Order Number 9309022

Taxonomic and frequency associations in memory in learning-disabled and non-disabled children

Lee, Carolyn Patricia, Ph.D.

The University of Arizona, 1992

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

TAXONOMIC AND FREQUENCY ASSOCIATIONS IN MEMORY IN LEARNING DISABLED AND NON-DISABLED CHILDREN

by

Carolyn Patricia Lee

A Dissertation Submitted to the Faculty of the

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 9 2

THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

As members of the Final Examination Committee, we certify that we have read the dissertation prepared by Carolyn Patricia Lee

entitled TAXONOMIC AND FREQUENCY ASSOCIATIONS IN MEMORY IN LEARNING DISABLED AND NON-DISABLED CHILDREN

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

C. Brainerd — 10/27/92
Charles J. Brainerd — Date

John E. Obrzut — 10/27/92
John E. Obrzut — Date

Darrell Sabers — 10/27/92
Darrell L. Sabers — Date

Date

Date

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copy of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

C. Brainerd — 11/17/92
Dissertation Director Charles J. Brainerd — Date

STATEMENT BY AUTHOR

This dissertation has been submitted in partial fulfillment of the requirements for an advanced degree at the University of Arizona and is deposited in the University Library to be made available to borrowers under the rules of the Library.

Brief quotations from this dissertation are allowed without special permission, provided that accurate acknowledgement of the source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the copyright holder.

SIGNED: Carolyn Patricia Lee

ACKNOWLEDGEMENTS

There are a number of people who were vital to the completion of this degree. My parents, Robert and Lauretta Lee, and my sister, Jeannette Lee, have encouraged me continually in my lengthy educational pursuits. I am particularly grateful to my mother, who fostered my academic aspirations. I am also indebted to Bruce Joseph for his support. Finally, I wish to acknowledge Karl Rosenquist, whose intellectual vigor ignited mine.

My advisor, Charles Brainerd, has provided me with a firm theoretical foundation, and has contributed valuable guidance in the completion of my dissertation. I appreciate the assistance of each of my dissertation committee members as well.

I am also grateful to the principals, teachers, and students in Sunnyside Unified School District, who participated so willingly in this project.

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

LIST OF TABLES

ABSTRACT

This study addressed the semantic memory processes of learning disabled (LD) and non-disabled children. The semantic memory deficits of LD students are familiar to most educators; however, the nature of these difficulties is not understood precisely. Some researchers propose that an early form of memory organization is association of items by frequency. These associative relations may be the precursors to taxonomic memory organization, thus may be weak in LD children. This study examined second and sixth grade children's free recall organization of two types of word lists: one in which items were associated by frequency and one in which items were related taxonomically; within each word list, half of the items were primary category members or frequency associates and half were secondary category members or frequency associates. It was hypothesized that younger, non-disabled children would rely more on frequency associations and that older, unimpaired subjects would tend to organize the material categorically. Learning disabled subjects were predicted to show impairments in the ability to form both frequency associations and categories during recall, particularly for the secondary items. These results were not found. Younger, non-disabled subjects organized words categorically as proficiently as their older peers, and LD children's

categorization abilities were comparable to non-disabled subjects'. The only item type for which LD subjects showed significantly less clustering than non-disabled subjects was secondary frequency associates, which were viewed as representing the periphery of the knowledge base. The principal difference between this study and previous, similar research was the use of individual, child-generated word lists. Because all words were highly familiar and meaningful to the children, relationships between most of the items were probably quite salient, more so than in other studies using adult-generated words as stimuli. Thus, this study indicates that LD children are not impaired in their ability to recognize and utilize semantic structure to facilitate learning if material is highly meaningful and familiar to them.

CHAPTER 1

INTRODUCTION

Memory is essential for personal, social, vocational, and academic functioning. Indeed, few tasks exist which do not involve memory processes in some way. For example, cooking, remembering names and addresses, performing job requirements, and academic demands all require the ability to store and retrieve information. Memory impairments interfere with many aspects of functioning. Learning disabled (LD) individuals experience difficulties in academic and social performance, many of which stem from memory deficits. Of particular relevance to educators and clinicians are the impairments in school functioning that result from memory weaknesses. Academic tasks at all levels require memory. The kindergartner must remember the alphabet and numbers, as well as common combinations of these such as his or her name and phone number. Memory demands multiply with each grade. By fifth grade, a student's memory must hold addition, subtraction, multiplication, and division facts and algorithms, names of presidents and explorers, important historic dates, and countless other pieces of information, including a vocabulary of over 28,000 words (Houck, 1984). Pupils must also retain rules for classroom and playground behavior, classmates' names, and school and classroom layouts.

Memory difficulties hinder acquisition of school and social knowledge. The memory deficits of LD children are well-documented in the literature (Johnson & Myklebust, 1967; Bauer, 1977; Sattler, 1990). Learning disabled children have been found to recall less information, underutilize organizational strategies, engage in less semantic processing, display less knowledge of their own memory processes, and use their limited capacity attentional resources ineffectively (Ceci, 1984). Researchers have proposed numerous causal factors in the memory difficulties of LD children; however, studies yield equivocal results. For example, some investigators have implicated automatic processing weaknesses in storage and retrieval (e.g., Ceci, 1984), while others suggest deficits in purposive or effortful memory processes (Bauer, 1977; Lorsbach & Gray, 1985). A similar dichotomy exists between storage and retrieval processes, with some researchers finding difficulties at the acquisition stage (Brainerd, Kingma, & Howe, 1986; Brown, 1988), while others posit weaknesses in retrieval (Israel, 1984). And yet few investigators have addressed the basis for these difficulties.

Acquisition of knowledge, whether automatic or effortful, is facilitated by some form of inherent organization or structure in memory, which allows new information to be stored in an orderly fashion.

Organization in memory also aids retrieval by providing search cues and interrelated networks of information (for example, Ackerman, 1985). Difficulties or weaknesses in memory organization may preclude acquisition and retrieval of information. Thus, it is imperative that memory structure be examined in LD children, for it underlies more general memorial and cognitive abilities.

Statement of the Problem

Semantic memory refers to the "organized knowledge a person possesses about words and other verbal symbols, their meaning and referents, about relations among them, and about rules for the manipulation of these symbols, concepts, and relations" (Kail & Nippold, 1984, p. 944). Semantic relations allow the child to structure and organize his/her world. Reasoning, comprehension, and inference all require "relation perception" (Baker, Ceci, & Herrmann, 1987). Traditionally semantic relationships in memory are studied through free recall experiments. Subjects learn lists of categorizable words presented in random order. Recall protocols are then examined to assess the degree of categorical clustering subjects impose on the items. Researchers have found numerous semantic memory deficits in LD children (Swanson, 1986). Thus, it appears that memory organization is impaired in many of these youngsters. However, the basis for this impairment is still not well understood. The development of semantic relations requires an understanding of basic relationships among items and information. These early relations have been examined in normal learners. Young children's associations are often based on frequency of items' co-occurrence in the lexicon or environment (Bjorklund, 1985). Frequency associations are studied using a free recall paradigm similar to that employed for semantic relation studies; the extent to which children recall items in clusters of frequency associates is assessed.

The precise connection between these early frequency associations and later semantic organization is not fully understood; however, Bjorklund (1985) proposes that young children's frequency and associative relations develop into later semantic organization. If early frequency-based associations do not develop, later weaknesses in semantic relationships may occur. Thus, exploring the relationship between frequency associations and semantic organization in normal learners is a worthwhile endeavor. Examining this connection in LD children is vital, for it may reveal early organizational deficits that precede semantic organizational difficulties.

Need for the Study

Currently memory research with LD children has focused on strategies for improving learning and performance, while basic questions about LD students' memories remain unanswered. Therefore, an in-depth investigation of these processes is required. A clearer understanding of the structure of LD children's memories may reveal basic weaknesses which require remediation before higher-order processes, such as effortful strategies, will prove effective. Additionally, knowledge about the precursors of semantic memory organization may aid educators in identifying potential learning problems at early ages, when they can be remediated most effectively so that they do not impede acquisition of more complex academic and social information.

Research Questions

This study will examine several issues related to memory structure in both normally achieving and LD children at two age levels. Specifically, research questions address:

1. The developmental precursors of categorical organization:
   a. Do frequency associations precede category relations in the development of children's semantic memory?
   b. Will younger children show a preference for clustering items associated by frequency, rather a

propensity to organize material by taxonomic structures?

2. Differences between LD and non-disabled children's clustering of frequency associates:
   a. Do younger LD children show fewer frequency associations in recall protocols than younger non-disabled children?
   b. Do older LD subjects show less clustering of items by frequency associations than older, non-LD counterparts?
3. The relationship between frequency associations and categorical organization:
   a. Do LD children who show deficient frequency associations also demonstrate impaired categorical organization, compared to non-disabled peers?
   b. Will older LD subjects who make fewer frequency associations also show less clustering of categorizable items?

Definitions

Because the following terms may be used in a variety of ways in other research, definitions pertaining to their use in this project are provided below.

<u>Learning Disability</u>: A general term that refers to a heterogeneous group of disorders manifested by significant

difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematics. These disorders are intrinsic to the individual, presumed due to central nervous system dysfunction, and may occur across the lifespan. They are not the result of other handicapping conditions (for example, sensory impairment, mental retardation, serious emotional disturbance) or extrinsic influences (such as cultural differences, insufficient or inappropriate instruction). (From NJCLD, 1988).

<u>Acquisition</u>: The initial encoding of material into long term memory, generally assessed by examining the subject's responses as he/she learns material. Failure to encode information at acquisition may cause detriments at retrieval.

<u>Retrieval</u>: The recall of previously stored or acquired information. Subjects bring information from long-term memory into conscious awareness, indicated by the subjects' articulating the stimulus in the experimenter's presence.

<u>Free Recall</u>: Experimental paradigm in which subjects are instructed to recall previously learned items in any order; no explicit structure is suggested.

<u>Cued Recall</u>: An experimental paradigm in which subjects are urged to recall information according to some predetermined scheme, such as recalling all the animals first, then all the furniture, etc.

<u>Semantic Memory</u>: Refers to the "organized knowledge a person possesses about words and other verbal symbols, their meanings and referents, about relations among them, and about rules...for the manipulation of these symbols, concepts, and relations." (Kail & Nippold, 1984, p. 944).

<u>Taxonomic Organization</u>: The process of organizing material according to a hierarchical structure, in which category members are grouped together by some higher order attribute. For example, cats, dogs, and horses are all members of the animal taxonomy.

<u>Frequency Association</u>: A relationship between items in memory based upon the items' frequent co-occurrence in the lexicon, environment, or individuals' experience. For example, chair/sit and king/crown may share a frequency association for many individuals by virtue to their common occurrence together in numerous contexts.

Learning to Criterion: Requiring that all subjects in an experiment learn a minimum amount of information before the acquisition session is terminated. For example, the experimenter may continue the activity until each subject can recall 90% of the material. When all subjects learn to criterion during acquisition, differences at recall cannot be attributed to differential rates of acquisition.

Primary Category Members: The first four items given by a subject when asked to provide category members during the word generation portion of the experiment. These items are assumed to be representative of the subject's immediate knowledge of the category since they are emitted in the first few positions.

Secondary Category Members: The last four items articulated by a subject when asked to list category members during the word generation sessions of the experiment. These items are assumed to represent more tenuous knowledge, since they are not among the first few provided by the subject.

Primary Frequency Associates: The first three items provided by the subject when asked to name "something that goes with ____" during the word generation session of the experiment. Because these responses are among the first few given, they are viewed as primary components of the subject's knowledge of items linked to the stimulus word.

Secondary Frequency Associates: The last three items given by the subject during the word generation sessions when instructed to name "something else that goes with ____." These responses are seen as representing secondary associations in the subject's knowledge base, since they are among the last provided for the stimulus word.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

It is necessary to understand the processes involved in semantic memory development in normal individuals before atypicalities can be examined. Thus, this review will begin with an overview of semantic memory development in non-disabled learners, including the paradigm typically employed to study these processes. Possible precursors to semantic memory will be described as well, particularly those which involve association by frequency. Additionally, the interaction between semantic memory and specific memory processes (storage and retrieval) will be examined. Next, semantic memory processes in learning disabled children will be discussed. Finally, proposed explanations for LD subjects' semantic memory difficulties will conclude the review.

Experimental Paradigm for Memory Research

Researchers in the field of memory development generally follow a standard procedure to study semantic relationships in memory. Subjects are given a list or lists of randomly presented words or pictures from several categories; for example, furniture, animals, and fruits. Subjects study each list, then complete a buffer activity, such as letter shadowing, to erase items from short term memory and ensure that retrieval from long term memory occurs. Subjects then recall as many of the items as possible. Intervals between study and recall range from 30 seconds to two weeks or longer. Either free recall or cued recall may be used. When free recall is used, the researcher carefully examines the protocols to determine the degree of categorical clustering which the subject has imposed on the items. In a cued recall experiment, the amount of words recalled from each category is the datum of interest.

Semantic Memory Development in Normal Individuals

In a brief review of very young children's performance on cognitive tasks, Ceci (1983) reports that they "have preferred processing the nonsemantic attributes of a stimulus," such as color, shape, and sound, relying more on perceptual information than broader taxonomic relations. However, some form of categorical organization appears quite early in life. Greco, Hayne, and Rovee-Collier (1990) reported that three-month-old infants categorized objects on the basis of physical appearance. Reznick and Kagan (1983) found that twelve-month-old infants seemed to possess categories based on perceptually available properties, functional qualities, and feeling states and affects shared by events.

Preschoolers appear to organize their knowledge on the basis of functional and complementary relationships. Smiley and Brown (1979) studied organization in preschoolers with sorting tasks. The children tended to create groupings based on complementary properties; however, they were capable of sorting taxonomically when encouraged to do so. When the subjects were seen the next day, even those who had formed taxonomic groups appeared to prefer complementary relationships.

Between the ages of six and nine, children apply a similarity criterion, relying on perceptual and functional "sameness," which includes taxonomic relations (Bjorklund & Muir, 1988). However, other varieties of functional relationships may be salient to the young child as well. Lucariello and Nelson (1985) propose that children may organize information into "scripts"-- events, activities, and items that commonly occur together in the individual's environment. A "lunch" script, for example, might include a grilled cheese sandwich, soup, milk, and cookies. It probably would not include coffee, toast, and cereal. Items that have the same function in a script are referred to as "slot fillers." Lucariello and Nelson (1985) found that children who were given slot-filler lists to learn performed significantly better than those given complementary or taxonomic lists.

In general, developmental research has traditionally shown three trends: clustering of items above chance appears early in childhood; clustering increases with age; the tendency of clustering to predict accuracy in recall does not appear until adolescence (Wachs & Gruen, 1971). However, caution must be applied in interpreting these broad findings. Taxonomy has been confounded with frequency associations; lists used for memorization typically contain high frequency associates, so distinguishing between clustering based on categories and organization stemming from utilizing frequency associations is difficult (Frankel & Rollins, 1985). Thus, the first of these traditional results is inaccurate.

Impetus for Change in Organizational Strategies

The shift from functional/complementary relations to taxonomic/semantic organization in memory is well-documented in the literature. However, few researchers have addressed the impetus for this change in organizational strategies. Bjorklund (1985) has proposed that the origins of taxonomic organization may lie in the young child's frequency associations. He reports that young children often recall material in clusters of items that frequently occur together in the environment or in the lexicon, such as dish/spoon or chair/sit. These frequency associations occur automatically in the child's memory; clustering at recall requires no conscious effort. As the child acquires more knowledge about the world and its relationships, he/she gradually reflects upon these associations and realizes that items are related on the basis of more taxonomic or semantic properties. With this illumination comes the preference for semantically-based organization.

The idea that frequency associations precede taxonomic organization has some support in the literature. Several older studies lend credence to this theory. Frequency associations or complementary relations appear to be a primary form of organization in human memory. Ghatala and Levin (1973) studied children's ability to make frequency judgments when presented with words and pictures repeatedly. Kindergartners, third, and sixth graders were asked to judge how many times each item had been seen. At all grade levels, judgments were quite accurate, although there was some improvement with age. However, this study shows that even young children are quite capable of making frequency judgments, thus may have the capacity to form frequency associations with relative ease. Lange (1978) reported similar findings; ratings of frequency associations between items showed little change from third graders to adults, again supporting the primacy of these associative relations in memory.

A study by Bjorklund and Jacobs (1985) demonstrates this propensity using free recall of word lists. Items from the lists lent themselves to both categorical and frequency associations. For example, one group of words was dog, cat, cow, lion, tiger. These items are all animals, sharing a taxonomic association. However, dog, cat and lion, tiger also commonly occur together in the environment, text, and the lexicon. At all age levels (grades 3, 5, 7, 9, and adult) subjects employed frequency associations in their responses, using these to facilitate recall. Although older subjects also showed clustering by taxonomies, associative relations were apparent as well. Bjorklund and Jacobs (1985) believed that adults employ frequency associations when these are a greater aid to recall than are more categorical relations.

When young children are asked to sort items into groups, a similar pattern is found. Bjorklund and deMarchena (1984), for example, asked first, fourth, and seventh grade students to sort pictures by meaning. Stimuli were chosen that could be organized on the basis of taxonomic structure (head, feet; hat, shoes) or relying on associative relations (head, hat; feet, shoes). First graders showed a preference for associative sorting, while seventh graders relied more on categories.

Frankel and Rollins (1985) found analogous results, studying the clustering of items at recall among kindergarten, fourth, and tenth grade subjects given pictures related by either category or associative relation. Kindergarten and fourth grade children's protocols were dominated by pairs of highly associated items, while tenth graders showed a tendency toward categorization of items based on taxonomic classifications. Thus it appears that associative relations are primary in young children's store of information.

Other experiments examine young children's clustering of items at recall as well as the effects of organization on recall performance. An early experiment by Denney and Ziobrowski (1972) involved first graders and college students learning two lists of words. One list consisted of pairs of words that shared complementary relationships, such as pipe/tobacco, while the other list's pairs were related by similarity relationships, such as king/ruler. The former may be viewed as frequency associations, while the latter list corresponds to more taxonomic relationships. First graders' protocols revealed more clustering with the complementary lists, while adults showed more clustering on the similarity or taxonomic lists. Lucariello and Nelson's (1985) study, discussed above, also demonstrates a preference for association of items by frequency;

preschoolers recalled and clustered items more when presented with lists created from slot-filler category members (items which are associated by frequently occurring together) than when lists were based on taxonomic or complementary relations.

While younger children appear to have a preference for grouping items associatively, recall is facilitated greatly when personal organization is encouraged. Numerous studies have shown that preschoolers tend to group items according to functional, thematic, or relational categories, while older subjects demonstrate more taxonomic classifications (Worden, 1976). Thus, it is not surprising that younger subjects benefit less from experimenter-imposed taxonomic list structure than do older counterparts; these categories may not match the youngsters' inherent knowledge base structures. Several researchers have examined personal organization effects on recall amount and clustering.

Worden (1976) asked second and fifth graders to make groups of "things that go together or that are alike," using 25 simple line drawings. The stimuli were selected so that they could be classified into two different category schemes, taxonomic or thematic. A second group of children of both ages was presented with the stimuli placed into five spatial clusters based on taxonomic categories. A third group was given the items in the thematic scheme. After a short term memory buffer activity, all children were asked to recall the pictures. Fifth graders recalled more items than second graders, and all subjects in the self-generated free-sorting condition recalled more items than did children in the taxonomic group. Free-sort subjects did not, however, differ in performance from thematic subjects. Subjects in the self-generated sorting group also showed significantly more clustering at output than did the children in the taxonomic group, while the thematic group did not differ from the free-sort group. Additionally, Worden found that second graders' free sorts tended to be thematically based, consistent with other studies.

A study by Lange and Jackson (1974) reveals similar results. First, fourth, seventh, tenth grade, and college subjects were asked to place 20 drawings into groups that "go together the best." After participants sorted the pictures, they were asked to recall the items verbally. At all age levels, the degree of personal clustering and recall was significant, with subjects making frequent reference to their own classification schemes during the free recall activity. Interestingly, Lange and Jackson's first grade subjects created as many class inclusion or taxonomically related groups in their sorts as did the older subjects, while older children and college students often relied on alternative criteria, such as contextual relations between the items. Thus, younger children were quite capable of spontaneously constructing taxonomic groupings, which appeared to strengthen their recall. While these results are consistent with the idea that personal organization aids recall and enhances clustering, they are somewhat contrary to findings supporting a preference for associative relations among younger children. However, there are several possible explanations for this difference. Lange and Jackson used only 12 subjects per cell, while Worden had 30 per age group. Thus, different sample sizes may have affected the findings, with Lange and Jackson's smaller sample size preventing delineation of strong organizational trends in the data. Additionally, philosophical differences in the educational systems used in each study may have contributed to the greater preponderance of taxonomic organization in Lange and Jackson's subjects. Finally, clustering was assessed using different methods in the two studies, so findings are not directly comparable. Despite these differences, it seems clear that personal organization of whatever sort does influence recall and clustering.

Thus, the literature shows a general progression from organization based on functional or associative relations to classifications relying more on taxonomic or semantic categories as children's cognitive development progresses. And yet the precise nature of this shift has not been clearly identified. It is also apparent that when experimenter-defined categories are used, children's own organizational structures may not be revealed.

Knowledge Base and Memory Processes

The literature describing memory development shows improvements in memory capacity and use of strategies to facilitate storage and recall with increasing age. In general, younger children recall fewer items and are less adept at recognizing and imposing organization on to-be-remembered material (Kobasigawa, 1974; Naus, Ornstein, & Kreshtool, 1977; Siegler, 1991). However, a small group of studies has shown that in special circumstances young children can recall as much or more information than older children or adults in memory experiments. When material to be learned is very familiar to children, they may demonstrate memory abilities superior to those of older subjects.

Chi (1978) asked both ten-year-olds and adults to study chess positions, then reconstruct them from memory. The children in this study were experts at chess, while the adult subjects were novices. The ten-year-olds outperformed the adults in the reconstruction task. However, when given a digit-span task, the adults remembered more. Thus, the children in this study did not possess exceptional memories for all information; their memory abilities were superior to adults' only when the material was extremely familiar to them and relatively unfamiliar to the older subjects.

Chechile and Richman (1982) examined memory improvements with age between kindergarten and second-grade subjects. However, the material to be learned varied in degree of meaningfulness. Prior experiments had allowed the researchers to assess stimulus meaningfulness; meaningfulness was measured by the mean number of associations children could provide for a target word. Words with more associates were considered more meaningful than words that triggered fewer associates. In the 1982 experiment, groups of children learned lists of items that varied in meaningfulness ratings. Kindergartners and second graders recalled the same number of items when lists were equated for meaningfulness. The second grade subjects given a list with a higher meaningfulness rating than the kindergarten subjects' list recalled more than their younger counterparts. Interestingly, the earlier experiment which elicited the meaningfulness ratings showed that words which obtained a low rating from kindergarten subjects often earned a high rating from second graders. Thus, identical words differed in meaningfulness for the two age groups. Yet when words were equally meaningful for younger and older subjects, recall differences were absent.

For some years educators have recognized the importance of utilizing children's background knowledge to improve learning. In general, when children learn material that contains familiar elements, they retain more information; when material consists of less well-known components, retention is weak. A study by Landis (1982) is typical of this literature. Second and fifth grade children listened to two short biographical passages; one was about a famous historical figure (such as Abraham Lincoln), while the other related the life of a fictitious person (such as Robert Baker). Half of the children heard the story of the famous individual; half heard the fictitious person's tale. One week later the subjects were given a sentence-recognition task in which they had to choose between story and nonstory items. Both second and fifth graders recalled more information about the famous character. In fact, the scores did not differ significantly between the grade levels. Thus, when a child's knowledge can be brought to bear on material to be learned, age differences in amount recalled diminish.

These studies indicate that age differences in memory ability may stem from inequities in subjects' store of knowledge. When asked to learn unfamiliar material, such as chess positions, even adults have some difficulty retaining information. Yet when material is familiar and meaningful, age differences are less obvious. When individuals are given the opportunity to encode a stimulus in a meaningful way, semantic associations are formed; these facilitate deeper encoding and more efficient recall (Walker & Poteet, 1989).

Most experiments reported in the developmental memory literature are based on material chosen by the researchers. Given the results discussed above, it is plausible that some age differences may be due to the material used, rather than to deficiencies or immaturity in young children's semantic memory abilities. Knowledge base develops as a child grows older (Siegler, 1991); when items to be learned are beyond the child's current realm of knowledge, difficulties in remembering are sure to occur. Thus, it is important that researchers consider children's knowledge and store of information when constructing memory tasks. When children are familiar with the material their memories may be similar to adults', just as adults' memories may be similar or inferior to children's when material is foreign to them (Chi, 1978).

Semantic Memory Development in Learning Disabled Children

Studies of memory in LD children generally fall into three categories: descriptive (comparisons of LD children and non-LD children's recall abilities); instructive (teaching LD children methods for enhancing their memory abilities); and theoretical (individual differences and methodological issues in the study of memory) (Cooney & Swanson, 1987). Extensive literature describes instructional research, detailing a variety of strategies that may improve recall of material in LD children. Yet specific processes in memory functioning are not well understood.

Semantic memory processes vary along several dimensions. Researchers distinguish between automatic and purposive processing. Automatic semantic processing "refers to the spontaneous and unconscious extraction of some aspects of a stimulus' meaning," while purposive semantic processing involves "conscious forms of analysis" (Ceci, 1984, p. 353). Some researchers have proposed that semantic memory difficulties in LD subjects are caused by failure to engage in automatic forms of processing. Learning disabled children may rely on more effortful processes that involve limited-capacity attentional resources. Studies of reading, for example, indicate that some LD subjects lack automatic reading skills, such as word recognition, and must aim their efforts at these activities, thus detracting from more effortful comprehension processes (Ceci, 1983). However, other researchers suggest that purposive semantic processes are impaired. For example, Bauer (1977) studied single-trial immediate and delayed free recall in LD and non-disabled nine- and ten-year-olds. With immediate recall of longer word lists, the LD group showed fewer primacy effects than the non-disabled group, but similar recency effects. In the delayed recall condition with longer lists, LD subjects had lower primacy and recency than non-disabled children. Bauer interpreted these findings to demonstrate that LD children show deficient rehearsal and/or storage in long-term memory, which implicates effortful processing.

Other studies provide further evidence for impaired purposive semantic processing in LD children, while automatic processes appear to remain intact. Ceci (1984) asked seven-, ten-, and thirteen-year-old LD and non-LD subjects to learn lists of 38 words. Four of the words per list were semantically related. Two of these items were presented contiguously, while the other two were not. The semantically related words that were spaced were less likely to be recalled by younger children and by all age levels of LD subjects than by the older non-disabled participants. Ceci interpreted these results to show that LD children's automatic semantic processing resembles that of non-disabled children, while their effortful processes are uniquely impaired.

Lorsbach and Gray (1985) also implicated effortful rehearsal processes as the site of impairment in LD subjects. Second and sixth grade disabled and non-disabled boys were given a false recognition task. To assess which attributes were encoded by the two age and ability groups, study and test items were manipulated to form visual, acoustic, and semantic distractors. Second graders and sixth grade LD children had more false recognitions when visual distractors were present, while sixth grade non-disabled children showed a shift in encoding preference and were more distracted by semantic items. Lorsbach and Gray suggest that these results indicate that LD subjects fail to use effortful semantic processing strategies, in this case elaborative rehearsal.

Investigations of semantic clustering provide further support for deficient purposive processing in LD children. Howe, O'Sullivan, Brainerd, and Kingma (1989) asked LD and non-disabled second and sixth grade students to memorize either categorizable or unrelated lists of words. Learning disabled subjects had considerable difficulty using implicit category structure to store and retrieve items, and did not improve in this ability with age. Older non-disabled children did show age improvements in utilizing categories to facilitate recall.

When LD subjects are given cues at recall, however, they perform like non-disabled students. Moe and Harris (1983) presented categorizable pictures to LD and non-disabled children. Pictures were shown either randomly or blocked by category. The subjects were also shown six category cue cards and told that they could look at them if it would help them to remember the stimuli. In this cued recall condition, LD and normal subjects' recall did not differ significantly. The LD children appeared quite capable of using semantic categorization when given cues. However, LD subjects who were shown the categorizable cards in random order without an external cue recalled significantly less than non-disabled children. This study supports a purposive processing deficit in LD children.

Wong, Wong, and Foth (1977) examined cued and free recall in LD and average achievers. Similar to Moe and Harris (1983), they found that both LD and non-disabled children showed the same degree of clustering and memory organization in a cued condition, while LD subjects clustered less in the uncued situation. The authors interpreted these findings as supportive of deficits in strategic processing skills in LD children.

Role of Knowledge Base in Memory of Learning Disabled Children

Weaknesses in purposive semantic processing may stem from deficiencies in knowledge bases of LD children. If children cannot recognize the relationships between words, they will not be capable of utilizing semantic processing strategies. There is strong evidence that semantic knowledge and organization develop from frequency associations and complementary relationships that the child holds in long-term memory. Bjorklund and Bernholtz (1986) studied the knowledge bases of good and poor readers at the junior high school level. The subjects were asked to rate items from twelve categories in terms of typicality. The researchers then created lists of words for each individual based upon the typicality ratings he/she gave. Two sets of findings were significant. First, poor readers chose fewer items as typical category exemplars than did good readers. Second, all children's recall was greater for typical than for atypical items, and poor readers recalled as many items as good readers in both cued and free recall conditions. However, poor readers remembered fewer words when adult-defined typicality ratings were used. This study suggests that LD children (poor readers) may possess different knowledge bases than normals; LD subjects' conceptual stores may be impoverished compared to non-disabled children's.

Israel (1984) reports several studies that indicate differences in the conceptual stores of LD and non-disabled children. When asked to make word associations, LD subjects responded with functional or perceptual items to a much greater extent than did non-disabled children. Normal learners tended to give paradigmatic, or categorical, responses. This may indicate that the LD child's knowledge base contains fewer, or weaker, categorical taxonomies.

Studies have not addressed the effects of meaningfulness of items on LD children's memory processes. However, since these youngsters appear to exhibit some deficiencies in knowledge base, it is possible that items to be remembered will be less meaningful to LD subjects, particularly when material is chosen by the researcher. A study by Schneider, Korkel, and Weinert (1989) examined memory differences between children with above-average and below-average IQs who had differing degrees of knowledge about the material to be remembered. The material was familiar and thus probably meaningful to some children, while unfamiliar and less meaningful to others. Subjects were given a story about a fictitious young soccer player and his adventures in one game. Subjects differed not only on IQ scores; they also possessed dissimilar degrees of knowledge about soccer. Four groups of children participated: above-average IQ and high soccer knowledge; above-average IQ and low soccer knowledge; below-average IQ and high soccer knowledge; below-average IQ and low soccer knowledge. When asked to recall information from the story, children with high soccer knowledge at both levels of IQ remembered more about the stories than children with low soccer knowledge at both IQ levels. General cognitive ability was not significant in recall performance; particular acquired knowledge was. Although the children in this experiment did not have specific learning disabilities, they did differ in ability as measured by an intelligence test. Therefore, it seems that general ability is less important in remembering some types of information than is the knowledge base into which the child can integrate the new material. Studies in which LD subjects learn material that corresponds to their own stores of knowledge are lacking and would, perhaps, be revealing.

Locus of Learning Disabled Subjects' Memory Difficulties

Learning disabled children's semantic memory difficulties appear to stem from weaknesses in purposive semantic processing, possibly caused by a knowledge base which differs both qualitatively and quantitatively from that of normal learners. Learning disabled children's decreased levels of spontaneous clustering and perhaps some of their difficulties in more conceptual learning tasks may be explained by this purposive processing impairment. However, it is also important to examine the locus of this difficulty. A distinction must be made between the acquisition and long-term retention, or forgetting, of information. During the initial encoding, or acquisition stage, storage and retrieval processes take place, typically within a brief period of time (a few minutes). Information must be stored and then retrieved to assess acquisition. Long-term retention addresses the degree of forgetting over a longer period of time, such as a day or a week. Memory deficits may occur within either stage of the acquisition process (storage or retrieval), or at long-term retention. The child may encode information with less semantic processing then have difficulty retrieving it due to an impoverished memory trace during acquisition. Or the information may be encoded adequately but becomes less available for retrieval due to insufficiencies in use of semantic processes at the later stage of long-term retention. Without an understanding of the locus of the deficits, successful remediation by educators cannot occur.

Many investigators in the field of learning disabilities fail to specify which process they are studying, so reported memory deficits are ambiguous. However, several researchers have examined acquisition versus long-term retention processes in LD children and have found that acquisition appears to be impaired, while long-term retention may be similar in LD and non-disabled subjects (Brainerd & Reyna, 1991). Learning disabled individuals appear to experience more weaknesses in long-term retention when lists of unrelated material are used; however, with categorized material, differences between LD and non-LD subjects diminish (Brainerd & Reyna, 1991; Brown, 1988). So if the LD child can acquire information initially, he/she can retrieve it successfully, apparently using semantic structure to facilitate recall. However, it appears that many LD subjects experience difficulty at the acquisition, or initial encoding, stage. Within this stage, either storage or retrieval may be to blame. Scant research exists that attempts to distinguish between these two processes in acquisition.

The few studies that have examined the storage and retrieval processes in LD and non-disabled children have generally shown that memory appears to be impaired primarily at storage in LD subjects. These studies rely on mathematical modeling to assess storage and retrieval processes. Brainerd, Kingma, and Howe (1986) studied storage and retrieval in both normal and LD children in grades two and six. Pictures and words were used as stimuli; subjects were asked to learn the items to criterion. For both types of stimuli, LD subjects had more difficulty storing the items than did non-disabled youngsters. However, once information had been stored, LD children were able to retrieve the items as efficiently as normal peers. Brown (1988) also addressed storage and retrieval processes in LD and non-disabled children. She found evidence that storage was impaired in LD children memorizing lists of categorized words, while retrieval was similar for LD and non-disabled subjects. Findings that implicate storage processes are not entirely consistent. One study has indicated greater differences in retrieval processes in LD subjects. Howe, O'Sullivan, Brainerd, and Kingma (1989) reported that LD children's difficulties were localized at retrieval rather than at storage. However, in a review of the extant literature on storage failure versus retrieval failure, Brainerd and Reyna (1991) conclude that the majority of studies indicate that retrieval abilities do not distinguish LD from non-disabled children. Within the acquisition process, storage failure appears to be the deficit in LD subjects.

Additional support for the storage failure hypothesis may be found in other studies of recall not specially designed to distinguish between storage and retrieval. Bauserman and Obrzut (1981) found that average readers retrieved more information from their long term memories, while disabled readers read more items from their short term stores. These results may indicate that disabled readers do not encode information as readily into their long term memories as non-disabled children do, pointing to acquisition processes as the site of failure.

Swanson (1983) also contributes evidence for storage difficulties in LD children. He attributed differences in recall among LD and normal readers to semantic encoding difficulties. When the LD subjects encoded information, they apparently failed to utilize available semantic properties of the stimuli that could facilitate storage processes.

Thus, the available literature supports the idea that LD children can retrieve information effectively if they can transfer items to their long-term memories. Indeed, semantic memory processes appear similar in LD and non-disabled subjects when long-term retention is assessed. However, studies indicate that disabled subjects have difficulty with the acquisition of taxonomic material, particularly at the storage stage. These results should implicate less purposive semantic processing at the initial study trial or acquisition phase. Yet very sparse research exists which explores the cause of these initial processing difficulties. A depressed knowledge base, such as that found by Bjorklund and Bernholtz (1986) and implicated by Israel (1984), may explain the encoding weaknesses of LD children. The semantic properties that tie varying stimuli together conceptually may be less salient to the LD child because his/her general store of semantic information is underdeveloped.

CHAPTER 3

METHODOLOGY

Method

The methodology used in gathering and analyzing the data will be described in this chapter, beginning with subject selection, materials, and procedures. Data analyses follow, with details of measures of clustering used, as well as descriptions of the statistical analyses.

Subjects

Sixty children from public elementary schools in the Tucson metropolitan area served as subjects in the experiment. Most children in the district come from lower- to lower-middle-income families. The district serves pupils from diverse linguistic and ethnic backgrounds, including Hispanic, Native American, African American, and White. To ameliorate the effects of language and cultural differences, teachers were asked to refer only those children who had never received bilingual or English-as-a-Second-Language (ESL) instruction; thus, all subjects were fluent speakers of English. Twenty five children were Hispanic, 33 were White, and 2 were African American. All subjects selected had intelligence scores within the average range, one standard deviation above or below the mean of 100 (between 85 and 115).

Once permission from the district's director of research was obtained, individual school principals were contacted and asked to participate in the study. Teachers were then asked to refer members of their classes who would suit the above criteria. All children identified by their teachers as possible subjects were given letters requesting parental permission to participate in the project. Those students for whom parental approval was secured served as the pool from which subjects were chosen according to the criteria discussed above and below. Subjects were selected from two grade levels and two ability levels.

Fifteen second grade children were chosen from regular classes; these subjects served as the non-disabled, younger group. Teachers were asked to choose only those children whose academic performance was average, with no significant past difficulties. Their ages ranged from 7 years, 6 months to 9 years, 0 months, with a mean of 8 years, 1 month. Seven females and 8 males comprised the non-disabled, younger group. All non-disabled children had recently completed the Iowa Tests of Basic Skills and teachers selected students whose performance on these measures fell within the average range. In order to control more stringently for effects of intelligence, all non-disabled second graders were given the Matrix Analogies Test (Naglieri, 1985), an essentially non-verbal measure designed to assess reasoning skills. Children were tested as a group in a quiet setting according to the test manual instructions. A standard score was obtained for each child then converted to a percentile; each percentile was then converted to a score equivalent to the scale used for the Wechsler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1974). Subjects whose scores were between 85 and 115 were then selected. No children had scores outside of this range. Intelligence scores for the non-disabled second grade children ranged from 87 to 111 with a mean of 97.7.

Fifteen LD second grade subjects were selected through referral from resource teachers. All of these children had been identified as learning disabled by a psychoeducational assessment indicating that they met the school district requirements for classification as learning disabled in the presence of average intelligence. Subjects' Full Scale scores on the WISC-R ranged from 85 to 108, with a mean of 92.0. The children's ages spanned 7 years 11 months to 8 years 11 months, with a mean of 8 years 5 months. Seven females and 8 males participated as the younger, LD group.

Recently researchers in the field of learning disabilities have voiced concerns about the heterogeneity of LD students. These children's deficits are not alike. Thus, many professionals suggest that subtypes of LD children be created to reflect this diversity (Kavale &

Forness, 1987; Keogh, 1987). When researchers use subjects broadly diagnosed as LD without describing their disability patterns, results may not generalize to other LD children with different clusters of deficits. Because this study addressed the conceptual deficits of LD children, all subjects showed evidence of conceptual weaknesses. Learning disabled subjects' files were examined for indicators of conceptually-based deficits. Specifically, scores on the Similarities subtest of the WISC-R were used to indicate conceptual weaknesses. The Similarities subtest assesses a child's ability to apply reasoning skills to discover the common properties or abstract categories that unite two different concepts (Kaufman, 1979). Additionally, the Similarities subtest requires semantic cognitive processing (Kaufman, 1979). Thus, difficulties completing this activity may implicate both conceptual and semantic processes. Initially subtest scores on the Woodcock Johnson Psychoeducational Battery-Revised (Woodcock & Johnson, 1989) were to be used to assess conceptual skills. Unfortunately, many learning disabled children in the district were not given this test. Testing differences led to little similarity among subjects' files. However, all children were given the WISC-R, so a score on the Similarities portion was available for each subject. Subtest scores three or more points below the mean of 10 indicate weaknesses (Kaufman, 1979). Therefore, all LD children selected had scores of 7 or lower on the Similarities subtest, with a range of 2 to 7 and a mean of 5.2.

Fifteen average-achieving sixth grade students served as the non-disabled, older group. Their ages ranged from 11 years 6 months to 13 years 2 months, with a mean age of 12 years 3 months. Seven females and eight males served as non-disabled, older subjects. Selection processes paralleled those described for younger, non-disabled subjects. Sixth grade, non-disabled children were also given the Matrix Analogies Test (Naglieri, 1985) and a score equivalent to the WISC-R was obtained for each subject. No potential subjects had scores below 85; however, two were above 115 and were thus disqualified. Selected subjects' intelligence scores ranged from 88 to 111 with a mean of 98.1.

Fifteen LD sixth grade subjects served as the older, disabled group. These children were selected according to the same criteria used for the younger, LD group. Their ages ranged from 12 years 1 month to 13 years 5 months. Three females and 12 males made up the older, LD group. It was not possible to match disabled and non-disabled sixth graders on sex; the middle school classes for LD children were comprised disproportionately of males. However, the ratio of males to females reflects the composition of the district's resource classes for learning disabled students. Additionally, past researchers have found no differences between male and female adolescent subjects on memory measures (Sattler, 1990). Participants' Full Scale WISC-R scores ranged from 86 to 109, with a mean of 95.2. Scores on the Similarities subtest of the WISC-R were 7 or lower for each child selected, ranging from 5 to 7 with a mean of 6.42.

Materials

Data were gathered in three sessions. Materials for the first session consisted of two types of probes: words associated by frequency (FA) and category prompts (CM). Probes were selected based on previous research examining frequency associations and categorization in children (Israel, 1984; Bjorklund & Thompson, 1983). These items were printed on a sheet, upon which the researcher recorded all children's responses. Complete lists of stimuli are found in Table 1. Materials for the second session were individual words printed on 3 X 5 inch cards in 1/2 inch black or dark blue letters. The different colors were a convention to allow the researcher to distinguish between frequency association and category member stimuli. Additionally, a letter shadowing sheet was presented as a buffer activity. This sheet contained printed letters in random order.

Procedures

Previous research has shown that children's word knowledge may not correspond to adults'. Thus, when researchers create lists with categorizable or complementary material, children may not take advantage of organizational strategies since adult norms do not always match those of individual children (Bjorklund & Bernholtz, 1986). Therefore, children in this study created their own lists so that the potential for personal organization would be maximized.

Children were seen in three sessions. During the first session, all subjects were asked to generate two word lists. One list consisted of words associated by frequency (FA). The researcher presented each subject with a stimulus word and asked that the child respond with another word that "goes with" the stimulus. An example is, "Tell me something that goes with teacher." Each child was asked to provide seven responses for each stimulus word; after the initial response, the researcher queried, "Tell me something else that goes with _____." Once it was clear that the child understood the task, verbal instruction was given only as needed. However, each new probe was introduced with the phrase "Tell me something that goes with _____." A total of 7 stimulus words was presented, with the subject providing 7 associates for each.

The second word listing task involved generation of category members (CM). Each subject was asked to name nine members of a category. An example is: "Tell me some pieces of furniture." Seven category probes were given; subjects gave nine responses for each.

Second grade disabled and non-disabled subjects completed the list generation tasks individually with the researcher. Each child was given the probes orally and was asked to give a verbal response. Responses were tape recorded and written by the experimenter. Sixth grade LD subjects completed the task in the same way. These three groups performed the activity orally so that reading and writing difficulties would not interfere. Sixth grade non-disabled subjects were given the task in writing as a group, as reading and spelling at this grade level are sufficient for completion of the activity. Additionally, presenting the task to the entire group was less disruptive for both students and teachers. The researcher introduced each stimulus word orally and in writing on an overhead projector; children's response forms contained only blanks for the response words so that subjects would not work ahead. The two classroom teachers and the researcher monitored subjects to be certain that they understood the task and completed it correctly. Half of the subjects were given the FA list generating task first, and half completed the CM list first.

From these individually created word lists, the researcher made two shorter lists for each subject to learn. One list contained items from the association task, or words associated by frequency of co-occurrence in the child's experience or lexicon. The initial three responses given for each stimulus were considered primary frequency associates (FA); the last three responses were secondary FA. The FA word list contained 16 words. Eight of these items were primary FA. For example, if a child responded to bird with fly, nest, eggs, babies, sky, tree and beak, one component of his/her word list would be bird, fly, nest, eggs. Each list contained two groups of primary FA words. The additional eight items were secondary FA. Two groups of these secondary associates comprised the remainder of the list. Using the above example, a secondary FA group would be bird, sky, tree, and beak. Each stimulus word was used only once, however. Thus, for bird only a primary or only a secondary set would be created.

The second word list contained category members. These were drawn from each child's own listing of category items. Primary category members (CM) were defined as those emitted first, second, third, or fourth by the child when given the stimulus; secondary CM were the final four responses. The list learned contained 16 words from four categories, with four category members for each. Two of these category sets contained primary CM, and two were composed of secondary CM. For example, if a child responded to the category prompt furniture with table, chair, sofa, desk, bed, dresser, bookcase, ottoman the primary CM would be table, chair, sofa, desk while the secondary CM would be bed, dresser, bookcase, ottoman. Each broad category was represented only once per list. For example, a subject's list might include members from the following four categories: furniture, animals, vegetables, and vehicles. Of these, two sets of members would represent primary CM, and two sets would be comprised of secondary CM.

Individual FA and CM lists were constructed by the researcher using the above procedures. Because each child generated more words than were used for acquisition, the frequency associated groups and the broad categories were selected randomly, except in cases where a child had not completed one of the lists. This occurred with several of the younger children, who were nearly reduced to tears by the word generating activity. Children seemed to have particular difficulty with the "vegetable" and "furniture" categories and the "friend" associate. For these few youngsters, the researcher required that six of the probes be completed for each list type. Thus, no subject was presented with all items he/she had provided.

Because acquisition appears to be the point of memory impairment in LD children (Brown, 1988; Howe, O'Sullivan, Brainerd, & Kingma, 1989), this was the focus of the study. Acquisition sessions took place approximately five to ten days after the list generating sessions. Each subject was seen individually in a quiet room. During the acquisition sessions, each subject learned his/her lists to a criterion of 100% correct. Subjects learned the FA list and the CM list in separate sessions in order to avoid fatigue and errors of intrusion. Half of the subjects learned the FA list first; half learned the CM list first.

The experimenter presented the subject with each item in pseudo-random order; no frequency associates or members of the same category were presented contiguously. Order of presentation was planned before the sessions to correspond to this pattern. Each item was printed on a 3 X 5 white card in 1/2 inch black or dark blue letters. In order to keep materials organized, a single set of cards was created for each child, with CM words on one side (printed in black) and FA words on the other side (printed in blue). The researcher read each word aloud, asked the child to say it, then allowed 15 seconds for study. After the subject had studied all words from the list, he/she completed a 60-

second letter shadowing buffer activity to erase items from short term memory. Then subjects were asked to recall the words orally; the order of recall was recorded by the researcher. Study-buffer-recall cycles continued until subjects achieved a criterion of 100% recall. Subjects learned the second list one to ten days later. Most children were seen two days later. A few were seen one or up to ten days later due to the occurrence of the district's spring break, planned school activities, and prolonged absences.

Table 1

Stimuli

Words Associated by Frequency	Categories
1. teacher	1. animals
2. street	2. vehicles
3. man	3. body parts
4. bird	4. clothing
5. star	5. vegetables
6. friend	6. furniture
7. pencil	7. musical instruments
(adapted from Israel, 1984)	(adapted from Bjorklund & Thompson, 1983)

Data Analysis

Measures of Clustering

Preliminary data analysis involved an examination of the degree of clustering imposed by each subject on each of the two lists (frequency associated and categorical) during the final trial of the acquisition session. Because all subjects learned lists to a criterion of 100% correct, examining clustering of items on the final trial, in which all items were recalled, mitigated the possible effects of differing memory abilities, which could have resulted in some subjects' recalling fewer items, thus apparently showing less clustering, on initial trials.

Researchers have used various methods to assess subjects' clustering of items at recall. Bousfield (1953) described a procedure termed the ratio of repetition (RR), which has been defined as "the fraction representing the number of repetitions of items divided by the total items listed" (Bousfield, 1953, page 234). A modified ratio of repetition (MRR) was developed by Bower, Lesgold, and Tieman (1969) and a clustering index (C) was discussed by Dalrymple-Alford (1970). Each of these measures represented modifications of the original ratio of repetition (Roenker, Thompson, & Brown, 1971). Other measures that examine degree of clustering relative to chance have also received attention in the literature (for example, Bousfield &

Bousfield, 1966; Dalrymple-Alford, 1970). However, because the purpose of the present study was to detect clustering based on underlying semantic relations, measures of chance clustering were not appropriate. Both C and MRR suffer from limitations as well. Roenker, Thompson, and Brown (1971) report that these measures create difficulties in ascertaining the relative amount of clustering, since the score representing chance clustering changes with the number of categories that the subject recalls. For the present study, this limitation was important; a measure was needed that would assess clustering even when category members/frequency associates were recalled with minimal structure.

Another measure of clustering widely used in the literature is the adjusted ratio of clustering (ARC), formulated by Roenker, Thompson, and Brown (1971) to overcome the difficulties discussed above. The ARC score represents "the proportion of actual category repetitions above chance to the total possible category repetitions above chance for any given recall protocol" (Roenker, Thompson, & Brown, 1971, page 46). The authors also note that the ARC score serves as an empirical measure of clustering and does not reflect the underlying organization mechanisms in free recall. Although numerous researchers have used ARC to assess subjects' clustering of items at recall, it was judged to be inappropriate in this study. In order to calculate an ARC score, a score reflecting the expected (chance) number of category repetitions is required (Roenker, Thompson, & Brown, 1971). This score, termed E(R), is calculated in part by using the total number of items recalled. In the present study, this was problematic. ARC was formulated to provide a measure of clustering of items on a single list; this experiment had, in essence, two sublists for each protocol, as well as four possible sets of clusterable items per main list. Therefore, ARC scores were not reflective of children's clustering.

Ratio of repetition (RR) scores were used as an alternative. For each protocol, a RR score was calculated for each of the four category or frequency associate blocks. Ratio of repetition scores were computed for the primary items as a group for each list (CM and FA), as well as for the secondary items as a group for each of the two lists. This yielded four RR scores for each subject: primary CM, secondary CM, primary FA, secondary FA. Ratio of repetition scores range from 0 to 1, with higher scores indicating more clustering.

Although sufficient to assess children's clustering, RR scores were insensitive to any clustering that did not occur contiguously. If a single item were interspersed between two members of a category or two frequency associates, the

RR score would reflect no clustering. Ratio of repetition scores treat all noncontiguous items as not clustered. However, children often inserted an item into a category or frequency associate block, then returned to the original category or associates, continuing on until the block was completed. Thus, it was necessary to create a measure that would reflect clustering more precisely, differentiating between a subject's recalling one category member, then a part of another category, then the other members of the original category, and a subject's recalling a category member, then a nonmember, a member, then a second nonmember, for example. The first example shows more clustering than the second example, and this difference was viewed as important in examining precisely the degree of clustering between the younger/older group and the LD/non-LD group.

The alternate measure of clustering created for this study was a set of distance scores. The order of recall was used to obtain a score for each category or frequency associate block. For each block of four items, the distances between each of the items was computed; this involved six subtractions: item 1 - item 2, item 1 - item 3, item 1 - item 4, item 2 - item 3, item 2 - item 4, item 3 - item 4. For each subtraction, a difference score was obtained and its absolute value was used. These scores were then converted to numerical values, ranging from 0 to 3. A distance score of 1 was given the value of 3; a distance score of 2 was given the value of 2; a distance score of 3 was given the value of 1; and all scores greater than 3 were given a value of 0. These were then squared to create all positive values. Squaring also served to weight items recalled closer together more heavily than items recalled farther apart (Table 2).

Table 2

Distance Score Conversions

Distance Score	Converted Value	Squared Score
1	3	9
2	2	4
3	1	1
>3	0	0

The squared scores were then added to yield one score for each block. These ranged from 0, reflecting no clustering, to 36, showing maximum clustering of all 4 items. This procedure provided 4 overall clustering scores for each subject: primary CM, secondary CM, primary FA, secondary FA. Thus, both ratio of repetition and distance scores were calculated, with parallel subsequent analyses conducted using each of the two sets of scores. The RR score was calculated to obtain a standard measure of clustering that could be compared with previous work by other researchers. The distance score was calculated to assess clustering more precisely and allow for sensitive comparisons within and between the groups.

Analyses of Covariance

Once distance scores and RR scores were computed to assess degree of clustering of items for each subject, a series of four-way ANCOVAs was run, using IQ score as the covariate. A 2 (grade: second/sixth) X 2 (group: LD/non-LD) X 2 (list type: CM/FA) X 2 (primary/secondary associates or category members) mixed factorial design was used, with two between (grade and group) and two within (list type and primary vs. secondary associates/category members) subjects variables. Age, group, list type, and primary/secondary associates/category members served as the independent variables; the RR or distance score as a measure of clustering of items was the dependent variable. Significance was assessed with a test-wise alpha of .05.

CHAPTER 4

RESULTS

Introduction

The first set of analyses performed on the data yielded scores reflecting the organization of children's recall protocols. Thus, ratio of repetition scores and distance scores are reported first. Analyses of covariance are detailed next, followed by a comparison of number of trials required to learn lists to criterion and correlations between clustering of the category and frequency lists. A discussion of the power of the experiment concludes this chapter.

Scores Reflecting Clustering

Before ANCOVA results are reported, subjects' clustering scores will be discussed in order to provide an overview of each group's performance. For each subject, both ratio of repetition (RR) and distance scores were calculated. Scores were then averaged across groups, providing RR and distance score means for second grade learning disabled children, sixth grade learning disabled children, second grade non-disabled subjects, sixth grade non-disabled subjects, and learning disabled subjects across grade levels. Additionally, both types of scores were computed for each list type (category members/frequency associates) and for each item level (primary/secondary).

Ratio of Repetition Scores

Ratio of repetition scores range from 0 to 1. The RR score mean for LD children's primary CM items across grade levels was .481; the score mean for non-LD subjects was .500. Ratio of repetition scores for secondary CM words were .481 for LD children and .414 for non-LD subjects. Ratio of repetition score means for primary FA items were .452 for LD children and .495 for non-disabled children. Secondary FA items had RR scores of .338 for LD subjects and .448 for non-LD subjects.

For primary category members (CM), second grade LD children's RR score mean was .457; second grade non-LD subjects' score mean was also .457. Sixth grade LD subjects' RR score mean for primary CM was .505, and non-LD sixth graders' score mean was .543. For secondary CM, RR score means were .429 for LD second graders, .400 for non-LD second grade subjects, .533 for LD sixth grade children, and .429 for non-LD sixth grade subjects.

Primary frequency associates' RR score means were .400 for LD second graders, .429 for non-LD second graders, .505 for LD sixth grade subjects, and .562 for non-LD sixth grade students. Secondary FA RR score means were .305 for LD second graders, .371 for non-LD second graders, .371 for LD sixth grade children, and .524 for non-LD sixth grade subjects (Table 3).

Thus, in examining the RR scores, a trend for all groups to show moderate clustering is evident. Ratio of repetition scores range from 0 to 1.0; the groups' scores ranged from .305 to .562. Neither very low clustering nor near-perfect clustering were the norm according to the groups' RR score means.

Distance Scores

Distance scores range from 0 to 36. Learning disabled children's primary CM distance score mean was 19.250 and non-disabled children's was 20.183. For secondary CM items, LD children's score mean was 18.733, while non-disabled subjects' score was 16.500. Primary FA distance scores were 18.517 for LD subjects and 19.217 for non-LD children. Secondary FA distance score means were 14.167 for LD subjects and 17.883 for non-disabled students.

Primary CM distance score means were 18.633 for LD second grade subjects, 18.133 for non-LD second graders, 19.866 for LD sixth graders, and 22.230 for non-LD sixth grade subjects. Secondary CM distance score means were 15.966 for LD second grade children, 15.566 for non-LD second grade subjects, 21.00 for LD sixth graders, and 17.433 for sixth grade non-LD subjects. Primary FA distance score means were 16.10 for LD second grade subjects, 16.933 for non-LD second graders, 20.933 for LD sixth graders, and

21.500 for non-LD sixth grade subjects. Distance score means for secondary FA were 13.433 for LD second grade subjects, 15.100 for non-LD second graders, 14.900 for LD sixth grade children, and 20.666 for non-LD sixth graders (Table 4).

When distance score means for the groups are considered, a trend for moderate clustering is seen, similar to that found for the RR scores. Distance scores range from 0 to 36; the means for the groups ranged from 13.433 to 22.230. None of the groups showed extremely low clustering, and none demonstrated a trend for perfect clustering.

Table 3

Ratio of Repetition Score Means

Grade	Group	List type	RR score mean
all	LD	CM (P)*	.481
all	NLD	CM (P)	.500
all	LD	CM (S)*	.481
all	NLD	CM (S)	.414
all	LD	FA (P)	.452
all	NLD	FA (P)	.495
all	LD	FA (S)	.338
all	NLD	FA (S)	.448
2	LD	CM (P)	.457
2	NLD	CM (P)	.457
6	LD	CM (P)	.505
6	NLD	CM (P)	.543
2	LD	CM (S)	.423
2	NLD	CM (S)	.400
6	LD	CM (S)	.533
6	NLD	CM (S)	.429
2	LD	FA (P)	.400
2	NLD	FA (P)	.429
6	LD	FA (P)	.504
6	NLD	FA (P)	.562
2	LD	FA (S)	.305
2	NLD	FA (S)	.371
6	LD	FA (S)	.371
6	NLD	FA (S)	.524

* (P) denotes primary items (S) denotes secondary items

Table 4

Distance Score Means

Grade	Group	List type	Distance score mean
all	LD	CM (P)	19.250
all	NLD	CM (P)	20.183
all	LD	CM (S)	18.733
all	NLD	CM (S)	16.500
all	LD	FA (P)	18.517
all	NLD	FA (P)	19.217
all	LD	FA (S)	14.167
all	NLD	FA (S)	17.883
2	LD	CM (P)	18.633
2	NLD	CM (P)	18.133
6	LD	CM (P)	19.866
6	NLD	CM (P)	22.230
2	LD	CM (S)	15.966
2	NLD	CM (S)	15.566
6	LD	CM (S)	21.00
6	NLD	CM (S)	17.433
2	LD	FA (P)	16.10
2	NLD	FA (P)	16.933
6	LD	FA (P)	20.933
6	NLD	FA (P)	21.50
2	LD	FA (S)	13.433
2	NLD	FA (S)	15.100
6	LD	FA (S)	14.900
6	NLD	FA (S)	20.666

Analyses of Covariance

Parallel analyses of covariance (ANCOVAs) were run using both RR and distance scores as the dependent variable in order to compare the two measures and corroborate findings. Separate ANCOVAs were run for each list type (CM/FA) at each level of meaningfulness (primary/secondary), for a total of 4 ANCOVAs: primary CM, secondary CM, primary FA, and secondary FA. The ANCOVAs using RR scores as the dependent variable will be discussed first.

ANCOVAs Using Ratio of Repetition Scores

Ratio of repetition scores are based on the total number of words recalled, less one, divided by the number of intracategory repetitions observed. These were computed to provide scores that could be compared to those obtained in other similar studies. With RR score as the dependent variable, for primary CM, there were no significant main effects for IQ, grade, or group; the grade X group interaction was not significant. For secondary CM, no significant main effects for any of the variables were present either. For primary FA, a main effect for grade was found, $\underline{F}(1, 55) = 5.33$, $\underline{p} < .05$. For secondary FA, grade, $\underline{F}(1, 55) = 6.58$, $\underline{p} < .05$; and group, $\underline{F}(1, 55) = 7.11$, $\underline{p} < .05$, main effects were found. The covariate, IQ, was not significant in any of the analyses. Thus, between subjects, grade was significant for primary and secondary FA items and group was significant for secondary FA items alone (Table 5). Within-subjects factors were examined with a repeated measures analysis of variance. Significance was found for primary versus secondary items $F(1, 55) = 9.32$, $p < .05$; list type was not significant (Table 6).

ANCOVAs Using Distance Scores

Distance scores are based on the number of items interspersed between category members or frequency associates and provide a sensitive measure of both contiguous and non-contiguous clustering. The ANCOVAs using distance scores as the dependent variable showed similar results to those obtained using RR scores. For the primary CM, there were no significant main effects or interactions. For the secondary CM, a main effect for grade was found, $F(1, 55) = 4.70$, $p < .05$. When primary FA distance scores were the dependent variable, grade was again significant, $F(1, 55) = 5.69$, $p < .05$. For secondary FA, both grade, $F(1, 55) = 4.18$. $p < .05$; and group, $F(1, 55) = 5.16$, $p < .05$, main effects were found. The covariate, IQ, was not significant in any analysis, nor was the grade X group interaction (Table 7). A repeated measures ANOVA showed significance for the within-subjects factor of primary versus secondary items $F(1, 55) = 9.61$, $p < .05$ (Table 8).

Table 5

ANCOVAs Using Ratio of Repetition Scores (Between Subjects)

Dependent Variable: Primary Category Members

Source	DF	Mean Square	F
IQ	1	0.00	0.03
Grade	1	0.07	1.90
Group	1	0.01	0.16
Grade X Group	1	0.01	0.15
Error	55	0.03	

Dependent Variable: Secondary Category Members

Source	DF	Mean Square	F
IQ	1	0.01	0.44
Grade	1	0.07	2.48
Group	1	0.05	1.71
Grade X Group	1	0.02	0.81
Error	55	0.03	

Dependent Variable: Primary Frequency Associates

Source	DF	Mean Square	F
IQ	1	0.10	3.02
Grade	1	0.18	5.33*
Group	1	0.01	0.26
Grade X Group	1	0.01	0.18
Error	55	0.03	

*$p < .05$

Dependent Variable: Secondary Frequency Associates

Source	DF	Mean Square	F
IQ	1	0.00	0.18
Grade	1	0.18	6.58*
Group	1	0.19	7.11*
Grade X Group	1	0.02	0.92
Error	55	0.03	

* $p < .05$

Table 6

Repeated Measures ANOVA Using RR Score (Within Subjects)

Source	DF	Mean Square	F
List Type	1	0.10	1.76
Error	55	0.04	
Prim./Second.	1	0.31	9.32**
Error	55	0.03	
List Typ X Prm/Sec	1	0.03	1.06
Error	55	0.02	

**$p < .01$

Table 7

ANCOVAs Using Distance Scores (Between Subjects)

Dependent Variable: Primary Category Members

Source	DF	Mean Square	F
IQ	1	2.95	0.05
Grade	1	112.22	2.04
Group	1	21.31	0.39
Grade X Group	1	26.81	0.49
Error	55	55.04	

Dependent Variable: Secondary Category Members

Source	DF	Mean Square	F
IQ	1	0.18	0.00
Grade	1	209.47	4.70*
Group	1	70.65	1.59
Grade X Group	1	50.39	1.13
Error	55	44.53	

*$p < .05$

Table 7--CONTINUED

Dependent Variable: Primary Frequency Associates

Source	DF	Mean Square	F
IQ	1	97.64	1.88
Grade	1	295.36	5.69*
Group	1	0.29	0.01
Grade X Group	1	0.04	0.00
Error	55	51.87	

*$p < .05$

Dependent Variable: Secondary Frequency Associates

Source	DF	Mean Square	F
IQ	1	1.80	0.04
Grade	1	183.75	4.18*
Group	1	226.73	5.16*
Grade X Group	1	56.93	1.29
Error	55	43.98	

*$p < .05$

Table 8

Repeated Measures ANOVA Using Distance Score (Within Subjects)

Source	DF	Mean Square	F
List Type	1	89.43	1.45
Error	55	61.67	
Prim./Second.	1	366.30	9.61**
Error	55	38.11	
Lst Typ X Prim/Sec	1	8.25	0.22
Error	55	37.80	

**$p < .01$

Additional Analyses

In order to study acquisition processes in LD and non-disabled subjects, the number of trials required to learn items to a 100% criterion was examined. Average number of trials to criterion was computed for each of the grade levels and groups, and a series of ANCOVAs was run using number of trials as the dependent variable.

In learning CM items, learning disabled children required a mean of 4.233 trials, and non-disabled youngsters' mean was 4.133. Frequency association lists were learned in 4.567 trials by LD children, and in 4.40 trials by non-disabled children. Thus, second grade children as a whole learned both of their lists slower than sixth graders, and LD subjects learned both lists slightly slower than non-disabled children.

Second grade LD subjects' average trials to criterion for CM lists was 4.933; non-LD second graders' mean was 4.40. Sixth grade LD subjects learned CM lists in 3.533 trials, while non-LD sixth graders required 3.867 trials. For the FA lists, LD second grade children's mean was 5.20 and non-LD subjects' mean was 4.467. Sixth grade LD subjects learned FA lists in 3.933 trials; non-LD sixth graders' mean was 4.333. For CM lists, therefore, second grade LD children learned more slowly than non-disabled agemates, while sixth grade LD subjects learned more quickly than non-LD sixth grade children. The same was true for FA lists; second grade LD students required more trials to criterion overall than non-disabled counterparts, while sixth grade LD children learned lists more rapidly than non-LD subjects (Table 9).

Table 9

Average Number of Trials to Criterion

Grade	Group	List type	Average Number of Trials
all	LD	CM	4.233
all	NLD	CM	4.133
all	LD	FA	4.567
all	NLD	FA	4.400
2	LD	CM	4.933
2	NLD	CM	4.400
6	LD	CM	3.533
6	NLD	CM	3.867
2	LD	FA	5.200
2	NLD	FA	4.467
6	LD	FA	3.933
6	NLD	FA	4.333

The significance of these findings was assessed through a series of ANCOVAs, using trials to criterion as the dependent variable. A three-way ANCOVA was performed for each list type, using a 2 (CM/FA list) X 2 (second/sixth grade) X 2 (LD/non-LD) design, with IQ as the covariate.

For CM lists, main effects were found for IQ, $F(1, 55) = 6.67$, $p < .05$; and grade, $F(1, 55) = 21.44$, $p < .05$; and a grade X group interaction, $F(1, 55) = 4.05$, $p < .05$, was present. For the FA lists, grade, $F(1, 55) = 6.85$, $p < .05$; and grade X group, $F(1, 55) = 4.62$, $p < .05$, were significant. Group alone was not significant in either analysis (Table 10).

An additional analysis was completed to examine the relationship between clustering of CM and FA items. Pearson r correlations were obtained for each group and grade level combination by using distance score means for the CM and FA lists. Significance of each correlation was assessed at the .05 level. One correlation was significant: Second grade LD children's scores revealed a relationship between clustering of CM and FA items ($r = .518$, $p <. 05$). The other correlations were not significant at the .05 level, nor was the correlation for CM and FA clustering, averaged across all grades and groups (Table 11).

Table 10

ANCOVAs for Trials to Criterion

Dependent Variable: Trials to Criterion for CM Lists

Source	DF	Mean Square	F
IQ	1	3.90	6.67*
Grade	1	12.54	21.44*
Group	1	0.00	0.00
Grade X Group	1	2.37	4.05*
Error	55	0.58	

*p < .05

Dependent Variable: Trials to Criterion for FA Lists

Source	DF	Mean Square	F
IQ	1	3.24	3.49
Grade	1	6.36	6.85*
Group	1	0.06	0.06
Grade X Group	1	4.29	4.62*
Error	55	0.93	

*p < .05

Table 11

Pearson R for Clustering of CM and FA Items at Recall (Distance Score as a Measure of Clustering)

Grade	Group	Pearson r	Significance (P < .05)
2	LD	0.51842	0.0477*
2	NLD	-0.06650	0.8138
6	LD	-0.29751	0.2815
6	NLD	-0.24593	0.3769
all	LD	0.16300	0.3894
all	NLD	-0.02099	0.9123
all	all	0.06093	0.6438

Power of the Experiment

Past studies of children's organization of word lists have often used a larger subject pool and/or a greater number of words for memorization than the present experiment did. Power of statistical tests increases with larger sample sizes (Keppel & Zedeck, 1989). Thus, previous studies might be viewed as more powerful statistically due to their abundant sample sizes. However, increased number of observations also enhances statistical power (Keppel & Zedeck, 1989). Because much previous work employed single-trial recall designs, the number of observations was relatively constrained. The present study, although using only 60 subjects, used multiple observations by requiring each subject to learn lists to criterion, which involved numerous trials. Power may be assessed by examining the total number of observations made during the experiment. Observations may be viewed as individual data points. Number of data points can be calculated by multiplying the number of subjects by the number of words per list by the number of trials (observations). More data points indicate more observations. When compared to previous similar studies, the present experiment has a greater number of data points. For example, a study by Bjorklund and Jacobs (1985) assessed 60 children's organization of a list of 24 categorizable words on a single trial. This produced 1,440 data points. Bjorklund and Bernholtz's (1986) study of poor readers had 120 subjects and 20 words, with one trial, for 2,400 data points. The present study had 60 subjects, 32 words (16 per list), and an average of 8 trials per subject, which created 15,360 data points (Table 12). Thus, this study has more observations and greater statistical power than previous similar works.

Table 12

Number of Data Points in Previous and Current Studies

Study	Subjects	Trials	Words	Data Points
Bjorklund & Bernholtz (1986)	120	1	20	2,400
Bjorklund & Jacobs (1985)	60	1	24	1,440
Lee (1992)	60	8	32	15,360

CHAPTER 5

DISCUSSION

Introduction

Many of the findings in this study were contrary to those of previous works. Learning disabled children performed similarly to non-disabled peers in several areas. Younger subjects' performances were somewhat unexpected as well; their conceptual abilities appear more mature than they have in other studies. A discussion of younger and older, non-disabled children's performance begins the discussion, followed by an examination of LD subjects' patterns. Findings and possible explanations will be integrated into previous studies and well-established theory. Qualitative observations made during the word generation and acquisition sessions follow, as the children's comments and information regarding the school programs may provide further insights into their performances. A comparison of the findings of this study and those of previous, similar words will then be made. Next a brief comparison of RR and distance scores is made. The relevance of the study's findings to educators will then be examined. Limitations of the study follow. Finally, areas for future research conclude the dissertation.

Children's Clustering of Words at Recall

Younger Versus Older Children

Previous research has shown a general developmental trend in organization of children's memories. Younger children have been found to impose less semantic structure on words as they recall them, showing little organization of categorizable items. However, when asked to learn material associated by frequency, youngsters appear to recall items by activating these relations automatically in memory (Bjorklund, 1989). Thus, it was expected that the non-disabled second grade children in this study would show more clustering of the frequency association items than the categorizable material. This was not the case, however. An inspection of Tables 3 and 4 shows that second grade children had the highest RR and distance scores for the primary category members (CM). Both RR and distance scores reveal somewhat more clustering of primary FA items than secondary CM items, which corresponds more closely to results of previous research. The second graders' lowest RR and distance scores are found for the secondary FA items. If young children do have a propensity for clustering material according to frequency associations, all levels of frequency associates should show more clustering than comparable category member words. The younger children in this study clustered category members, not frequency associates, the most.

Sixth grade, non-disabled subjects were expected to show a preference for grouping items by category structure. Interestingly, at this grade level, the highest RR clustering scores are found for primary FA items, with primary CM, secondary FA, and secondary CM scores ranking second, third, and fourth, respectively, for degree of clustering. A similar pattern is found for distance scores, although primary CM show the most clustering with this measure, with primary FA next, secondary FA and secondary CM last (Tables 3 and 4).

The significance of these clustering scores was assessed through a series of ANCOVAs. When RR scores were used, for both the primary and secondary CM items, grade was not significant; younger children's clustering of these items did not differ significantly from older children's. When distance scores were used in the analyses, grade was significant for secondary CM words but not for primary CM words. Thus, second and sixth grade subjects' clustering of primary CM items was quite similar; younger children's clustering of primary categorizable words was not inferior to older children's, as previous work would suggest.
With secondary CM items, grade was significant when distance scores were used. As discussed below, distance scores

appear to provide a more sensitive measure of clustering. With this increase in precision, a difference between younger and older subjects appears: With less salient, secondary CM items, second graders show a significant difference compared to sixth graders in their degree of clustering.

When FA items were assessed for differences in clustering between the younger and older children, grade was significant for both primary and secondary FA words, using both RR and distance scores. Thus, for words associated by frequency, second graders show less clustering than sixth graders. Younger children do not display a preference for clustering items associated by frequency.

In this study, it appears that younger children have a propensity to cluster items taxonomically. Second graders' highest clustering score means were found for primary CM words. As predicted by previous studies, younger children show more organization of primary words than secondary words; when distance scores are examined, second graders' highest scores are seen for primary CM and primary FA items. Between-subjects repeated measures analyses of variance show this difference too; significance was found for primary versus secondary items. Examining the means, lowest scores are associated with secondary items.

Therefore, for non-disabled children, the following pattern emerges: Younger children show the highest clustering of primary, taxonomically related items; older children's maximum clustering is found for primary, frequency associated items with RR scores, and primary CM words when the more sensitive distance scores are used. All non-disabled children showed the most clustering of primary items and the least clustering of secondary items.

An examination of the average trials to criterion provides further support for the idea that younger children activate categorical relations in memory more easily than frequency relations. Non-disabled second graders learned the CM lists more quickly than the FA lists (Table 9). Category member items were clustered more at recall and were learned in fewer trials than FA items. Older subjects also learned CM items more rapidly than FA items (Table 9), though showed similar clustering of frequency associates and category members. For younger children it seems that organization enhances memory, while older subjects' organization and recall abilities appear less well-connected in this study.

An initial hypothesis of this study was that there would be a relationship between clustering of FA and CM items. For non-disabled children, this was not the case. The Pearson r analyses revealed no significant relationships between cluster measures of FA and CM words for the non-disabled subjects. Thus it appears that children's ability to impose organization upon one type of items is not specifically linked to their capacity to organize others. It seems that younger children's clustering of FA items is not related to their clustering of categorizable items, as was proposed initially.

The results of this study do not confirm the idea that taxonomic relationships develop from frequency associations in young children's memories, or that frequency associations are an earlier form of memory organization than taxonomies. Indeed, this seems almost opposite to the findings revealed here. Younger children organized categorizable items more than frequency associates, and older children clustered frequency associates similarly to categorizable items. There are several possible explanations for these unexpected findings.

The major difference between this study and previous similar works is the selection of items for the children to learn. Most earlier studies used stimuli from published norms. This project allowed children to provide their own items, which meant that each subject's words were highly familiar to him/her. By using words from published norms, previous researchers may have decreased the meaningfulness of the items for the subjects. Children's category knowledge differs from adults' (Bjorklund, Thompson, & Ornstein, 1983). Additionally, within a single category items may vary in terms of typicality or representativeness (Rosch, 1973). Differences in item typicality have been found to influence adults' performance on category member verification tasks (Rosch, 1973). Thus, meaningfulness or typicality of items affects subjects' cognitive manipulation of them during memory tasks. If items are not meaningful or perceived as typical, memory performance is sure to suffer.

The importance of geographical location, sociocultural context, and current environmental milieu will be discussed; children's word generation responses appeared heavily influenced by these factors. It is unlikely that published norms would include "javelina" in the animal category, but for children living in the Sonoran Desert this creature is commonplace, perhaps more so than a chipmunk or a badger, for example. Yet the latter two animals would appear in traditional adult norm lists, while the javelina would not (Thorndike & Lorge, 1944). Because children in this study were allowed to complete the categories with their own knowledge, it is likely that categorical structure was highly salient. In other words, children clearly recognized all the items as typical, meaningful members of a specific category.

Researchers have shown that when items are equally meaningful younger children can recall as many as older children (Chechile & Richman, 1982). Perhaps, with highly meaningful material, younger subjects can organize as well as older subjects too. Thus, one explanation of second graders' superior clustering of categorizable items is that the items were very meaningful and category structure was readily evident. Previous works relying on stimuli chosen by the researchers may have used items not easily recognized by young subjects as belonging to specific categories, which therefore were organized less at recall.

Two other possible explanations for these unexpected findings center on the nature of the word generation tasks. As discussed in the qualitative section, many children remembered the word generation session as they attempted to learn the words. Because specific category names were given to them during the earlier task, it is possible that these served as an organizing or cuing device. Smiley and Brown (1979) showed that even preschoolers can organize items taxonomically when asked to do so, but seem to have a preference for more associative relations. Perhaps in some way second grade children used the previously given category labels as a cue. As they attempted to recall the words during the acquisition sessions, they may have remembered that certain items were said initially in response to a cue;

for example, in remembering "chair" a child might recall that he/she gave this response when asked several days earlier for some furniture items, then use "furniture" as a cue to retrieve further items. However, this does not explain why sixth graders should cluster frequency associates similarly to category members at recall. Much previous work supports the idea that use of more taxonomic strategies prevails by early adolescence. Why, then, should older subjects fail to show a distinct preference for clustering category members? If second graders were able to use previously given category cues, it is plausible that sixth graders should have this capacity too. And yet older children did not appear to use category structure as readily as younger subjects. Perhaps another aspect of the task itself can provide an explanation.

The ANCOVAs (using distance scores) showed effects for age for secondary CM, primary FA, and secondary FA items. There were no age effects for primary CM items. Children's general difficulty in generating frequency associates will be discussed below. The nature of that particular task seemed confusing to many students. Often a child would give one or two associates and then have some trouble continuing on. This hesitation was noted for both grade levels, though younger children appeared to have the most difficulty. Such a task seemed unfamiliar to many subjects. Perhaps the instructions given were not sufficient to activate associates in children's memories. Thus, many of the words generated may have been relatively devoid of meaning in relation to the stimulus word. If this were the case, frequency associates as a whole might be viewed as less meaningful than category members, particularly for younger subjects. Most children completed the category lists, especially the first few items, without difficulty. Thus, the category items might have been more salient than the frequency associates. Since there were no significant age differences in clustering of primary CM items, it seems that these first few words were meaningful to all children. However, clustering of secondary CM and all FA items led to a significant grade effect. Thus, these items might be seen as less meaningful than primary CM words for younger children. Meaningfulness of the items would therefore be central to this explanation as well as to the previous one.

A final possible explanation for the younger children's increased clustering of CM words might view these items as associated by frequency in addition to their taxonomic bonds. For example, peas and carrots are both members of the vegetable category, and may also share an association by their frequent co-occurrence in boxes of frozen vegetables. A child might recall them together because he/she associates them closely, rather than by virtue of their shared categorical attributes. If this were the case, younger children's increased clustering of CM words could simply be interpreted as an alternative form of frequency association. Indeed, many children's category words might be associates of each other, such as cat/dog, shirt/pants, or hand/finger. There is a difficulty with this hypothesis: While some category members might share an association by frequency, not all do. A few examples from children's recall protocols may clarify this point. One non-LD second grader recalled the following items contiguously during her CM acquisition session: goat, elephant; computer, cushions. The first two were from her "animal" word list, and the last two came from the "furniture" category. Another non-disabled second grader's recall protocol included ferret, dog; ankle, arm for the "animal" and "body part" categories, respectively. While these pairs of items share membership in a single category, they do not appear closely associated by frequency. Sixth grade, non-disabled children also recalled category members contiguously that show no overt frequency associations, such as chipmunk/anteater and feet/neck. Certainly children of all ages did often recall items together that could be frequency associates, such as chair, desk; lion, tiger; pants, shirt. However, such possible associates were not exclusive to the children's protocols. Indeed, such obvious associates as cat/dog or leg/ankle were not always recalled in pairs. Thus, the idea that many category members were recalled as frequency associates is not entirely borne out by the data.

Summary

In summary, younger children in this study showed the most clustering of categorical items, while older subjects clustered frequency associates and category members similarly. This is contrary to findings of previous works. Although several explanations for these results are possible, the most likely seems to relate to the meaningfulness of the items. Category members were probably quite meaningful to younger children; they generated them with greater ease than the frequency associates. Age differences were found for only secondary CM items, and for all FA items. This may be interpreted to show that secondary CM and all FA items were less salient to the younger children, thus were clustered less readily at recall. If primary CM items were highly meaningful, they should show the highest degree of clustering for the second grade children. Indeed they do (Tables 3 and 4). Sixth graders' most meaningful items appear to be the primary frequency associates when RR scores are used, and primary CM with distance scores; these items may not differ much in meaningfulness (Tables 3 and 4). Perhaps for non-disabled children, regardless of age, meaningfulness is the key to memory organization, rather than specific category or associative structure. While certain items will share membership in categories or associations by frequency, meaningfulness seems to superimpose itself and predominate as the bond which connects items in memory. The results of this study do not conclusively answer the question of primacy of frequency associations or categories in memory. However, they do affirm that meaningful items are more amenable to cognitive processing.

Learning Disabled Versus Non-disabled Children

The central hypothesis of this study was that learning disabled subjects would demonstrate significantly less clustering than non-disabled children of items at recall. Since previous work indicated that LD children have deficiencies in semantic and taxonomic memory, it was thought that younger LD children would show particular weaknesses in clustering of frequency associates and older LD subjects would have parallel difficulties in clustering of category members. If frequency associations precede categorical relations in memory development, children with weaker taxonomic networks should also have less stable associative relations in memory. Such distinctive difficulties were not uniformly seen in the LD children in this study. Learning disabled subjects at both grade levels actually showed more clustering than non-disabled children for several of the lists. The ANCOVAs using RR scores showed a significant group effect only for one list type (secondary FA), while the ANCOVAs based on distance scores revealed significant differences between the groups on two lists (primary and secondary FA), indicating that the LD subjects did impose less organization on some of the lists. However, the sweeping disparities initially expected were not found.

Learning disabled children overall had higher clustering scores than non-disabled children for secondary CM lists. This pattern is seen in the second grade LD children's secondary CM distance scores, which are higher than those of non-LD subjects, and in sixth grade LD children's secondary CM scores, which are also higher than non-disabled counterparts'. Both distance and RR scores show these differences (Tables 3 and 4). For primary category members, second grade LD children's scores are higher than non-LD youngsters' when distance scores are used, and are equal to non-disabled students' when RR scores are examined (Tables 3 and 4). Learning disabled second graders showed less clustering than non-LD students for both primary and secondary frequency associates. Sixth grade LD children's scores were lower than non-disabled subjects' for primary CM items and for both primary and secondary FA items. This is reflected in higher clustering scores for non-disabled children overall for primary CM, primary FA, and secondary FA items (Tables 3 and 4).

It was expected at the outset of the study that LD children would show specific difficulties with category member items. They did not. Indeed, LD subjects actually showed more clustering of secondary CMs than did non-disabled children. Researchers' previous works have characterized LD children as deficient in recognizing category structure and using it spontaneously to aid in recall. When provided with a category cue, however, LD children can use categorization efficiently to improve retention and recall of items (Brown, 1988). Previous research provides two possible explanations for the LD children's facility with spontaneous categorization in this study.

The first explanation centers on the assistance of cuing. Although the children in this study were not given category cues during the acquisition sessions, they may have remembered the category titles given them during the word generation sessions. Indeed, from children's comments made while they attempted to learn the words, this seems quite likely. Numerous LD children, both second and sixth graders, articulated category names, asking if the remaining words came from "animals" or "vegetables" or "body parts," for instance. A second grade LD boy, described as quite disabled academically by his teachers, provides an example of this use of self-cuing. While trying to remember the words, he asked quietly if there were "any more animals?". Although it is not possible to prove conclusively that children remembered the initial probes given during the word generation sessions, this seems possible, particularly since previous work has found little categorization ability in LD children unless cuing is used. However, there is another explanation, partially supported by the literature, that may be less nebulous.

Bjorklund and Bernholtz (1986) found that LD subjects clustered items categorically in a similar manner to non-disabled subjects under a special set of circumstances: When children learned lists of categorizable words that they had chosen previously for category typicality, they showed as much clustering as non-disabled subjects. When given standard lists, based on adult norms, the LD subjects' clustering was significantly lower than non-LD children's. Bjorklund and Bernholtz (1986) interpreted these results as showing that LD children's knowledge base differs from that of non-disabled children, who possess knowledge bases similar to adults'. Yet when allowed to choose category exemplars that were highly typical in their own minds, LD children performed similarly to non-LD children on a recall task. Bjorklund and Bernholtz's (1986) study is analogous to the present experiment in that children created their own lists, based on personal knowledge rather than experimenter-prescribed items from adult lists. Indeed, the idea of allowing children to use their own store of information to create the word lists stemmed from Bjorklund and Bernholtz's (1986) work.

Thus, the second explanation for the LD children's ease in spontaneously categorizing items involves the high degree of familiarity each child had with his/her items. Each child clearly recognized each word, and was aware that each item was a member of a superordinate class. This awareness was demonstrated during the word generation sessions; children's responses came from their own, individual stores of knowledge, rather than from externally derived norms. It is therefore possible that the unexpected taxonomic organization shown by the LD subjects was a function of the words used for memorization. Most previous work showing weaknesses in LD children's categorization abilities has used items supposed by the researcher to be typical or atypical category exemplars. Items may not correspond to children's stores of information; what a researcher conceives of as a typical exemplar may be atypical for a child. For example, "javelina" may be a highly familiar and typical animal to an Arizona child but foreign to children in Georgia or Illinois. In the present study, all items were familiar to the children because they came from their own stores. Thus, the LD children's categorization capabilities may be more a function of the material used than of their superior strategies. Since both LD and non-LD second graders categorized quite easily, this explanation appears plausible. Previous studies may have attributed less semantic or taxonomic organization to young and LD children because the items for memorization were not necessarily highly salient members of their respective categories.

Learning disabled children's knowledge bases may indeed differ from their non-disabled counterparts', as Bjorklund and Bernholtz (1986) have suggested. Since analyses did not show significant differences between LD and non-LD subjects for category member items, it is difficult to confirm this point. However, allowing children to access their own knowledge of categories clearly had beneficial results. Because the only major difference between this study and others of the same ilk is the use of individual, child-generated norms, this singular twist may be responsible for the results detailed above.

Differences between the LD and non-disabled children were found for frequency associated items; LD subjects clustered these items less at recall than did non-LD students. An examination of the RR and distance score means, and the ANCOVAs as well, shows that LD children of both ages imposed significantly less organization on FA lists than did non-disabled children. The secondary FA lists, especially, appear difficult for the LD subjects to organize at recall. The differences between sixth grade LD and non-LD subjects on this list were the largest of any found. Learning disabled children's RR score mean was .371 while non-LD children's mean was .524; distance scores were 14.900 for LD children and 20.666 for non-disabled subjects. Learning disabled children as a whole do appear to have significant difficulty in using frequency associations to organize information for retention and recall. This may indicate a fundamental weakness in the associative networks in LD children's knowledge base. Considering the difficulties LD subjects had in generating their frequency association lists, it may also reflect the lower meaningfulness of the FA words. The stimulus word and its three associates may have been weakly connected for the LD subjects and viewed more as single items than as related material. Perhaps because no overt structure was apparent, items were organized less at recall. Those LD subjects who did attempt to organize the FA items seemed to benefit from this structure. A sixth grader who created mental pictures to encompass all of the items is a fine example of this.

However, it seems that such a superordinate strategy was not obvious to most of the LD subjects.

Thus, meaningfulness of the items appears paramount in LD subjects' memory organization. The clustering scores and within-subjects repeated measures analyses of variance reflect this. Second graders clustered primary CM words most, followed by secondary CM, primary FA, and secondary FA items. Those category items generated first seemed most amenable to organization, probably because they were the most meaningful to the young LD children. Frequency associates were clustered less, and the secondary FA items were the least organized overall. When the children's great difficulty in generating these last few associates is recalled, such a finding is not surprising. These items were probably more peripheral members of the children's associative networks, thus were not particularly meaningful and bore little relation to the stimulus word. The difference between LD and non-LD children is of interest here; the greatest disparity between the groups' clustering scores was found for the secondary FA items for both the second and the sixth graders. These items may represent the weakest semantic connections for LD children.

The Pearson r correlation studies show significance for the relationship between clustering of FA and CM items for only one group of LD children: second graders. The correlations were not significant for any other group (non-LD second or sixth, LD sixth). For young LD children, there may be a relationship between ability to cluster taxonomically and by frequency association. However, in this study, the relationship appears to be in the opposite direction from theoretical expectations. Second grade LD children showed more clustering of CM items than FA items; thus, recognizing category structure may be linked to recognizing association by frequency, rather than frequency association's being the determining factor in forming taxonomic relationships. Yet for older LD and all non-disabled subjects, no relationship was found. Younger LD children may have a more sweeping deficit in recognizing connections between words, particularly those with weaker associative links. However, as LD children mature, they appear to recognize category structure for highly meaningful items, much as non-disabled children do.

It is of interest to note that the groups did differ in their overall patterns of clustering, particularly the sixth grade subjects. Second graders in both groups showed the most clustering of primary CM items and the least clustering of secondary FA items. The second graders as a whole were similar in their preferences for clustering specific types of items. Sixth graders, however, showed somewhat different patterns. Learning disabled subjects clustered secondary CM items the most, while non-LD children organized the primary FA words most. Learning disabled children's scores were lowest for secondary FA items, while non-disabled subjects' scores were lowest for secondary CM items. This may reflect a difference between LD and non-LD older children. Non-disabled children may recognize connections between items associated by frequency most readily, while LD children may rely more on categorical relations. The sixth grade, LD subjects' higher clustering of secondary category members is of interest too; non-disabled, older subjects clustered primary CM items more than secondary CM items. Younger children from both groups clustered primary CM words most as well. Since children appear to cluster most the items that they recognize as highly typical exemplars of a category (Bjorklund & Bernholtz, 1986), it seems that younger LD children recognized the first four items that they had generated as the most typical members of the categories, while older LD subjects apparently viewed all the category members as equally typical. Non-disabled sixth graders showed the expected pattern: Primary category members were clustered more than secondary category members. This may provide some evidence for differences in LD children's knowledge base. With maturity, non-disabled children's knowledge bases become more defined, with a few certain items becoming highly typical exemplars of particular categories. Learning disabled children, on the other hand, may not experience this shift to more fine-grained taxonomic knowledge; the features that define membership in a particular category may remain less clear, leading to a broader conception of category membership and a less specific taxonomic knowledge base.

A final aspect of the LD subjects' performance that warrants some discussion is the connection between trials to criterion and group. The ANCOVAs revealed significant effects on the CM lists for IQ and grade, but not for group. Significance for the FA lists was found for grade, but not group. Thus, LD children's mean trials to criterion were not significantly different from non-disabled subjects'. Learning disabled children have been characterized as having more difficulty in learning material than non-disabled counterparts (Bjorklund & Bernholtz, 1986; Wong, Wong, & Foth, 1977). However, in this study the groups did not differ in trials required for learning the material to criterion. Perhaps the meaningfulness of the items is responsible for this finding as well. If this is the case, implications for educators abound: If material can be made highly salient by utilizing a child's own knowledge, he/she may learn with a facility similar to non-disabled peers.

Summary

In summary, the learning disabled subjects in this study showed relatively high clustering of categorizable items and lower organization of items associated by frequency. Their facility with using category structure was unexpected. However, it is possible that the use of self-generated norms was responsible; children clearly recognized each word as belonging to a superordinate class. Thus, other researchers' proposed semantic memory difficulties in LD children may be due to the items used for memorization; they may not correspond to the children's personal stores of knowledge.

The LD subjects' difficulty in clustering items associated by frequency may relate to the manner in which these items were generated. Learning disabled children seemed to require great effort in stating associates for stimulus words; thus it is likely that their responses represented weak connections in their knowledge bases. The items may have been relatively devoid of meaning in relation to the stimulus word. Those few students who did manage to see a connection, and articulated this to the researcher, demonstrated high clustering of FA items in their recall protocols. A specific relationship between clustering of FA and CM items was found for only the LD second graders, but appeared in the opposite direction to that expected; younger

LD children clustered CM items more than FA words. While differences in knowledge bases between LD and non-LD children were not conclusively found, the older LD subjects seemed to possess a less-well defined conception of typical category exemplars than non-LD counterparts. Evidence of this difference was not found for the younger children, so it may indicate some disparity in knowledge base that increases as LD children mature. Finally, the trials required to learn the lists to criterion did not differ significantly for the LD and non-LD children. Learning disabled subjects appeared to learn items at a rate similar to non-disabled children. The familiarity of the items may have enhanced children's abilities to learn them at a rate comparable to non-disabled peers.

Qualitative Information from Word Generation and Acquisition Sessions

Introduction

Results from the quantitative analyses may be understood more fully when information from the word generation and acquisition sessions is discussed as well. Children's behavior and comments may provide insights into the processes they used as they attempted to learn the words. Additionally, information about the children's environments and cultural settings may prove beneficial in understanding aspects of their performances.

<u>Word Generation Sessions</u>

Children experienced some difficulties during the word generation sessions, particularly while completing the frequency associations task. Both second and sixth grade subjects appeared confused by the activity; several children initially gave rhyming words for the stimulus (such as "preacher" when asked to provide an associate for "teacher"), and many others said they could not think of anything and required considerable prodding and examples from the researcher. Perhaps the instructions ("Tell me something that goes with ______") were not sufficiently clear to activate semantic associates in children's memories. However, because the subjects did show clustering of frequency associates at recall, it seems that the task did produce some interconnected words.

Children had less difficulty with the categorical word generation task. All subjects understood the instructions (i.e., "Tell me some animals"); problems arose only when children were unfamiliar with members of a particular category. Younger subjects in general showed more frustration with this task, seeming to exhaust their semantic stores earlier than older subjects. However, with encouragement most children completed the activity. The category that produced the most vexation for children was vegetables. Many subjects had trouble naming nine members of this category. Numerous children stated fruits, and some even expanded the category to include foods in general. For example, among the non-disabled second graders, 16 percent of the responses were types of fruit (examples: orange, pineapple, grapes, plum, banana), and 8 percent of the items were from other categories of edibles (macaroni, cheese, ice cream, meat, dressing, rice, dip). One child even said "recipes"! Thus, the vegetable prompt seemed to activate other food items in the children's memories. Some of the children's difficulty with this category may be linked to sociocultural factors. Often subjects would provide several vegetables, then begin naming other foods. They seemed unfamiliar with the array of vegetables available. Because many of the subjects were from lower income homes, it is likely that the more exotic vegetables were not a part of their daily diets. Some children may not have been exposed to more than three of four types of vegetables. Other children, however, quickly named such vegetables as sprouts, mushrooms, spinach, and broccoli. Thus, the children's past experiences probably influenced their choice of items during the word generation task.

This can be illustrated vividly by the non-disabled second graders. One of the classes had recently completed an academic unit on endangered species from around the world. When asked to name animals, many children from this class exercised their new knowledge and gave such responses as pelican, toucan, polar bear, seal, dolphin, and lemming. When the researcher entered these students' classroom, handmade posters displaying these animals adorned the walls of the room. Several children even showed the researcher their projects. Thus, the subjects' recent experiences appeared to influence their immediate store of knowledge and choice of items during the word generation task.

Learning disabled subjects also showed this tendency to use current classroom information in their word generation responses. One of the second grade regular classes from which several LD children came had introduced a unit on the human body. The walls of the building near the classroom were covered with life-size tracings of the children with various internal organs hand-labelled and pasted on the forms. When asked to name body parts, many of these students gave responses such as brain, bones, skin, lungs, heart, kidneys, gallbladder, intestines, and spine. Indeed, such anatomically precise items comprised 18 percent of the LD children's responses. Only 7 percent of non-disabled second graders gave analogous responses (veins, bones, muscles, brain), and none named the internal organs so readily given by the LD children. Again, specific acquired information influenced the children's accessing their memories; recently learned, new information was often at the forefront of their knowledge. Some children used highly personal information to complete the word generation task. For example, one sixth grade LD student listed helmet and firesuit as clothing, explaining that his father drove race cars and routinely wore this unusual attire. These items were quite salient to him, certainly more so than they would be to most other children.

Another interesting trend noticed during the word generation task was the influence of geography on children's responses. Several subjects named animals such as javelina, lizard, and road runner; cilantro and chile appeared in the vegetable category; and shorts, tanktops, and bikinis were present on the clothing lists. Both animals and vegetables native to the Southwest were found in the children's protocols, as were clothing items appropriate for the late spring desert climate. While it is not surprising that geographical location should inspire particular responses, it is important to note this influence. Most researchers in the past have asked children (and adults) to learn lists of words selected from published norms. These norms may not be relevant for subjects living in areas foreign to the norming sample. Thus, subjects may not recognize the connections between items as readily and may not organize them in the same manner as subjects closer to the norm group would. This may serve as a caution to other researchers to consider the relevance of items to subjects, with particular attention given to geography and culture.

Acquisition Sessions

During the acquisition sessions, many children's comments indicated that they were strategic in their attempts to learn the words. Children at both grade levels and in both the non-disabled and LD groups occasionally articulated their thoughts regarding the words to be learned. Children remembered the word generation task and referred back to it in several ways. Many subjects, in trying to recall the last few words from their lists, asked the researcher questions aimed at narrowing their search. Categories were recognized and children attempted to use this broader knowledge to aid in the activity. For example, one second grade learning disabled boy who teachers had described as having particular difficulty with his school work asked, "Are there any more animals?" while attempting to retrieve the last items on his list. Children also recalled items that were not on their lists, but which they had given during the word generation task. For example, one second grade LD child named head and hand, which he had said several days earlier during the word generation portion of the experiment. These words were not on his list of items to be learned, but other body parts were. Additionally, he said "lion," though it was absent from the final list but had been listed by him in response to the animal probe. These intrusions indicate two possibilities: that children remembered the words they had given during the initial sessions, and used this knowledge to assist in the later learning task; or that once the general category had been accessed other likely, personally familiar items were named with the hope that they would be part of the list. Several subjects, upon being told that their intrusions were not included on the acquisition list, were quite insistent that indeed they were, and asked, "Are you sure that isn't one of them?"

Children also seemed to employ some strategies while learning the frequency associates lists. Several subjects indicated that they placed the material into a larger context, creating in essence a category into which they could fit the words. This was most apparent with "teacher" and its associates. Two learning disabled, sixth grade boys said that they were trying to remember things around a classroom to help retrieve the items. One older, LD student in particular employed this strategy with considerable success. He learned his frequency associate list in two trials and demonstrated perfect clustering for two of the groups. He volunteered that he had created a "big picture with a street, a school, and a bird flying over." His list contained the probes street, teacher, bird, and pencil, with each of their three associates. Another LD sixth grader who learned his list in three trials spontaneously elaborated on the items during the second showing of the cards. For example, he said, "Kid-- a child," which apparently helped him to remember these two items contiguously. Thus, some students were quite adept at formulating strategies to assist in their learning.

These observations may provide some information about children's cognitive processes that will aid in understanding the results of the data analysis. It is apparent that children's current academic, social, and geographical environments will influence their stores of knowledge and should be addressed when researchers choose items for subjects to learn. Additionally, it seems that even young, LD children in this study were able to employ some self-generated strategies to enhance their learning.

Comparisons with Other Studies

Most previous work exploring clustering of items by children at recall differs from the present study in one important respect: Many researchers have used single trial designs. As subjects' trials increase, their clustering tends to increase as well (Wachs & Gruen, 1971). Thus, it is possible that the higher clustering shown by subjects in this experiment is an artifact of their increased trials. To explore this possibility, clustering scores from the first trial of this study were compared with those of other, single trial experiments. It was not possible to match experiments precisely; clustering measures differ considerably, so experiments using ratio of repetition scores (or, in one case another score that is computed quite similarly) were selected. The grade levels used in other experiments did not correspond perfectly either, but were as comparable as possible. All studies used words from categories, and all but one used only highly typical items. One study reported findings for typical and atypical items. These can be compared with the primary and secondary items employed here. First, studies using non-disabled children will be reported, then studies with LD subjects will be compared to the present one.

Bjorklund and Jacobs (1985) studied categorization effects with non-disabled children from several grade levels. Third and seventh graders' (average ages 9-0 and 12-11) RR scores for typical category members were .42 and .54, respectively. In the present study, second graders' (average age: 8-1) mean RR score for the first trial was .38, and sixth graders' (average age: 12-3) RR mean score was .48. Thus, the non-disabled children in this study showed similar clustering of items to those in the Bjorklund and Jacobs (1985) study.

Wong, Wong, and Foth (1977) reported clustering scores for learning disabled (poor readers) children whose mean age was 10-1. The clustering score used was the item clustering index (ICI), which is computed similarly to the RR score. Wong, Wong, and Foth's (1977) subjects' clustering score mean on a single trial was .66; the second grade, LD children in the present study (average age: 8-5) had a mean RR score of .56. Bjorklund and Bernholtz (1986) studied clustering of typical and atypical items in junior-high school LD students (poor readers) with an average age of 13-4, and found a RR score mean of .49 for typical items and .24 for atypical items. The sixth graders in this study (average age: 12-8) had a RR score mean of .44 for primary category members, and .33 for secondary category members (Table 15). Thus, LD subjects' clustering scores on the first trial of this study were similar to those found in other studies. The slightly lower scores reported for the present experiment may be due to the children's ages; children in this study were younger than those in other studies. Since clustering of items tends to increase with age (Bjorklund & Jacobs, 1985), the small differences may be attributed to the other researchers' subjects being a bit older. When LD children in this study are compared to non-disabled children in other studies, second graders are found to show higher clustering of items than that seen in previous work. Sixth grade LD subjects, however, show less clustering than non-LD counterparts in other studies. Therefore, in this experiment the younger LD children performed better than non-LD children in previous works, while the older LD subjects' clustering was lower than that seen in prior studies.

To explore the possible effects of multiple trials, ANCOVAs were completed for the first trial clustering scores of subjects in this experiment, using primary CM, secondary CM, primary FA, and secondary FA as dependent variables. The ANCOVAs revealed no significant effects. This indicates that all subjects in this experiment performed similarly on their first trial; the group differences were not evident until later trials. Thus, the opportunity for multiple trials appeared to assist children in recognizing category and/or frequency associate relations and served to create the differences seen between the LD and non-LD children, as well as between younger and older children. However, on their first trial the LD children in this study did not differ significantly from non-LD children. The other works discussed did reveal significant differences between the LD and non-LD children with single trial designs. Perhaps the use of self-generated words led to all children's performing similarly on the first trial of this study.

Table 13

Comparison of First Trial Clustering Scores between Studies

Group	Average Age	Author(s)	Cluster Score
NLD	9-0	Bjorklund & Jacobs (1986)	.42
NLD	8-1	Lee (1992)	.38
NLD	12-2	Bjorklund & Jacobs (1986)	.54
NLD	12-8	Lee (1992)	.48
LD	10-1	Wong, Wong, & Foth (1977)	.66
LD	8-5	Lee (1992)	.56
LD	13-4	Bjorklund & Bernholtz (1986)	.49 (typ.) .24(atyp.)
LD	12-8	Lee (1992)	.44(prim.) .33 (sec.)

Comparison of Clustering Measures

Two different methods were used through out this study to assess the degree of clustering imposed upon the material by the subjects: ratio of repetition scores and distance scores. Analyses using the two measures yielded similar results, but the distance scores appeared more sensitive to clustering, and analyses based upon these scores revealed differences between the groups not found with the RR scores. For example, the ANCOVAs using distance scores as the dependent variables differed slightly depending upon which score was used. When RR scores were employed, significance for grade was found for primary and secondary FA items only. When distance score was the measure used, significant effects were seen for both primary and secondary FA items and for secondary CM words. Because the calculation of the distance scores considers the distance between items, rather than solely items recalled contiguously, it provides a finer measure of clustering, particularly when items are recalled in a general group with one or two non-members interspersed. Thus, distance scores may be preferable due to their increased sensitivity in revealing less rigid clustering of items. Ratio of repetition scores mask any groupings that are not uniformly contiguous.

There is another drawback in using RR scores, particularly in an experiment such as this. Calculating the scores proved inordinately difficult for the lists used in this project. Because each list contained two levels of words (primary and secondary) and four groups of words (four categories/frequency associate clusters), there were considerable questions regarding which number to use for the N (number of items) term of the formula. A researcher who has used RR scores in numerous projects was contacted and confessed that she was not sure what the proper N should be, as her projects had not used lists with so many manipulations. She referred the question to her former advisor, an expert in the study of children's clustering and memory organization. The advisor was able to answer the question, but even this required several communications and queries. Thus, implementing RR scores proved quite vexing, even to researchers extremely familiar with their use. Distance scores are simple to calculate and are appropriate for word lists with several levels of categories and meaningfulness. They also appear more sensitive to subtle differences in clustering. Therefore, distance scores seem the preferable means of measuring clustering in an experiment such as the present one.

Educational Implications of the Study

For several years special educators have advised teachers to consider children's knowledge bases when introducing new concepts and material. When children can apply their knowledge to new tasks, performance is enhanced (for example, Landis, 1982). Educators have recognized the importance of children's own background knowledge and have discussed numerous methods for activating it, such as brainstorming, pre-reading, and schema activation strategy (Bos & Vaughn, 1991).

Brainstorming is a technique in which the teacher provides a stimulus word and children are asked to list all the words or phrases that they associate with the stimulus. The teacher then lists all the students' items on the board and may help the children to discuss, organize, or categorize the information. Pre-reading involves introducing a topic; having students generate and list associations; asking children to reflect upon their responses (such as "What made you think of _____?") to become aware of their prior knowledge and how it relates to the concept; and reformulating the knowledge, providing children with a chance to articulate how the discussion may have altered or enhanced their previous knowledge of the topic, as well as benefit from other students' comments. Schema activation strategy also involves a prereading discussion, emphasizing how children's own experiences are similar to story characters'. Next main ideas from the story are introduced and students again relate personal experiences to these. Students are also asked to predict something akin to their own experience that might occur in the story. After the prereading discussion and the actual reading of the story, the teacher asks inferential questions about the text, requiring children to support their answers with information from the story or with their prior knowledge (from Bos & Vaughn, 1991).

Thus, the idea of considering children's personal stores of knowledge is not new to educators. However, the results of this study emphasize the importance of considering children's knowledge base when formulating tasks and when assessing skills. When children are given information that is highly familiar and meaningful to them, they seem much more capable than many previous researchers have indicated. Young children can organize material taxonomically without assistance from external sources. Learning disabled children can recognize category structure and utilize it to enhance their learning of words. Few researchers have found such advanced skills in their subjects. Yet few researchers have considered the importance of individual children's knowledge when constructing lists of material to be learned.

Thus, whenever possible educators should allow children to access their prior knowledge and apply it to the task at hand. Considering the results of this study, activities such as those discussed above appear crucial to ensuring that children, particularly those with learning disabilities, will organize and retain information in the classroom. Additionally, it seems imperative that information have meaning to children. When teachers assume that youngsters recognize relationships between items, they may be relying more on their own, adult conceptions and failing to recognize that children's minds may hold different information.

Educational psychologists and developmental psychologists who assess children's skills for academic or research purposes must be aware of the importance of children's personal knowledge base as well. Cultural and linguistic differences have been discussed in relation to standardized testing (Salvia & Ysseldyke, 1981; Sattler, 1989), but it seems that few psychologists have considered differences stemming from geography and current classroom activity. The second grade, LD children who listed such items as liver, gallbladder, and veins for body parts provide an illustration of this. They were activating their recently acquired knowledge to complete the word generation task. Such conventional body parts as arm, hand, or foot were not primary examples in their minds on the day the word generation task was given. Had the task been administered two weeks earlier or two weeks later, the children's responses might have changed. Similarly, had the researcher chosen such items as liver and gallbladder and given them to children from another class to memorize, these words might have been devoid of meaning entirely, for other students did not complete the academic unit on internal organs. When ability tests are given to children, their performances must be considered in light of their current state of knowledge. Standardized tests are constructed in such a way that any child whose age places him or her within the range of the norming group is assumed to possess the knowledge assessed by the test. This may not always be the case.

Similarly, when researchers attempt to study children's cognitive skills, such as memory organization ability, they must be aware of the artificial constraints placed upon children when items do not correspond to personal knowledge. Certainly it is of interest to compare children's functioning to that of adults, and for this purpose researchers may wish to construct their tasks using adult norms. However, it must be emphasized that adults possess more knowledge; they have been exposed to considerably more information than have children. Thus, while children's knowledge may correspond to adults' in some areas, it may be widely different in others. Unless children's unique and current state of knowledge is considered, their abilities may appear less sophisticated than they truly are.

Limitations of the Study

One of the primary difficulties facing researchers who examine cognitive processes in learning disabled children is the selection of subjects. A child's participation in a resource program for LD students does not guarantee his/her possessing a diagnosed learning disability. In this study, all LD subjects met school district criteria for having a learning disability through a psychoeducational evaluation by a certified school psychologist. Children's files were then checked for evidence of specific conceptual weaknesses, indicated by low scores on the Similarities subtest of the

WISC-R. However, this method of subject selection was not optimal. It would have been preferable to have several measures of conceptual functioning. Unfortunately, this was not possible. Thus, while all children in this study were diagnosed as LD by a school psychologist and had Similarities scores below average, conceptual weaknesses may not have been the only deficit for all subjects. So results of this study may not generalize to all subtypes of LD children.

Another limitation of this study concerns the procedures used for the first portion of the experiment. Children's abilities to recall and organize items associated by frequency were assessed by asking them to learn words they had provided as frequency associates of stimulus items. These stimuli and their associates were presented several days later for memorization during the acquisition sessions. Children had some trouble generating the frequency associates. It is possible that the task demands and/or instructions were unclear to some children. Thus, the frequency associates they provided may not have adequately represented the children's stores of associational knowledge. Although the word generation instructions were based on those used in other similar experiments, they may not have allowed children to access the relationships fully.

Children's semantic knowledge was assessed through tasks requiring the recall of individual words. Results based upon such an activity may not apply to higher-level academic functioning, which involves recognizing much more complex relationships between greater masses of material.

Finally, the constraints imposed upon the study by geography and culture should be considered in interpreting and generalizing the results. Most subjects were from lower to lower-middle socioeconomic groups, and their cultural backgrounds were not uniform. While the sample was representative of the school district from which it was taken, it may not be representative of other districts in other regions of the country.

Directions for Future Research

The results of this study do not correspond to those of many other similar works. Thus, the first step in future research should be a replication of this experiment. Additionally, analogous procedures and materials should be used with different samples of children, particularly students from other socioeconomic and cultural backgrounds, since this study used children from primarily lower-socioeconomic groups. It would be of interest to compare the current findings with those gathered from children in other geographical areas as well, particularly to assess the degree of influence of geography on children's responses to the animals, vegetables, and clothing categories.

Because the LD children in this study performed quite unlike LD students in other experiments, particular attention should be paid to the selection of subjects. Subjects in this study were broadly defined as having conceptual deficits. However, it would be preferable to utilize multiple measures to place children in this category of disability. School district and teacher's policies prevented a complete examination of subjects' psychoeducational histories, thus evidence for conceptual deficits was not optimal. Future studies might continue to use the Similarities portion of the Wechsler Scales, with the addition of other measures of semantic and conceptual development, such as the Analysis-Synthesis, Passage Comprehension, and Verbal Analogies subtests of the Woodcock Johnson Psychoeducational Battery-Revised. By using several measures, a more defined conceptual subtype of learning disability might arise. Most special educators will confirm that children whose primary deficit is the formation of concepts and the ability to recognize the relationships between items and ideas do exist, and provide a challenge for remediation. And yet, when allowed to access their own knowledge bases, these youngsters appear rather capable of organizing information, apparently differing from non-disabled students only in their ability to recognize associations among less meaningful, more peripheral items.

Certainly these proposed differences between LD and non-disabled children should be explored further. Because the word generation tasks may have provided cues for the children during the acquisition sessions, it would be preferable to administer the two activities with several weeks in between, rather than just a few days. However, in doing this, current knowledge may be less available for processing; with the passage of time, information learned in the classroom may fade and become less familiar to children, as well as more secondary in terms of knowledge base organization. Thus, while spacing the two activities would diminish the cues in the children's memories, it might also weaken the relationships between highly salient items. For example, the children who had recently completed the endangered species unit might have learned about Arctic animals during the time between word generation and acquisition if several weeks had passed. Such creatures as lemmings and iguanas might become secondary category members, and polar bears and penguins might become primary. These issues must be considered when creating tasks that center on children's abilities to organize and retain information.

Another area for future research is the influence of children's knowledge base on material other than individual words. Would younger and older children, and LD and non-LD subjects, perform similarly if more academic types of information were used? This study should be extended to include more realistic academic tasks than simply memorizing words. For example, children's learning of geography might be assessed by asking them to express their current knowledge of a particular area, then incorporating that knowledge into material to be learned. For instance, children might be asked to state what they know about China. Two or three of their individual ideas could then be woven into a standard short essay about China. Children's retention of factual material from the passage could then be assessed and compared across ages and groups.

The results of this study raise many issues regarding the capabilities of learning disabled children. Future research must explore these children's capacities further, with a sensitivity toward subjects' unique stores of knowledge and the influence these may have on performance. Such studies may provide essential insight into LD children's cognitive processes, which could lead to modifications in educational practices and materials. These, in turn, might enable children with learning disabilities to acquire new knowledge as readily as non-disabled students. Enhancing learning for all students is, after all, the primary goal in all branches of education.

REFERENCES

Ackerman, B. P. (1985). Children's retrieval deficit. In C. J. Brainerd (Ed.), Basic Processes in Memory Development: Progress in Cognitive Development Research (pp. 1-46). New York: Springer-Verlag.

Baker, J. G., Ceci, S. J., & Herrmann, D. (1987). Semantic structure and processing: Implications for the learning disabled child. In H. L. Swanson (Ed.), Memory and learning disabilities: Advances in learning and behavioral disabilities (pp. 1-40). Greenwich: JAI Press.

Bauer, R. H. (1977). Memory processes in children with learning disabilities: Evidence for deficient rehearsal. Journal of Experimental Child Psychology, 24, 415-430.

Bauserman, D. N., & Obrzut, J. E. (1981). Free recall and rehearsal strategies in average and severely disabled readers. Perceptual and Motor Skills, 52, 539-545.

Bjorklund, D. F. (1985). The role of conceptual knowledge in the development of organization in children's memory. In Brainerd, C. J. & Pressley, M. (Eds.). Basic processes in memory development (pp. 103-142). New York: Springer-Verlag.

Bjorklund, D. F. (1989). Children's thinking: Developmental functions and individual differences. Wadsworth, Inc.: Belmont, CA.

Bjorklund, D. F., & Bernholtz, J. E. (1986). The role of knowledge base in the memory performance of good and poor readers. Journal of Experimental Child Psychology, 41, 367-393.

Bjorklund, D. F., & deMarchena, M. R. (1984). Developmental shifts in the basis of organization in memory: The role of associative versus categorical relatedness in children's free-recall. Child Development, 55, 952-962.

Bjorklund, D. F., & Jacobs, J. W. (1985). Associative and categorical processes in children's memory: The role of automaticity in the development of organization in free recall. Journal of Experimental Child Psychology, 39, 599-617.

Bjorklund, D. F., & Muir, J. E. (1988). Children's development of free recall memory: Remembering on their own. _Annals of Child Development_, _5_, 79-123.

Bjorklund, D. F., & Thompson, B. E. (1983). Category typicality effects in children's memory performance: Qualitative and quantitative differences in the processing of category information. _Journal of Experimental Child Psychology_, _35_, 329-344.

Bjorklund, D. F., Thompson, B. E., & Ornstein, P. A. (1983). Developmental trends in children's typicality judgments. _Behavior Research Methods and Instrumentation_, _15_, 350-356.

Bos, C. S., & Vaughn, S. (1991). _Strategies for teaching students with learning and behavior problems_. Allyn and Bacon: Needham Heights, MA.

Bousfield, W. A. (1953). The occurrence of clustering in the recall of randomly arranged associates. _Journal of General Psychology_, _49_, 229-240.

Bousfield, A. K., & Bousfield, A. M. (1966). A measurement of clustering and sequential constancies in repeated free recall. _Psychological Reports_, _19_, 935-942.

Bower, G. H., Lesgold, A. M., & Tieman, D. (1969). Grouping operations in free recall. _Journal of Verbal Learning and Verbal Behavior_, _8_, 481-493.

Brainerd, C. J., Kingma, J., & Howe, M. L. (1986). Long-term memory development and learning disability: Storage and retrieval loci of disabled/nondisabled differences. In S. J. Ceci (Ed.), _Handbook of cognitive, social, and neuropsychological aspects of learning disabilities: Vol. 1_. (pp. 161-184). Hillsdale, N. J.: Lawrence Erlbaum Associates.

Brainerd, C. J., & Reyna, V. F. (1991). Acquisition and forgetting processes in normal and learning-disabled children: A disintegration/redintegration theory. In Obrzut, J. E., & Hynd, G. W. (Eds.), _Neuropsychological foundations of learning disabilities_ (pp. 147-178). Orlando, FL: Academic Press.

Brown, K. F. (1988). _Development of long term memory retention processes in learning disabled and non-_

disabled children. Unpublished doctoral dissertation, University of Arizona, Tucson, AZ.

Ceci, S. J. (1983). Automatic and purposive semantic processing characteristics of normal and language/learning disabled children. Developmental Psychology, 19, 427-439.

Ceci, S. J. (1984). A developmental study of learning disabilities and memory. Journal of Experimental Child Psychology, 38, 352-371.

Chechile, R. A. & Richman, C. L. (1982). The interaction of semantic memory with storage and retrieval processes. Developmental Review, 2, 237-250.

Chi, M. T. H. (1978). Knowledge structures and memory development. In R. S. Siegler (Ed.), Children's thinking: What develops? (pp. 73-96). Hillsdale, NJ: Erlbaum.

Cooney, J. B., & Swanson, H. L. (1987). Memory and learning disabilities: An overview. In H. L. Swanson (Ed.), Memory and learning disabilities: Advances in learning and behavioral disorders (pp. 1-40). Greenwich, CT: JAI Press.

Dalrymple-Alford, E. C. (1970). The measurement of clustering in free recall. Psychological Bulletin, 1, 32-34.

Denney, N., & Ziobrowski, M. (1972). Developmental changes in clustering criteria. Journal of Experimental Child Psychology, 13, 275-282.

Frankel, M. T., & Rollins, H. A. (1985). Associative and categorical hypotheses of organization in the free recall of adults and children. Journal of Experimental Child Psychology, 40, 304-318.

Ghatala, E. S., & Levin, J. R. (1973). Developmental differences in frequency judgments of words and pictures. Journal of Experimental Child Psychology, 16, 3, 495-507.

Greco, C., Hayne, H., & Rovee-Collier, C. (1990). Roles of function, reminding, and variability in categorization by 3-month-old infants. Journal of Experimental

Psychology: Learning, Memory, and Cognition, 16, 617-633.

Houck, C. K. (1984). Learning disabilities: Understanding concepts, characteristics, and issues. Englewood Cliffs, NJ: Prentice-Hall.

Howe, M. L., O'Sullivan, J. T., Brainerd, C. J., & Kingma, J. (1989). Localizing the development of ability differences in organized memory. Contemporary Educational Psychology, 14, 336-356.

Israel, L. (1984). Word knowledge and word retrieval: Phonological and semantic strategies. In G. P. Wallach & K. G. Butler (Eds), Language learning disabilities in school-age children (pp.230-250). Baltimore: Williams & Wilkins.

Johnson, D. J., & Myklebust, H. R. (1967). Learning disabilities: Educational practices and principles. Orlando, FL: Grune and Stratton.

Kail, R., & Nippold, M. A. (1984). Unconstrained retrieval from semantic memory. Child Development, 55, 994-951.

Kaufman, A. S. (1979). Intelligent testing with the WISC-R. New York: John Wiley and Sons.

Kavale, K. A., & Forness, S. R. (1987). The far side of hetero-geneity: A critical analysis of empirical subtyping research in learning disabilities. Journal of Learning Disabilities, 6, 374-382.

Keogh, B. K. (1987). In Vaughn, S., & Bos, C. S. (Eds.), Research in learning disabilities: Issues and future directions (pp. 3-18). Boston: Little Brown and Company.

Keppel, G. & Zedeck, S. (1989). Data analysis for research designs. New York: W. H. Freeman and Company.

Kobasigawa, A. (1974). Utilization of retrieval cues by children in recall. Child Development, 45, 122-134.

Landis, T. Y. (1982). Interactions between text and prior knowledge in children's memory for prose. Child Development, 53, 811-814.

Lange, G. W. (1978). Organization-related processes in children's recall. In P. A. Ornstein (Ed.), Memory development in children (pp.101-128). Hillsdale, NJ: Erlbaum.

Lange, G. W., & Jackson, P. (1974). Personal organization in children's free recall. Child Development, 45, 1060-1067.

Lorsbach, T. C., & Gray, J. W. The development of encoding processes in learning disabled children. Journal of Learning Disabilities, 18, 222-227.

Lucariello, J., & Nelson, K. (1985). Slot-filler categories as memory organizers for young children. Developmental Psychology, 21, 272-282.

Moe, G. L., & Harris, J. D. (1983). Effects of encoding and retrieval strategies on the recall of learning disabled children. Journal of General Psychology, 109, 233-246.

National Joint Commission on Learning Disabilities (1988). [Letter to NJCLD member organizations].

Naglieri, J. A. (1985). Matrix Analogies Test-Short Form. Columbus, OH: Charles E. Merrill.

Naus, M. J., Ornstein, P. A., & Kreshtool, K. (1977). Developmental differences in recall and recognition: The relationship between rehearsal and memory as test expectation changes. Journal of Experimental Child Psychology, 23, 252-265.

Reznick, J. S., & Kagan, J. (1983). Category detection in infancy. Advances in Infancy Research, 2, 79-111.

Roenker, D. L., Thompson, C. P., & Brown, S. C. (1971). Comparison of measures for the estimation of clustering in free recall. Psychological Bulletin, 76, 45-48.

Rosch, E. (1973). On the internal structure of perceptual and semantic categories. In T. E. Moore (Ed.), Cognitive development and the acquisition of language (pp. 111-144). New York: Academic Press.

Salvia, J., & Ysseldyke, J. E. (1981). Assessment in special and remedial education. Boston: Houghton-Mifflin.

Sattler, J. M. (1990). Assessment of Children. San Diego: Jerome M. Sattler.

Schneider, W., Korkel, J., & Weinert, F. E. (1989). Domain-specific knowledge and memory performance: A comparison of high- and low-aptitude children. Journal of Educational Psychology, 81, 306-312.

Siegler, R. S. (1991). Children's thinking. Englewood Cliffs, NJ: Prentice Hall.

Smiley, S. S., & Brown, A. L. (1979). Conceptual preference for thematic or taxonomic relations: A nonmonotonic age trend from preschool to old age. Journal of Experimental Child Psychology, 28, 249-257.

Swanson, H. L. (1983). Relations among metamemory, rehearsal, activity, and word recall of learning disabled and non-disabled readers. British Journal of Educational Psychology, 53, 186-194.

Swanson, H. L. (1986). Do semantic memory deficiencies underlie learning disabled readers' encoding processes? Journal of Experimental Child Psychology, 41, 461-488.

Thorndike, E. L., & Lorge, I (1944). The teacher's word book of 30,000 words. New York: Columbia University.

Wachs, T. D., & Gruen, G. E. (1971). The effects of chronological age, trials, and list characteristics upon children's category clustering. Child Development, 42, 1217-1227.

Walker, S. C., & Poteet, J. A. (1989). Influencing memory performance in learning disabled students through semantic processing. Learning Disabilities Research, 5, 25-32.

Wechsler, D. (1974). Wechsler Intelligence Scale for Children-Revised. San Antonio, TX: The Psychological Corporation.

Wong, B., Wong, R., & Foth, D. (1977). Recall and clustering of verbal materials among normal and poor readers. Bulletin of the Psychonomic Society, 10, 375-378.

Woodcock, R. W., & Johnson, M. B. (1989). Woodcock Johnson Psychoeducational Battery-Revised. Allen, TX: DLM Teaching Resources.

Worden, P. E. (1976). The effects of classification structure on organized free recall in children. Journal of Experimental Child Psychology, 22, 519-529.