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# Inhibition and Sentence Processing in Children with Learning Disabilities

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Inhibition and Sentence Processing in Children with Learning Disabilities

A Field Project

Presented to the

Department of Psychology

and the

Faculty of the Graduate College

University of Nebraska

In Partial Fulfillment

of the Requirements for the Degree

Education Specialist

University of Nebraska at Omaha

by

Sherry Wilson

May, 1994

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FIELD PROJECT ACCEPTANCE

Acceptance for the faculty of the Graduate College, University of Nebraska, in partial fulfillment of the requirements for the degree Education Specialist, University of Nebraska at Omaha.

Committee

| Name | Department |
|---|---|
| | Psychology |
| | Psychology |

Co-Chairman

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4-13-94

Date

Abstract

In recent years, theorists have noted that developmental and individual differences may exist in the ability to suppress information that is irrelevant to a given task (e.g.,, Bjorklund & Harnishfeger, 1990; Dempster, 1992; Gernsbacher, 1988; Hasher & Zacks, 1988). The present study examined whether language/learning disabled (L/LD) children have greater difficulty than nondisabled (NLD) children suppressing irrelevant information during a sentence memory task. Children were presented with sentences that highly constrained a terminal noun. Upon presentation of the sentence, subjects were asked to predict the terminal noun in each sentence. For half of the sentences, the subject's prediction was disconfirmed with a low-probability ending. For the remaining half of the sentences, the subject's prediction was confirmed. In either case, subjects were instructed to remember the terminal noun. Memory for both confirmed and disconfirmed words was tested indirectly with a sentence completion task that measured the amount of repetition priming. The L/LD children were expected to show greater difficulty than nondisabled children in their attempt to inhibit the disconfirmed endings of each sentence. Although statistical analysis showed no main effects for either population (L/LD, NLD) or condition (disconfirmed, target), analysis did show a significant population x condition interaction. Further analysis of the L/LD data revealed that the L/LD children showed memory only for disconfirmed, nontarget information. The L/LD children maintained incorrect or irrelevant information, rather than suppressing the information and facilitating the relevant information. The NLD children showed similar amounts of retention for both disconfirmed and target words. These results indicate that the mechanisms of inhibition are less efficient in L/LD children. Results were discussed within the context of several contemporary theories of suppression.

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# Chapter I

## Introduction and Purpose of Study

Inhibition is a vital cognitive process that involves suppressing or dampening the activation of memory traces. When the efficiency of inhibitory mechanisms is reduced, irrelevant information has increased access to working memory, and remains activated for longer periods of time. Inhibition has been the subject of a great deal of research in both children and adults (Bjorklund & Harnishfeger, 1990; Dempster, 1992; Hasher & Zacks, 1988). Individual and developmental differences exist in inhibitory mechanisms that are involved in selective attention.

The purpose of the current study was to test the hypothesis that learning disabled children are less efficient in the suppression of irrelevant information than nondisabled children. The hypothesis was tested by employing a procedure that had been used recently by Hartman and Hasher (1991). The children involved in the current study included 21 language and learning disabled (L/LD) children and 20 nondisabled (NLD) children in the fourth-grade. The children were administered a series of high- and low-cloze sentences, each missing the final word. Subjects were instructed to provide an ending word for each sentence. For half of the sentences (filler sentences), the subjects' endings were confirmed by the examiner. For the other half of the sentences (critical sentences), the subjects' endings were disconfirmed as the examiner provided an unexpected (yet plausible) sentence ending as the target word. On a subsequent indirect memory test, subjects were required to provide word endings to medium-cloze sentences. Priming effects were calculated in order to demonstrate the efficiency of inhibitory mechanisms during sentence processing in children with and without learning disabilities. The L/LD children were expected to show greater repetition priming for the disconfirmed, nontarget words.

# Chapter II

## Literature Review

Although models of inhibition vary according to certain details, they generally describe a similar process. Dempster's (1992) framework described age-related differences in interference-sensitive tasks as dependent upon the functioning and efficiency of the frontal cortex. Dempster provided evidence that young children, older adults, and subjects with frontal lobe damage exhibit similar patterns of performance deficits on interference-sensitive tasks. Dempster indicated that tasks of selective attention, including priming tasks, are affected by the individual's ability to inhibit distracting stimuli, and that this ability improves as the child develops. Young children do not inhibit as efficiently as older children, who in turn do not inhibit as efficiently as young adults. The improvements in inhibitory mechanisms proceed to decline as a result of adult aging. Dempster concluded that the ability to inhibit distracting or irrelevant stimuli is a major factor in the development of intellectual competence and in the subsequent decline of that competence in later years. In addition, the frontal cortex is the area of the brain associated with inhibition. As the frontal cortex is one of the last areas of the brain to develop and one of the first areas to decline with aging, cognitive processes such as inhibition also are among the last to develop and the first to decline with aging.

One framework that describes individual differences in comprehension and that details the vital roles of activation and inhibition is Gernsbacher's (1982) Structure Building Framework. The Structure Building Framework proposes that the cognitive processes involved in language comprehension are general processes and mechanisms, not dedicated solely to language comprehension. According to the Structure Building Framework, the goal of comprehension is "to build a coherent mental representation or structure of the information being comprehended" (Gernsbacher, 1988, p.2). Such a goal is accomplished in three subprocesses: (1) laying a foundation, (2) mapping coherent information onto the developing structure, and (3) shifting to establish new substructures when new information is inconsistent with the current substructure. The mental substructures consist of memory cells (neurons) that represent stored memory traces. A memory cell could be either an individual cell or a group of cells representing a memory trace. The memory cells' level of activation is controlled by the two general cognitive processes of enhancement (i.e., increased activation) and suppression (i.e., decreased activation). When the memory cells are activated by incoming stimuli, they emit processing signals that either suppress or enhance activation of other memory cells. Suppression and enhancement monitor the activation levels of memory cells. The suppression process is imperative in the comprehension of sentences (Gernsbacher, 1988; Gernsbacher, Varner, & Faust, 1990; Gernsbacher & Faust, 1990). The framework supports the idea that individual differences in comprehension may not be specific to language, but rather are related to these general cognitive processes and affect visual, auditory, and kinesthetic stimuli.

According to Gernsbacher's (1988) framework, decreased access to recently comprehended data is due to the shifts from actively building a structure to the initiation of a new structure. Data are most accessible during the active building and processing of that substructure and less accessible after shifting to a new substructure that deals with new data. In one study, Gernsbacher (1988) created a situation that required more frequent shifting on the part of all learners by using stories that were scrambled. The skilled comprehenders showed reduced access (reduced memory) to recently comprehended, scrambled stories than to normally-sequenced stories. The less-skilled comprehenders displayed almost no difference in accessibility to recently comprehended data between the scrambled and the normally-sequenced stories. Gernsbacher proposed that the less-skilled comprehenders possess inefficient suppression mechanisms that allow information to remain activated even when it is no longer relevant.

This supposition of inefficient suppression was tested in another phase of the study. Based on scores from a comprehension battery, subjects were placed in either the skilled or less-skilled comprehenders group. Subjects read sentences with an ambiguous word ending, and then were exposed to a test word, which was presented at two points: immediately or 850 ms after reading the sentence. Subjects were required to determine whether the probe word was relevant or irrelevant to the previous sentence. Test words that were a related meaning of the ambiguous word, but inappropriate to the context, were considered irrelevant. About half the sentences were followed by relevant probe words and half were followed by irrelevant probe words. Both the skilled and the less-skilled comprehenders showed interference (difficulty rejecting the irrelevant probe word, or the incorrect meaning of the ambiguous word) at the first test point. At the second testing point, however, only the less-skilled comprehenders displayed interference. Apparently, as time passed, the skilled readers were able to suppress irrelevant meanings of ambiguous words that were inappropriate to a specific context. Less-skilled readers, on the other hand, failed to suppress the inappropriate meanings of ambiguous words.

Gernsbacher and Faust (1990, p.88) describe how the cognitive process of suppression "fine tunes the meanings of words" by suppressing less likely meanings. They demonstrated that less-skilled comprehenders possess less efficient suppression mechanisms. When confronted with ambiguous words, both skilled and less-skilled comprehenders experience activation of multiple meanings of the word, regardless of the context. Comprehenders respond just as quickly to the alternative meanings of the ambiguous word as to the appropriate meaning given the context, and respond less quickly to irrelevant words unrelated to any meaning of the ambiguous word. This indicates that when the comprehender encounters ambiguous words, "both appropriate and inappropriate meanings are activated ... and both meanings are more activated than unrelated concepts" (Gernsbacher & Faust, 1990, p.99). However, this activation of multiple meanings occurs for a brief amount of time before the irrelevant meanings' activation levels decrease. According to Gernsbacher's Structure Building Framework, the inappropriate or irrelevant meanings become less activated through the cognitive mechanism of suppression: "Dampening the activation of inappropriate meanings could be one of the most important roles that the mechanism of suppression plays in sentence comprehension" (p.101).

Gernsbacher and Faust (1990) continued to disprove that other mechanisms are responsible for decreased activation of inappropriate meanings as outlined by other theories. For example, decay theory predicts that with neutral sentences, inappropriate as well as appropriate meanings become less activated after a delay due to decay. However, Gernsbacher and Faust found that inappropriate meanings were less activated than appropriate meanings after a delay. This difference in level of activation is inconsistent with the decay theory, and indicates that activation of the inappropriate meanings was suppressed.

In an attempt to explain age-related declines in the efficiency of inhibitory processes and in comprehension level, Hasher and Zacks (1988) proposed an alternative framework. They proposed that breakdowns in the efficiency of inhibitory processes allow irrelevant information into short-term working memory, sustain activation of irrelevant information in working memory for an extended amount of time, and result in outcomes such as "weaker or poorer quality initial encoding ... and ... competition among related ideas" (p.215). Hasher and Zack's framework resembles that of Gernsbacher's (1988), except Hasher and Zacks described efficiency of inhibitory processes within a developmental framework. This theory takes into account aging adults' poorer retrieval on memory tasks that involve suppression of distracting information. Hasher and Zacks further stated that reduced inhibitory functioning can result in more distractibility, more inappropriate responses, increased response time to make competing responses, and increased forgetfulness. These inhibitory difficulties possibly are found in adults with depression, children with attention disorders, and people with schizophrenia.

Hasher and Zack's theory focuses on contents of working memory, not on storage capacity. The inhibitory mechanisms are important for the operation of working memory and for selective attention. Inhibitory mechanisms are supposed to limit into working memory relevant information, or "goal-path" stimuli necessary for comprehension. In contrast, "off-goal-path" ideas are not relevant to understanding or are "peripheral to the formation of a coherent and detailed representation of a text" (p.212). Non-goal-path information (e.g., daydreams) may enter working memory. However, efficient inhibition suppresses the activation of these irrelevant thoughts.

If inhibitory mechanisms are faulty or inefficient due to slowing of neural functioning, or when goals of the recipient of information differ from the goals of the dispenser of information, results can be significant: "In parallel-architecture attention systems, a breakdown in inhibition will lead to cross talk among simultaneously active messages, preventing organized responses" (Hasher & Zacks, 1988, p.213). As stated earlier, Hasher and Zacks contend that severe breakdowns in inhibition could result in schizophrenia or attention deficit disorders. They also contend that more moderate breakdowns in inhibition could result in breakdowns in comprehension, or at least limit comprehension and memory functioning. Inefficient inhibition allows: (a) off-goal-path information access to working memory, and (b) prolonged maintenance of the irrelevant information in working memory.

The effects of irrelevant information entering working memory depend on the level of attention allowed to the off-goal-path information. Depending upon the intensity of attention to off-goal-path (irrelevant) data, the goal-path (relevant) data might go unprocessed. The comprehender (the reader or listener) may not process key elements of a message and therefore may be unable to establish coherent links between the pieces of information that are processed. Hasher and Zacks (1988) state that the comprehender is "unable to establish coreference among the phrases and sentences" (p.214), resulting in incorrect understanding of a message.

According to the Hasher and Zacks' model, another result of inefficient inhibition is decreased ability to switch attention from one target or category of events to another (cf. Gernsbacher, 1988). The authors cite the example of reading a passage that contains many changes in setting or scenery as difficult for the reader to comprehend. The entrance of irrelevant information into working memory sets up a situation that facilitates at least two classic mechanisms of forgetting: initial encodings of information are weaker, and competition exists between related ideas. The irrelevant information may prevent access to pertinent data. Failing to retrieve the relevant, or target, information interferes with comprehension.

Hasher and Zacks argue that conditions for accessing relevant information are exacerbated according to environmental conditions that increase competition, such as requiring rapid responses from the comprehender. Another contributing factor is contextual support: as contextual support decreases, effective inhibition and selection also decrease.

In a similar vein, Bjorklund and Harnishfeger (1990) used the Hasher and Zacks' (1988) theory of inefficient inhibition to explain the developmental differences in children's selective attention abilities. They incorporated the Hasher and Zacks' (1988) theory into a limited resources model of cognitive phenomena, and described how neurological development in children leads to increased inhibitory efficiency and improved selective attention. Bjorklund and Harnishfeger concluded that the maturing child's changing neurological system results in increased inhibitory efficiency and decreased task-irrelevant information in working memory, thereby leading to improvements in selective attention.

Incorporating Hasher and Zacks' theory, Hartman and Hasher (1990) conducted a study that examined age differences in memory when irrelevant information was introduced along with target material. Younger and older adult subjects were required to read a series of high-cloze sentence frames with the final word missing. Half of the sentence frames were then completed with the expected ending, and half were completed with an unexpected, but acceptable, ending. Memory was then assessed by an indirect memory task in which subjects read medium-cloze sentence frames and completed the sentences with the first word that came to mind. Possible endings included the control word, the target word, or the disconfirmed word. The older adults showed priming for both the target and disconfirmed word endings, whereas the younger adults showed priming of the target word endings only. In other words, the older adults showed equivalent memory for both the relevant and irrelevant words. The younger subjects showed memory for only relevant words. These findings supported the hypothesis that the older adults would display inefficiency in suppressing the processing of irrelevant information.

In a related study, Hamm and Hasher (1992) asked younger and older adults to read several passages that contained either expected or unexpected, but acceptable, conclusions. Consistent with Hasher and Zacks' (1988) theory, the older adults showed sustained activation of the alternative conclusions (irrelevant information) and lower levels of inference recall. As Hamm and Hasher stated, older adults' working memory limitations made it difficult to "simultaneously retrieve the passage's relevant antecedent information, use their general knowledge, and also maintain current information to reconcile the discrepancies among facts in the misleading version and to arrive at the most appropriate interpretation" (p.1).

Tipper and his colleagues (Tipper, 1985; Tipper & Cranston, 1985; Tipper & Driver, 1988; and Tipper, Bourque, Anderson, & Brehaut, 1989) conceptualize inhibition within the larger context of selection. More specifically, the mechanism of selection is viewed as processing the attended stimuli and inhibiting the irrelevant stimuli. Tipper contends that selective attention is fundamental for adequate functioning in an environment filled with conflicting stimuli. In order to determine how an organism chooses the appropriate stimuli for processing, Tipper (1985) designed a study that examined the fate of ignored stimuli. In explicating his experiment, Tipper describes two positions that involve the type of representations of ignored objects. The precategorical view holds that the "initial parallel analysis of a visual scene achieves internal representations of only the physical features of objects" (p.572). The postcategorical view maintains that the initial parallel analysis attains at least a categorical level of representation. Whether representation is pre- or postcategorical, the fate of the ignored stimuli is unclear. One explanation is described as passive decay. Similar to Hasher and Zacks (1988), Tipper contends that passive decay theories cannot account for many experimental results, such as different levels of activation of stimuli. Both precategorical and postcategorical positions accept that the representations of ignored stimuli simply decay passively and are lost. Another explanation involves distractor inhibition and is consistent with the postcategorical view. With distractor inhibition, the representations of the ignored stimuli become associated with inhibition. During the process of attending, relevant information is selected, and irrelevant information is actively inhibited.

Tipper (1985) studied the effect of ignored primes on the later naming of identical selected probes, and also studied the effects of both ignored and selected primes on later selection of categorically related probes. Adult subjects were exposed to line drawings of two superimposed objects, and were instructed to ignore the green objects and attend to the red. After a 1-sec delay, subjects were required to name a probe display. Subjects showed impaired naming latencies if the probe display was the previously ignored object. Tipper demonstrated that reaction times to name a probe are increased if it has the same identity or is categorically related to a previously ignored object. Tipper stated (p.587):

> During target selection, the initial representations produced of ignored and selected objects are both further processed, but in different ways. Representations of selected objects appear to receive further processing to enable naming of the object, recall some seconds later, and recognition some minutes later. The resulting internal representations facilitate selection of subsequent probes requiring identical or similar representations. Representations of the ignored object also appear to receive further processing, as opposed to passive decay. In this case, the internal representations produced are such that selection of subsequent objects requiring those representations is delayed. It may be suggested that this delay reflects inhibition associated with the internal representations of ignored objects during selection.

Tipper and Cranston (1985) elaborated on the inhibition of response idea to explain the reversal of priming effects. They concluded that selective attention involves a dual mechanism of enhancing and maintaining representations of attended objects as well as the active inhibition of irrelevant or competing objects. Inhibition can be influenced by task demands and by subject strategies.

Tipper et al. (1989) applied the theory of inhibition to children's performance in priming tasks. More specifically, Tipper et al. suggest that the "ability to process automatically irrelevant stimuli develops rapidly; children are possibly more distractible because the ability to utilize the inhibition mechanism has not fully matured ..." (p.367). Children are viewed as poor selectors due to developmental lag in their ability to actively inhibit distractors. Although children are able to quickly use habituation mechanisms of selective attention by grade 2, they do not evidence use of inhibitory mechanisms. This study is consistent with the view that older children out-perform younger children due to increased ability to inhibit distracting stimuli.

In terms of function, inefficient inhibition can result in increased distractibility, more inappropriate responses, longer reaction times, and increased forgetfulness. These characteristics are very similar to characteristics of the learning disabled population.

The purpose of the current study was to compare inhibition and sentence processing skills in learning disabled and nondisabled children. Assuming that the learning disabled children possess less efficient inhibitory mechanisms (or decreased suppression), LD children were expected to have greater difficulty than nondisabled children suppressing irrelevant and distracting information during a sentence processing and memory task. The learning disabled children were expected to show repetition priming effects not only for the target (i.e., relevant) word endings, but also for the disconfirmed (i.e., irrelevant) word endings, whereas the nondisabled children were expected to show significantly larger repetition priming effects for only target words.

# Chapter III

## Method

### Subjects

Twenty-one language/learning disabled children (18 boys and 3 girls) and 20 nondisabled children (10 boys and 10 girls) were selected from a suburban school district in the midwest. The mean ages for the language/learning disabled (L/LD) group and the nondisabled (NLD) group were 10.4 (range: 9.8 - 11.6, SD = .47) and 10.7 (range: 10.1 - 11.3, SD = .34), respectively. Although the two groups differed in gender composition, gender differences are representative of the two populations. That is, the learning disabled population is represented by a larger proportion of males than females (e.g., Ysseldyke & Stevens, 1986). English was the primary language for all children. The L/LD children were previously identified by school district personnel as having both a learning disability and a language impairment. Verification of a learning disability was based primarily upon two criteria. First, the child's Full Scale IQ score was above the -1 standard deviation level on an individually administered test of intelligence. For those children who had a discrepancy between composite scores that was greater than 1 standard deviation, the higher score was used as the index of cognitive ability. The L/LD students had a mean Verbal IQ of 92.8 (SD = 14.5), a mean Performance IQ of 100.2 (SD = 15.9), and a mean Full Scale IQ of 96.1 (SD = 13.5). Second, the child's standard score in one or more achievement areas was at least 1.3 standard deviations below the child's assessed cognitive ability level. In addition, the standard score fell at or below 90 standard score points. Although the L/LD children previously had taken achievement tests for verification purposes at school, the children also were administered the reading and math subtests from the Wide Range Achievement Test - Revised (WRAT-R) (Jastak & Wilkinson, 1984) during this study in order to provide a comparison with the achievement results of the NLD children. The L/LD children obtained a mean reading standard score of 84.1 (SD = 15.0) and a mean math standard score of 87.1 (SD = 12.4) on the WRAT-R. Similar criteria were used to verify a language impairment. Again, at least average intellectual ability was documented and the child's expressive or receptive language performance yielded standard scores greater than 1.3 standard deviations below the child's assessed ability level. The L/LD children received a mean expressive language score of 82.7 (SD = 7.5) and a mean receptive language score of 75.7 (SD = 5.4) on the Clinical Evaluation of Language Fundamentals - Revised (Semel, Wiig, & Secord, 1987).

The selection of nondisabled students excluded those children who were the recipients of remedial services, as well as those who were enrolled in gifted and talented programs. Using standard scores prorated from scaled scores for the Block Design and Vocabulary subtests of the Wechsler Intelligence Scale for Children - Third Edition (Wechsler, 1991), the NLD students had a mean Verbal IQ of 104.6 (SD = 17.6), a mean Performance IQ of 111.4 (SD = 23.3), and a mean Full Scale IQ of 108.3 (SD = 19.3). For children age 10, intercorrelations for the Vocabulary subtest with the Verbal IQ and Full Scale IQ are .90 and .83, respectively (Wechsler, 1991, p. 274). Intercorrelations for the Block Design subtest with the Performance IQ and the Full Scale IQ are .81 and .70, respectively. The NLD children obtained a mean reading score of 108 (SD = 12.1) and a mean math score of 98.9 (SD = 13.1) on the WRAT-R.

## Materials

Study-list materials were constructed by generating a pool of 24 sentence contexts that highly constrained a terminal noun (e.g., "The carpenter hit the nail with his hammer."). The majority of these high-cloze sentence frames were obtained from a previous study by Lorsbach, Melendez, and Carroll-Maher (1990), or from the norms of Bloom and Fischler (1980). The remaining sentences were developed specifically for this study. Sentence frames were selected that kept the cloze probability of the terminal noun at a high level, yet still allowed for the possibility of another response. In addition to these 24 high-cloze sentence frames, a second low-cloze version also was constructed. The low-cloze version of each sentence context ended with a noun that provided an unpredictable, yet reasonable response (e.g., "The carpenter hit the nail with his truck."). Twelve additional sentences with highly constrained terminal-nouns also were generated and served as fillers in the study list. The nouns that were used as responses in the high-cloze, low-cloze, and filler sentences were similar in their mean frequency of occurrence, with the mean frequency-per-million being 170, 158, and 166, respectively (Carroll, Davies, & Richman, 1971). Table 1 presents examples of study and test sentences. (See Appendix A for a complete list of the study and test sentences.) Finally, two sentences were created for use as practice stimuli. The pool of 24 study-sentences was divided into two sets of 12 sentences (Set A and Set B). Two random versions of each set were created and were used equally often with both L/LD and NLD children.

Each subject was presented with a 24 item study-list, consisting of 12 low-cloze sentences from either Set A or Set B, along with the 12 high-cloze filler sentences. Presenting low-cloze sentences in the context of high-cloze filler sentences was done in order to encourage subjects to anticipate the more likely response to each sentence context. Critical sentences and filler sentences were presented randomly, with the restriction that no more than three critical sentences appeared in succession. The use of two filler sentences at the beginning and at the end of the study list was included as an additional constraint in order to minimize the possibility of primacy and recency effects.

A 48-item test list was constructed by generating sentences that moderately constrained the terminal nouns of the 24 high-cloze and 24 low-cloze sentences (cloze values between .30 and .70). Sentence contexts were piloted with a sample of fourth-

Table 1

Examples of Sentences used in the Study List and Test List

| Sentence type | Disconfirmed | Target |
| --- | --- | --- |
| Study list (critical items) | | |
| The carpenter hit the nail with his | hammer | truck |
| He mailed the letters without any | stamps | help |
| Indirect test | | |
| My father went to the hardware store to buy a new | hammer | |
| That man is driving a big, old rusty | | truck |
| The package was not sent because it did not have any | stamps | |
| My teacher asked me if I needed some | | help |

grade nondisabled children to determine whether each sentence had a moderate cloze value. To illustrate, the sentence context used in the study list, "The carpenter hit the nail with his _____ ," had a high-cloze ("hammer"), as well as a low-cloze ("truck"), ending. In this case, "hammer" provided the anticipated, but disconfirmed ending, whereas "truck" provided the low-cloze ending and served as the target noun. Memory for the expected terminal noun ("hammer") was tested indirectly by presenting a moderately-constrained sentence context, "My father went to the hardware store to buy a new _____ ." The noun ("truck") used in the low-cloze version was tested with the sentence context, "That man is driving a big, old rusty _____ ."

The entire 48-item test list was presented randomly to each subject. Twenty-four of these sentence contexts were designed to test the 12 critical items from the preceding study list. Of these 24 sentence contexts, 12 tested the anticipated, but disconfirmed sentence endings (disconfirmed condition), and 12 tested the terminal nouns that were actually presented with each sentence context (target condition). The remaining 24 sentence contexts were the test items for the alternate set of study sentences that was not presented to the subject (control condition) for study. These latter sentences provided the baseline control condition for each subject. Two different orders of presentation were generated and were used equally often with each study set and with each population.

Procedure

Each subject was tested individually in a quiet room in her or his own school. The study sentences were tape-recorded by an adult male and were presented at 13s intervals. Each stimulus interval began with the presentation of a given sentence frame. The duration of each sentence frame varied somewhat, depending upon the length of the frame itself. In most instances, however, the presentation of the sentence frame required about 2s. Six seconds later the terminal noun was presented. Following a 5s interstimulus interval, the next sentence frame was presented.

Each child was told that they would listen to a list of sentences. Subjects were asked to listen to each sentence as it was presented and to try to remember the last word for a subsequent memory test. Each child was told that there would be a pause before the presentation of the final word within each sentence. During this pause they were requested to predict the final word aloud. The experimenter recorded the nouns that were predicted by each subject. In addition, each child was cautioned that some of the sentences contained unexpected endings. Regardless of whether the word was expected or unanticipated, children were asked to try to remember only the word that was actually presented on the audio-tape. Following these instructions, each subject was given two practice sentences. One practice sentence presented an expected sentence ending (high cloze), and the other sentence presented an unexpected ending (low cloze).

Upon completion of the 24 study sentences, each child was given 7-8 minutes of nonverbal filler activity (e.g., math subtest of the WRAT-R). The length of time for the nonverbal filler activity varied slightly due to child variation. Following the filler activity, the sentence completion test was administered. The task was not presented as a memory test. Rather, subjects were told that they were required to complete more sentences. Instead of an audio-tape, the examiner read the sentence frames to the subject. Subjects were told that they would hear new sentences that were missing the final word. Each child was asked to listen and to complete each sentence with the first word, and only one word, that came to mind. The experimenter recorded the subjects' responses. The test sentences were presented at a faster pace than the study sentences; the interstimulus interval was approximately 2 seconds. The pace was increased partially to decrease the time spent in the testing session and partially to discourage children from supplying more than one word.

For the L/LD children, the testing session was ended by administering the reading subtest of the WRAT-R. For the NLD children, the activity was ended by administering the WRAT-R reading subtest, and the Block Design and Vocabulary subtests of the Wechsler Intelligence Scale for Children - Third Edition.

Following Hartman and Hasher (1991), an attempt was made to determine children's awareness of the nature of the sentence materials. Upon completion of the testing session, children were asked about their awareness of the relationship between the study and test lists. Children were initially asked two general questions: "What did you think of the research activity?" and "Did you think there was anything unusual about the sentences?" Subsequent questions to be more explicit about the relationship between the study and test lists (i.e., whether the child noticed any connection between the two lists, and if so, what they noticed and when) were not necessary as none of those children indicated anything unusual about the activity. No subject indicated that he or she was aware of the relationship between the study list and the test list. Two children commented that we did not do the 'memory quiz.'

# Chapter IV

## Results

For each subject, the proportion of sentence completions on the test list was calculated for each of three conditions: (1) disconfirmed condition: the proportion of words that matched the anticipated, but disconfirmed sentence endings from the preceding study list; (2) target condition: the proportion of words that matched the terminal nouns that were actually presented with each sentence frame; and (3) control condition: the proportion of words that matched the disconfirmed and target endings of study sentences that were not presented to a given subject. The three scores were used to calculate two repetition-priming scores for each subject. Priming effects of both the disconfirmed items and target items were calculated separately by subtracting the control score. Table 2 presents the means for each of the three conditions, as well as the priming effects associated with disconfirmed and target words.

Priming scores were submitted to a 2 x 2 mixed design analysis of variance (ANOVA), with population (LD or NLD) as the between-subjects variable, and priming condition (disconfirmed or target) as the within-subjects variable. Although the main effects of population ($F < 1$) and priming condition, $F\ (1,39) = 3.046$, $MS_e = .025$, $p < .09$, were not significant, the population x priming condition interaction was significant, $F\ (1,39) = 5.782$, $MS_e = .025$, $p = .021$. This interaction was examined further by testing separately the effects of priming condition with each population. Simple effects tests revealed that L/LD children experienced significantly greater priming effects for disconfirmed words than for target words, $F\ (1,39) = 8.826$, $MS_e = .025$, $p = .005$. Nondisabled children, on the other hand, experienced equivalent amounts of priming for disconfirmed and target words, ($F < 1$). For the L/LD group, priming was greater than zero for the disconfirmed words, $t\ (20) = 5.12$, $p < .001$, but not for the target words, $t < 1$. For the NLD group,

Table 2

Proportions from the Sentence Completion Task

| | Condition | | | Priming Effect | |
|---|---|---|---|---|---|
| Group | Disconfirmed | Target | Control | Disconfirmed | Target |
| LD | 46.33 | 33.67 | 35.33 | 11.0 | -1.67 |
| NLD | 45.6 | 47.9 | 39.25 | 6.35 | 8.65 |

priming effects were not significantly greater than zero for either the disconfirmed, $\underline{t}$ (19) = 1.28, $\underline{p} < .10$, or the target words, $\underline{t}$ (19) = 1.74, $\underline{p} < .10$. Therefore, although NLD children exhibited equivalent memory for both disconfirmed and target words, this amount was not significantly different than the control condition. The L/LD children displayed memory only for the disconfirmed word endings, which was significantly greater than the control condition. Although the reviewed literature does not indicate differences in inhibitory mechanisms based upon gender, $\underline{t}$ tests were conducted to identify any possible gender differences in the experimental groups' characteristics. Subsequently, no significant differences were found in priming effects in the NLD group.

## Discussion

The current research tested the hypothesis that the inhibitory processes of L/LD children are less efficient than the inhibitory processes of nondisabled children. The L/LD children were expected to show significantly greater priming effects with disconfirmed items than with targets, whereas NLD children were expected to show the reverse. The results are partially consistent with the original hypothesis. The data analysis showed no significant main effects of population or condition, however, there was a significant interaction. The L/LD children exhibited significantly greater priming for the disconfirmed words than for the target words. However, the NLD children did not show greater priming for target words over disconfirmed words.

In retrospect, the expectation of the hypothesis for the NLD children was unreasonable given the results of Hartman and Hasher (1991). In fact, the NLD children performed similar to the older adults in the Hartman and Hasher study. In relative terms, Hartman and Hasher found that older adults showed equivalent memory for both the disconfirmed and target words. In addition, they conducted $\underline{t}$ tests to determine whether the older adults' priming effects differed significantly from zero (i.e., significantly different from the control condition). The results approached, but did not reach, significance. Therefore, in absolute terms, the older adults' memory for disconfirmed and target words was statistically equivalent to memory for the control condition. Similarly, the NLD children in the current study showed equivalent memory for disconfirmed and target words. Additionally, $\underline{t}$ tests determined that memory for disconfirmed and target words was statistically the same as memory for the control words. In other words, the NLD children showed no improvement in memory for either the target or disconfirmed condition compared to the control condition.

Although the argument can be made that NLD children should have evidenced priming effects for the target words, another argument contends that the competition between related ideas contributed to the observed lack of priming. Hasher and Zacks (1988) proposed that once irrelevant information enters, or "enriches," working memory, increased competition exists at the time of retrieval. The different categories of information are linked together due to temporal proximity in working memory, which then contribute to competition between the ideas at the time of retrieval.

The performance of the NLD children also appear more consistent with developmental theory regarding the cognitive maturity necessary to suppress irrelevant information. The cognitive processes of older adults often resemble those of children. That is to say, many cognitive processes that mature in children are the same that tend to decline with age. Dempster (1992) stated that inhibition is "a major factor in cognitive development and aging" (p.46). Dempster cites evidence from advances in neuroscience, which suggest that the frontal lobes are involved in the ability to suppress internal and external stimuli, and that the frontal cortex is one of the slowest areas of the brain to develop and one of the quickest areas to deteriorate in later life.

Although NLD children appeared to display enhancement and not-yet-mature inhibition mechanisms, the L/LD children appeared to display an even less mature inhibitory processer, resulting in the elevated priming effects for the disconfirmed condition. In a similar vein, Lorsbach and Worman (1988) found that LD children experience greater amounts of negative transfer (i.e., prior experiences interfering with performance on a new task) than NLD children during a paired-associate task. Cognitive inflexibility impeded LD children from abandoning old associations and altering their behavior to accommodate the new learning task. They suggested that LD children experience more interference from prior related verbal learning than do NLD children, and that LD children have difficulty generalizing old information to new situations.

Lorsbach and Woman indicated that LD children rely upon automatic processes that foster rigid, stereotyped behavior. Children who experience cognitive inflexibility may fail to improve or to employ more efficient means for encoding information.

Another explanation for the results of the L/LD involves Gernsbacher's (1988) idea of the advantage of the first-mentioned participant. Gernsbacher suggests that after comprehending a sentence, the subject remembers the first-mentioned participant easier than the second-mentioned participant. In the Structure Building Framework, the first-mentioned participant forms the foundations for the sentence-level representation. It also is the foundation for subsequent information that is mapped onto the developing representation. The L/LD children in the current study may have benefitted from the first-mentioned participant advantage, thus explaining the higher priming effects for the disconfirmed (first-mentioned) words.

Hasher and Zacks (1988) stated that when suppression / inhibition becomes inefficient, then the learner may experience increased distractibility, more inappropriate responses, longer reaction times, and increased forgetfulness. Inappropriate responses were exhibited by L/LD children in the current study through their failure to suppress disconfirmed words, as well as their failure to maintain the activation of target words on the indirect memory test.

Tipper and Cranston (1985) provide some explanation for the pattern of results obtained with L/LD children. They concluded that selective attention involves a dual mechanism of enhancing and maintaining representations of attended objects as well as the active inhibition of irrelevant or competing objects. Inhibition can be influenced by task demands and by subject strategies. Anecdotal evidence from the current study suggests that the nondisabled children were more accustomed to engaging in learning strategies. The nondisabled children frequently were observed to enlist strategies to help remember the target words. For example, more NLD than L/LD children were observed repeating target words quietly to themselves or aloud, either one word at a time after presentation of the sentence or repeating as many of the previous target words as possible before the next sentence. The L/LD children appeared more passive, and tended to use few, if any, observable strategies.

Limitations of the current study include relatively small subject numbers in both experimental groups. The low number of subjects led to lower power in the statistical analyses. Larger numbers of subjects would reduce effects of individual variability and would more accurately represent the learning disabled and nondisabled populations as groups. It is possible that with larger sample sizes the NLD group would show priming effects in the target condition that differed significantly from zero. Another possible limitation is the assumption that gender differences are nonsignificant factors. Although the current study affirms that gender does not play a role in priming effects, further investigation into possible differences may reveal distinct characteristics attributable solely to gender.

The results of this study have significant implications for school psychology and future research investigating developmental and individual differences in comprehension. School psychologists are intimately involved with the identification, assessment, and intervention of learning disabled students. Improved understanding of the cognitive mechanisms that help determine inclusion as a learning disabled child will also improve understanding of strategies to compensate for the disability. In order to learn more about developmental changes in inhibitory efficiency and its effects on comprehension, younger and older (e.g., grades 2, 6, and 9) L/LD and NLD children could be evaluated using the Hartman and Hasher (1991) paradigm. To learn more about individual variations in comprehension, a future research project could analyze time differences in the response latencies between

L/LD and NLD students in a priming effects design. Anecdotal evidence from the current study suggests that comprehension may be related to the length of response latency. Clearly, more research is needed to help detect factors that impact comprehension in children. Ultimately, when these factors are more clearly defined, more effective intervention strategies can be devised to help children compensate for learning difficulties.

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## Appendix I

### Study Sentences and Corresponding Test Sentences - Subset A

| | | Terminal Nouns | |
|---|---|---|---|
| | | Expected | Unexpected |
| | **Practice** | | |
| 1. | We fed the bear at the | zoo | cave |
| 2. | I know him, but I cannot remember his | name | wife |
| | **Subset A** | | |
| 1. | He filled the bathtub with | water | toys |
| | For garden plants to grow, they need lots of | water | |
| | Mother said, "When you finish playing, please put away your | | toys |
| 2. | He mailed the letters without any | stamps | help |
| | The package was not sent because it did not have any | stamps | |
| | My teacher asked me if I needed some | | help |
| 3. | The bright sun was hidden behind a large | cloud | mountain |
| | Look in the sky and see that | cloud | |
| | The men will attempt to climb that steep | | mountain |
| 4. | The fireman is fighting a | fire | cold |
| | I wanted to warm up, so I stood beside the | fire | |
| | He stayed home from school and took some medicine for his | | cold |
| 5. | After seeing the tangles,the girl said, "I need to brush my | hair | dog |
| | She has very pretty | hair | |
| | The little boy was frightened by the big | | dog |

| | | | |
|---|---|---|---|
| 6. | The theater was so crowded he could not find his | seat | friends |
| | The student moved because she was in the wrong | seat | |
| | When he left home he amazed his | | friends |
| 7. | When it started to rain, they stopped the baseball | game | party |
| | My father bought tickets to the | game | |
| | We were having fun until we ran out of food at the | | party |
| 8. | The picture is hanging on the | wall | hook |
| | The spider is crawling on the | wall | |
| | The student opened the locker and put his hat on the | | hook |
| 9. | The student drew the picture using paper and | pencil | chalk |
| | I wrote the note with a | pencil | |
| | While teaching, Mrs. Jones dropped a piece of | | chalk |
| 10. | The carpenter hit the nail with his | hammer | truck |
| | My father went to the hardware store to buy a new | hammer | |
| | That man is driving a big, old rusty | | truck |
| 11. | The indian has a bow and some | arrows | knives |
| | He hit the bull's-eye with two | arrows | |
| | Although dangerous, the circus performer threw several | | knives |
| 12. | We made a sandwich with peanut butter and | jelly | bananas |
| | The fly landed on the jar of | jelly | |
| | The man peeled and ate two | | bananas |

Study Sentences and Corresponding Test Sentences - Subset B

| | Terminal Nouns | |
|---|---|---|
| | Expected | Unexpected |
| **Practice** | | |
| 1. We fed the bear at the | zoo | cave |
| 2. I know him, but I cannot remember his | name | wife |
| **Subset B** | | |
| 1. The exit was marked by a large | sign | man |
| Because it was so dark outside, I could hardly read the | sign | |
| The woman was introduced to the | | man |
| 2. The girl had chicken pox and could not go to | school | sleep |
| Mary got dressed to go to | school | |
| Billy was very tired and wanted to go to | | sleep |
| 3. I cannot lock the door without using my | key | hand |
| Father said, "We cannot leave unless I find my | key | |
| Danny caught the ball with his | | hand |
| 4. Go to the library and check out a good | book | magazine |
| I cannot do my homework because I forgot my | book | |
| While reading, I saw a picture of he movie star in the | | magazine |
| 5. The cowboy rode on a | horse | bicycle |
| When we visited the ranch we were able to pet the | horse | |
| The boy went to play on his new | | bicycle |
| 6. The batter swung and hit the | ball | coach |

| | | | |
|---|---|---|---|
| | As it rolled down the street, the dog chased the | ball | |
| | This year our soccer team will have a different | | coach |
| 7. | As he entered the building, the boy took the cap off his | head | bottle |
| | When he was playing, he bumped his | head | |
| | The catsup dripped from the | | bottle |
| 8. | The lawn mower ran out of | gas | oil |
| | My mom said, "We can stop at that filling station and buy some | gas | |
| | The mechanic spilled some | | oil |
| 9. | Mice like to eat | cheese | corn |
| | The sandwich would taste better with a slice of | cheese | |
| | The farmer is harvesting the | | corn |
| 10. | Don't touch the wet | paint | puppy |
| | The old house needs some | paint | |
| | The boy could not think of a name for the furry little | | puppy |
| 11. | For breakfast, I ate a bowl of | cereal | fruit |
| | My father put some fresh strawberries on his bowl of | cereal | |
| | You should eat plenty of fresh | | fruit |
| 12. | They used an ambulance to rush the man to the | hospital | airport |
| | When I injured my hand, I went to the | hospital | |
| | They took a cab to the | | airport |

## Appendix II

### Filler Sentences used in the Study Lists

| | |
|---|---|
| 1. Bugs Bunny likes to eat | carrots |
| 2. Rain, rain, go away. Come again another | day |
| 3. Apples grow on an apple | tree |
| 4. Hickory, Dickory, Dock! The mouse ran up the | clock |
| 5. The chicken laid an | egg |
| 6. Butterflies fly by flapping their | wings |
| 7. He put a dollar into his piggy | bank |
| 8. We smell with our | nose |
| 9. A robin is a | bird |
| 10. A cow has four | legs |
| 11. Open your mouth and stick out your | tongue |
| 12. I learned how to sing a new | song |