibility is not entirely eliminated. The younger children responded differently to the task, they tended to wait to hear the IS even though they had been instructed and coached not to. Thus, there was a difference in the overall ability to follow task directions in the younger children. Finally, the children in this study responded with semantic priming while adults have consistently responded with inhibition in previous studies. The current study does not investigate the cause of this discrepancy, however, it is speculated that the children demonstrated subtle differences in auditory processing speed which yielded the seemingly disparate results.

Although the current data raises several unexpected points, preliminary responses for the original research questions on speed of processing and specific lexical representations are still available. Now that the performance of both younger and older typically developing children on the picture-naming interference task has been documented, the performance of language-impaired children on the same task can be evaluated and the remaining research questions can be addressed.

Lexical Processing in Language Impaired Children

The current experiment was designed to permit preliminary comparison of lexical processing in LI children, their age-matched, and language level-matched typically developing peers. The most important finding in this comparison was the absence of significant differences in reaction times of the LI children and their age-matched peers across all conditions. The LI group of children did respond consistently slower than the AM children, however, this difference
did not reach statistical significance. This finding suggests that on this task, the LI children were processing the stimulus words similarly to their age peers despite lower language capabilities.

The need for further comparison with the LI group and the LM group in this experiment was not considered essential in light of the LI's overall age-appropriate performance. The results of the comparison between the LI and AM groups alone provide preliminary answers to each of the three research questions posed in the introduction.

**Research Question 1: Semantic representation in language impaired children.**

Evidence from the analysis of naming errors in children with language impairments, and priming in earlier studies of children with reading and word-finding impairments suggested a possible deficit in lexical-semantic representation in children with SLI (Lahey & Edwards, 1999; McGregor & Windsor, 1996; Nation & Snowling, 1999). Typically developing young children demonstrated robust priming effects in online studies which investigated relationships between semantically associated words (Tazume, 1997; Powell, Wulfeck, Bates & Liu, 1997). The Relatedness condition in the current experiment allowed the comparison of the semantic representation and organization of categorically related words in typical children and language impaired children. The lack of a significant interaction between Group and Relatedness suggests that for the words employed in this study, the LI children had sufficiently detailed and organized lexical-semantic organization to compare favorably with their peers.

This finding by itself, could be taken as evidence that the lexical-semantic networks of language impaired children are spared from deficits, and do not contribute to lexical processing difficulties. However, considering the exploratory nature of this experiment, caution in interpreting the results must be used because the highly controlled and simple nature of the stimulus words employed in this experiment could have a tremendous influence on the results.
Research in the study of lexical access in language impaired children exemplifies the effect of the stimulus words on the experimental results. Montgomery's (1999) gating experiment yielded no differences in lexical processing between language impaired and typical children. Montgomery's stimuli were “highly familiar consonant-vowel-consonant words”, such as “boat”. In a similar gating study conducted by Dollaghan (1993) both “highly familiar” words and newly acquired nonsense words were employed. Dollaghan found significant differences in the responses of language impaired children and typically developing children in processing the newly acquired words. Therefore, investigations which measure the processing of more challenging words is necessary to determine whether children with language impairments have fully typical lexical-semantic networks.

**Research Question 2: Deficits in specific lexical processes.**

The finding of no significant Group by Time interaction for the LI and AM groups for either reaction times or naming errors implies that neither the picture naming nor the word perception processes were specifically deficient in the LI group, and that when compared to adults, the LI children like other children may have slower auditory processing. While the overall findings provide preliminary evidence against a specific processing account of lexical processing in SLI, the reaction times at +300 ms SOA invite further thought.

Specifically, in the LI group, semantic inhibition was observed at +300ms while semantic priming was observed in the AM and LM groups in the same condition. As the difference in the reaction times are relatively small, this reversal in response pattern may be entirely spurious in nature. However, the reversal may also represent an actual processing difference between children with language impairments and their language and age peers.

Again from a single-process perspective, the presence of inhibition at +300ms in the LI
group could be interpreted as evidence that compared to adults, who produce semantic inhibition at 0 ms, the LI group required more time to process the visual stimulus. Such a finding would not be out of line considering several studies demonstrating visual processing deficits in children with SLI. For example, children with SLI have been found to perform poorly on both motor and visual-spatial discrimination tasks compared to typically developing children (Powell, & Bishop, 1992). Also, in one study of short-term memory, school-age children with SLI performed most poorly on a digit recall test in conditions involving a visual stimulus and pointing response, rather than an auditory stimulus and verbal response (Gillam, Cowan, & Marler, 1998). However, if valid, this slowed visual processing should have exerted an influence on reaction times in other conditions as well, thus the argument is not a strong one.

In conclusion, although this difference in response was not statistically significant and cannot be fully accounted for with the current data, the possibility of subtly dissimilar lexical processing between children with language impairments and typically developing remains.

**Research Question 3: Generalized slowness of processing.**

The children with language impairments responded with longer reaction times than the children in the AM group; although this finding was not statistically significant it was clearly a consistent trend. The absence of Group differences in Relatedness and Time of IS presentation, and the presence of this non-significant trend would support a generalized slowing hypothesis for lexical processing difficulties in children with SLI. In this case, all of the processes involved in naming the picture and hearing the word were executed more slowly in children with SLI than in their peers. Because the degree of relative slowness in the LI group is consistent in all three Time conditions, an underlying general slowness of response over and above any specific visual processing slowness would be implicated.
One question which arises from the finding of a non-significant trend of generalized slowing is why the slow processing in the LI group was not statistically significant when significant slowing has been reported in previous naming studies (Lahey & Edwards, 1996). The simple nature of the stimulus list, and extraneous effects of repetition priming may provide preliminary answers to this question. Perhaps the children with LI had nearly achieved automaticity in the processing of the early acquired, highly frequent words employed as stimuli. As the LI group processed those words automatically, without spending processing resources, they were able to respond similarly to their age-peers, but still with a slight delay attributable to the generalized slowing factor.

Summary of findings in children with language impairments

In comparison to their age-matched peers, children with language impairments exhibited intact lexical-semantic processing for the words evaluated. Their overall speed of processing was somewhat lower than that of their typically developing peers, but this difference was not statistically significant. The reversed priming effect in the +300 ms condition, although possibly a spurious trend, would be consistent with a specific slowness in the processes of picture-naming, such as visual processing.

Implication of Findings for Future Research

Theoretical directions.

Like the study by Lahey and Edwards (1996), this current experiment was designed to evaluate specific component lexical processing skills by indirectly isolating those skills. In this case, the necessary coordination of the task’s two distinct lexical processing components (perception of the word, and naming of the picture) was useful in measuring the relative speed of each. This type of investigation is a crucial one for the area of lexical processing in SLI. Until
more lexical tasks are analyzed and each component process is evaluated in isolation using a factoring out process, we cannot select a general processing deficit account over a specific processing deficit account.

An area requiring further exploration is the model of lexical-semantic processing which must account for both semantic priming and inhibition findings, particularly in children. Future research should specify the course of development of these processes as well as their interaction within the lexical processing system.

**Future applications of the paradigm.**

The results of this experiment have demonstrated that the on-line, picture-naming interference task can be successfully administered to young children, including those with language impairments. Furthermore, with the parameters and stimuli selected for this implementation of the picture-naming interference paradigm, the language impaired children responded nearly the same as their same-age peers. These two facts, along with the presence of many options available for manipulation within the picture-naming interference task indicate that this paradigm is one with many possible applications in the SLI literature on lexical processing. For example, the picture-naming interference paradigm could be varied as follows:

1. To further investigate lexical-semantic representations and processing in children with SLI, the nature of the stimulus list could be manipulated to include more advanced vocabulary, less frequent vocabulary or more phonologically complex vocabulary.

2. To expand our knowledge about the time course of lexical processing in typical and language impaired children, more Time conditions could be included. For example, Tazume (1997) used 7 different Time conditions.

3. To more specifically address the issue of phonological representations and processing in SLI,
phonologically based IS could be employed. This option is an appealing one for two reasons, first, recent studies have conducted such an experiment with typically developing children (Brooks & MacWhinney, 2000). Second, such a study with language impaired children could serve to tease apart factors of phonological representation and phonological processing deficits since both the phonological relatedness and the Time of processing conditions could be manipulated.

(4) A longitudinal, or pre-learning and post-learning application of this paradigm would be an interesting means of tracking different stages in lexical acquisition in both typical children and those with SLI. Specifically, a study of the type of exposure to a word required before there is evidence of a complete underlying lexical representation or automatic processing of that word would be an interesting investigation.

Implications for clinical practice

As the results presented here represent a relatively narrow focus within a broader context of lexical processing issues, and they have yet to be replicated empirically, their direct application to clinical practice is premature. Nonetheless, these findings will eventually contribute to the clinical interventions used in treating lexical difficulties in children with language impairments by contributing to our understanding of the cause of these difficulties. For example, the generalized slowing hypothesis was supported by the findings presented here.

Taking that account into consideration, lexical intervention for children with SLI should include compensation for slowness of processing such as increasing processing time given, and providing information in shorter chunks. Therapy for vocabulary should include both strategies to create adequate semantic representations, and repetitive word level tasks designed to promote more rapid and
automatic lexical processing. As the children in the LI group of this experiment demonstrated, with enough exposure to lexical entries, children with LI are able to process those items nearly as well as their peers can.

On the more practical side, these results could also serve to inspire and justify the future development of computer administered on-line tasks in the clinical assessment of language impaired populations. In the current experiment, children as young as 6 years old completed the picture-naming interference task successfully, and in a brief period of time. On-line language processing assessments using a variety of tasks, and conducted in clinics or even in homes, is clearly an area with great potential.
REFERENCES


Brown, L., Sherbenou, R. J., Johsen, S. K., (1997). Test of nonverbal intelligence; a language free measure of cognitive ability, *Pro-ed, Texas*


Psycholinguistics, 19, 279-309.


Garlock, V. (1998). The development of spoken word recognition and phoneme awareness during the preliteracy and early literacy periods; a test of the lexical restructuring model. Dissertation abstracts international; section b, the sciences and engineering, 58(9b).


McGregor, K. K. (1997). The nature of word-finding errors of preschoolers with and


specific language impairment. *Topics in Language Disorders*, 17, 19-32.


APPENDIX 1 Details about all participants. All test scores are listed as raw score, standard score or quotient.

<table>
<thead>
<tr>
<th>ID</th>
<th>group</th>
<th>CA (months)</th>
<th>TONI (q)</th>
<th>CELF-3 CD (raw)</th>
<th>CELF-3 CD(ss)</th>
<th>CELF-3 FS (raw)</th>
<th>CELF-3 FS(ss)</th>
<th>CELF-3 RS (raw)</th>
<th>CELF-3 RS(ss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LI</td>
<td>95</td>
<td>100</td>
<td>9</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>22</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>LI</td>
<td>88</td>
<td>125</td>
<td>9</td>
<td>6</td>
<td>15</td>
<td>7</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>LI</td>
<td>100</td>
<td>97</td>
<td>8</td>
<td>5</td>
<td>12</td>
<td>5</td>
<td>32</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>LI</td>
<td>100</td>
<td>85</td>
<td>8</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>LI</td>
<td>101</td>
<td>95</td>
<td>10</td>
<td>5</td>
<td>21</td>
<td>7</td>
<td>24</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>LI</td>
<td>118</td>
<td>98</td>
<td>20</td>
<td>8</td>
<td>14</td>
<td>4</td>
<td>24</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>LI</td>
<td>113</td>
<td>88</td>
<td>15</td>
<td>6</td>
<td>28</td>
<td>8</td>
<td>28</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>LI</td>
<td>109</td>
<td>118</td>
<td>10</td>
<td>4</td>
<td>11</td>
<td>3</td>
<td>19</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>LI</td>
<td>121</td>
<td>95</td>
<td>7</td>
<td>3</td>
<td>17</td>
<td>4</td>
<td>30</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>LM</td>
<td>81</td>
<td>97</td>
<td>11</td>
<td>8</td>
<td>18</td>
<td>11</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td>11</td>
<td>LM</td>
<td>79</td>
<td>109</td>
<td>17</td>
<td>11</td>
<td>22</td>
<td>12</td>
<td>24</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>LM</td>
<td>82</td>
<td>97</td>
<td>10</td>
<td>8</td>
<td>22</td>
<td>12</td>
<td>30</td>
<td>13</td>
</tr>
<tr>
<td>13</td>
<td>LM</td>
<td>75</td>
<td>104</td>
<td>11</td>
<td>8</td>
<td>10</td>
<td>9</td>
<td>22</td>
<td>11</td>
</tr>
<tr>
<td>14</td>
<td>LM</td>
<td>79</td>
<td>97</td>
<td>15</td>
<td>10</td>
<td>9</td>
<td>9</td>
<td>42</td>
<td>10</td>
</tr>
<tr>
<td>15</td>
<td>LM</td>
<td>90</td>
<td>102</td>
<td>19</td>
<td>10</td>
<td>21</td>
<td>7</td>
<td>38</td>
<td>13</td>
</tr>
<tr>
<td>16</td>
<td>LM</td>
<td>85</td>
<td>109</td>
<td>15</td>
<td>8</td>
<td>23</td>
<td>10</td>
<td>36</td>
<td>12</td>
</tr>
<tr>
<td>17</td>
<td>LM</td>
<td>84</td>
<td>81</td>
<td>8</td>
<td>7</td>
<td>16</td>
<td>10</td>
<td>46</td>
<td>14</td>
</tr>
<tr>
<td>18</td>
<td>AM</td>
<td>86</td>
<td>94</td>
<td>22</td>
<td>12</td>
<td>22</td>
<td>9</td>
<td>22</td>
<td>14</td>
</tr>
<tr>
<td>19</td>
<td>LM</td>
<td>89</td>
<td>103</td>
<td>19</td>
<td>10</td>
<td>21</td>
<td>9</td>
<td>40</td>
<td>8</td>
</tr>
<tr>
<td>20</td>
<td>AM</td>
<td>96</td>
<td>100</td>
<td>22</td>
<td>12</td>
<td>30</td>
<td>12</td>
<td>49</td>
<td>12</td>
</tr>
<tr>
<td>21</td>
<td>AM</td>
<td>96</td>
<td>105</td>
<td>23</td>
<td>11</td>
<td>26</td>
<td>9</td>
<td>27</td>
<td>13</td>
</tr>
<tr>
<td>22</td>
<td>AM</td>
<td>98</td>
<td>95</td>
<td>15</td>
<td>7</td>
<td>28</td>
<td>9</td>
<td>36</td>
<td>7</td>
</tr>
<tr>
<td>23</td>
<td>AM</td>
<td>98</td>
<td>105</td>
<td>17</td>
<td>8</td>
<td>21</td>
<td>7</td>
<td>40</td>
<td>9</td>
</tr>
<tr>
<td>24 AM</td>
<td>104</td>
<td>117</td>
<td>25</td>
<td>12</td>
<td>26</td>
<td>9</td>
<td>33</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>-----</td>
<td>-----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>---</td>
<td>----</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>25 AM</td>
<td>109</td>
<td>121</td>
<td>23</td>
<td>9</td>
<td>35</td>
<td>11</td>
<td>62</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>26 AM</td>
<td>120</td>
<td>98</td>
<td>29</td>
<td>15</td>
<td>42</td>
<td>15</td>
<td>56</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>27 AM</td>
<td>122</td>
<td>105</td>
<td>28</td>
<td>13</td>
<td>35</td>
<td>10</td>
<td>56</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

CA: chronological age in months

TONI: quotient score on Test of Nonverbal Intelligence- third edition.


CD(raw): raw score on Concepts and Direction subtest of the CELF-3

CD: standard score on CD subtest

FS: Formulating Sentences subtest on the CELF-3

RS: Recalling Sentences subtest on the CELF-3