Order Number 9013161

A neuropsychological investigation of the memory skills of learning disabled children compared to normal children

Wilson, Sheryl Lee, Ph.D.

The University of Arizona, 1989

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

A NEUROPSYCHOLOGICAL INVESTIGATION OF THE MEMORY SKILLS OF LEARNING DISABLED CHILDREN COMPARED TO NORMAL CHILDREN

by

Sheryl Lee Wilson

A Dissertation Submitted to the Faculty of the

DEPARTMENT OF PSYCHOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 8 9

THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

As members of the Final Examination Committee, we certify that we have read the dissertation prepared by Sheryl L. Wilson

entitled A Neuropsychological Investigation of the Memory Skills of Learning Disabled Children Compared to Normal Children

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

Alfred W. Kaszniak — Date 11/16/89

James R. Allender — Date 11/16/89

Robert Lonsing — Date 11/16/89

John E. Obrzut — Date 11/16/89

George Domino — Date 11-16-89

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.

Alfred W. Kaszniak
Dissertation Director

Date 11/21/89

STATEMENT BY AUTHOR

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

Brief quotations from this dissertation are allowable without special permission, provided that accurate acknowledgement of 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 head of the major department or the Dean of the Graduate College when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Sheryl Wilson

DEDICATION

To my patient, loving husband Barney and my wonderful children, Jennifer and J.D. You made the journey possible.

TABLE OF CONTENTS

TABLE OF CONTENTS, continued

LIST OF TABLES

LIST OF TABLES, continued

ABSTRACT

Memory is a complex cognitive process which has been widely researched within the field of neuropsychology. In clinical studies of adults, the Wechsler Memory Scale (WMS) is widely used. At this time there is no comparable clinical tool within the child literature pertaining to memory. There are studies which have extended the age limits of the WMS, but the youngest sample ranged from 10 to 14 years of age.

The present research was conducted in two studies. The first study concerns the development of a memory scale for use with children aged six to twelve. This scale, Wilson's Adapted Memory Scale for Children (WAMS-C), was constructed utilizing the basic structure and subtests of the WMS. The scale was administered to 33 normal children, ranging in age from 6 to 12 years. It was hypothesized that the scale would reflect the developmental nature of memory as well as the relationship between memory and intelligence.

The second study compared the memory skills of a learning disabled (LD) sample of children to those of a sample of normal learning (NL) children. A specific profile of academic achievement was used to define the LD children who participated in this study. (Reading and Spelling impaired, and relatively better Arithmetic skills). Research conducted by Rourke and his associates identified this subtype of LD children and provided predictions pertaining to their differential performance on

verbal and visual tasks. The WAMS-C contains both verbal and visual memory tasks. It was predicted that these children would 1) do less well than NL children on the memory scale and 2) that these LD children would be impaired on the verbal memory portion of the WAMS-C, compared to NL children, but would exhibit equivalent performance on the visual memory tasks.

The results of the studies showed the WAMS-C to reflect the developmental nature of memory and the relationship with intelligence. Also, LD children had significantly lower scores on the WAMS-C. However, neither the verbal or visual subtests differentiated between groups. Rather, subtests which may reflect short-term memory deficits and/or attentional problems appeared responsible for the differences found.

CHAPTER 1

INTRODUCTION

Neuropsychological Approach to the Study of Memory

Memory is one of the most complex neuropsychological functions of the brain (Malloy & Nadeau, 1986). It is a broad concept that encompasses a number of different functions (Miller, 1986). And, within adult clinical populations, complaints about memory are quite common (Squire, 1986) with memory being the most frequently voiced complaint of post-traumatic patients (Benton, 1979) and the initial complaint of neurological patients with organic illness (Strub & Black, 1977). Therefore, the assessment of memory is an important component of both clinical and reasearch work conducted with adults (Lezak, 1983).

Adult Studies: Use of the Wechsler Memory Scale

The Wechsler Memory Scale (WMS) (Wechsler, 1945) is the most frequently used assessment tool employed to clinically assess memory (Kaszniak, 1986). The WMS was developed over ten years of experimentation directed toward the development of a rapid, simple, and practical memory examination (Wechsler, 1945). The original normative sample was based on men and women aged 25 to 50 years, with a sample size of 200.

The WMS consists of seven subtests. Test one consists of six simple questions of Personal and Current Information (e.g., "How old are you? Who is the President of the U.S.? Who is the governor?," etc.). Test two consists of five simple questions (e.g., "What year is it? What day of the month is it?, etc.) designed to test the subject's immediate Orientation.

Test three, labeled Mental Control, consists of three sub-items: counting backwards from 20 to 1, repeating the alphabet, and counting by three's. Test four, Logical Memory, consists of two memory passages. This test was intended to measure immediate recall of logical material. Test five is the familiar Memory Span for digits forwards and backwards.

Test six is a test of Visual Reproduction which requires the subject to draw from memory simple geometric figures exposed for a period of ten seconds. Test seven, labeled Associate Learning, consists of ten word pairs, some highly associated (e.g., up-down) and some not associated (e.g., cabbage-pen), which the subject is required to learn in three trials.

The WMS has often been criticized (e.g., Erickson, 1978; Erickson & Scott, 1977) and its weaknesses have been summarized by Prigatano (1978). These include: 1) a relatively small normative sample composed of an undisclosed number of age groups between the ages of 20 and 50; 2) the assumption that memory is a unidimensional function reflected by the Memory Quotient (MQ), 3) limitations with respect to the kinds of memory function tested, with six of its seven subtests being verbal in nature, and 4) low internal consistency of subtests and disparate difficulty levels between the subtests. Nonetheless, this scale continues to be widely used, with valuable revisions provided by Russell (1975) that have been incorporated into the Wechsler Memory Scale-Revised (Psychological Corp., 1987).

Russell (1975) has appropriately pointed out that to be a good measure of memory, the scale should include a task assessing both immediate and delayed memory. He added a delayed memory component to the WMS by retesting recall of the Logical Memory and Visual Reproduction stimuli thirty minutes after the original administration. It is interesting to note that Russell utilized only these two subtests, with both immediate and delayed recall and found these subtests to be strongly related to brain damage (Russell, 1975). However, most recent research has utilized the entire WMS, with the addition of the thirty minute delayed recall on Logical Memory and Visual Reproduction.

In research with elderly populations, the WMS has been helpful in differentiating elderly psychiatric patients with functional disorders from those with a variety of organic brain syndromes (Gilleard, 1980). The WMS has also been shown to validly differentiate demented adults from normal adults (Logue & Wyrick, 1979) and to differentiate persons with Dementia of the Alzheimer's Type (DAT) from healthy elderly persons (Brinkman, Largen, Gerganoff, & Pomara, 1983). Russell (1975) showed that his revised WMS could discriminate between patients with right- and left-sided lesions. Although these are just a few examples of the widespread use of the WMS, they provide evidence that a scale of this nature is of clinical utility.

Child Studies: The Need for a Comparable Tool

Within the neuropsychological literature concerning children, there is no comparable memory scale. The WMS was originally normed on adults aged 25 to 50 (*N* = 200) (Wechsler, 1945). Hulicka (1966) provided an extension of these ages with a new normative sample ranging from 15 to 89 years of age total (*N* = 333, 15-19 year old, *n* = 43). Ivinskis, Allen, and Shaw (1971) concentrated on a younger sample, extending the ages down to include 10 to 14 years (*N* = 30).

The recent revised version of the WMS was designed to represent the normal population of the United States between ages 16 years 0 months and 74 years 11 months. The 1980 United States Census and more recent special-purpose census reports were used to determine proportions of individuals in important demographic categories (i.e., age, sex, race, geographic region, education, and IQ) (Psychological Corp., 1987). A brief description of these variables is in order, due to the fact the WMS-R is a new instrument.

The plan for the standardization sample called for at least 50 cases in each of six age groups (16-17, 20-24, 35-44, 55-64, 65-69, 70-74) with a final total sample of 316 people. Approximate equal number of males and females were included at each age tested (males = 156, females = 160). Whites and nonwhites were included in the specifications for the sample in the same proportions given in the 1980 Census reports. The four major regions used by the Bureau of Census for analyzing their data (Northeast, Northcentral, South, and North) were sampled proportionally for the standardization sample. Educational level was not specified for individual members of the standardization sample. Instead, three educational categories (0 to 11 years; 12 years; 13 years or more) were proportioned within each group based on the 1980 Census data. Finally, each member of the sample was administered all or a portion of the Wechsler Adult Intelligence Scale-Revised as the intent was to obtain a sample of average general ability in each age group. The group IQ means ranged from 100.0 to 106.7. (For a more complete presentation of the standardization process utilized in the development of the WMS-R, please refer to the manual, Psychological Corp., 1987).

Although, there is evidence supporting the hypothesis that a measure of memory, such as the WMS, provides valuable information concerning the brain's functional integrity, there is no comparable tool for use with children. This should not be interpreted to mean there is a lack of interest in the memory functioning of children. There is a large body of research focused on memory in children, but not on the tools used to assess memory. For example, there is a vast literature on children's use of memory strategies (e.g., Brown, 1975; Flavell, 1970; Kail & Hagen, 1977; Ritter, Kaprove, Fitch, & Flavell, 1970). However, in reviewing this literature, it is apparent that there is no standardized method being used, with each laboratory devising its own set of memory tasks based on the specific question under investigation or the researchers' theoretical conceptualization of memory. One possible exception to this may be work with paired associate learning which has proven to be a sensitive technique for detecting memory impairment, although this method is limited by the fact that poor performance could be the result of factors other than circumscribed memory loss e.g., depression or inattention (Squire, 1986). There does appear to be a number of researchers utilizing this method of assessing children's learning and/or memory (e.g., Beery & Baumeister, 1973; Dean, 1984; Estes & Huizinga, 1974). Although the methodology is similar throughout the research, tasks may vary from laboratory to laboratory, with some using only word paired associates (e.g., Ervin, 1961; Petry, 1977), while others use such non-verbal paired associates such as colors or pictures (e.g., Beery & Baumeister, 1973; Estes & Huizinga, 1974; Vellutino, Steger, Harding, & Phillips, 1975). Thus, although there appears to be a great deal of interest and research in the area of children's memory abilities, this research has not provided a useful clinical instrument similar to the WMS.

Memory Development in Children. As discussed above, the literature on children's memory is problematic, but important consistencies have arisen which need to be considered when contemplating what one would expect to find when measuring memory in children. To begin, the term "memory" requires further elaboration.

Four categories of phenomena are useful to distinguish in analyzing memory development (Flavell & Wellman, 1977). The first, basic processes, includes the most fundamental operations and capacities of the memory system. For example, the processes by which an object is instantly and automatically recognized as familiar (Flavell, 1985).

The second category, knowledge, refers to the more or less automatic effects of what one has come to know on what one will store and retrieve. In other words, a person's acquired knowledge, or his "memory in the wider sense" (Piaget & Inhelder, 1973), powerfully influences what s/he stores and what s/he retrieves from storage or "memory in the strict sense."

The third category is a special class of storage and retrieval activities which are called memory strategies. Deliberately rehearsing someone's name in order to memorize it would be an example of a memory strategy. The fourth category is referred to as metamemory, and it refers to an individual's knowledge or cognition about anything pertaining to memory (e.g., that certain kinds of information are harder to learn and remember than others) (Flavell, 1985).

Research focused on these categories has consistently found that they are developmental in nature. Basic processes develop during the course of infancy (Mandler, 1984; Olson & Sherman, 1983; Olson & Strauss, 1984). Knowledge is acquired with age and experience;

> Older individuals will presumably store, retain, and retrieve a great many inputs better or differently than younger ones, for example, simply because developmental advances in the content and structure of their semantic or conceptual systems render these inputs more familiar, meaningful, conceptually inter-related, subject to gap-filling, or otherwise more memorable for them (Flavell & Wellman, 1977, p. 4).

As children grow older, they generally seem more prone and able to make the sorts of inferences that allow for a full, integrated, and meaningful memory representation of what they experience (Liben, 1982;

Nelson, Fivush, Hudson, & Lurcariello, 1983; Paris, 1975; Paris & Lindauer, 1977).

The category of memory strategies encompasses the large and diverse range of potentially conscious activities a person may voluntarily carry out as means to various mnemonic ends (Flavell, 1985). Some of these include rehearsal, clustering, and elaboration. It has been found that the development of memory strategies increases and improves with age (Brown, Bransford, Ferrara, & Campione, 1983; Flavell, Beach, & Chinsky, 1966; Keeney, Cannizzo, & Flavell, 1967). Several authors have described the general course of memory strategy development and the interested reader is referred to these articles (Brown et al., 1983; Naus & Ornstein, 1983; Waters & Andreassen, 1983).

Metamemory also improves with age. There is recent evidence that primitive concepts of remembering and forgetting begin during the early preschool years, as part of the development of the child's implicit "theory of mind" (Bretherton, McNew, & Beeghly-Smith, 1981; Johnson & Wellman, 1980; Shatz, Wellman, & Silker, 1983). Once the child has acquired some sense of what it is to remember and forget:

> There is...much to learn about the capacities, limitations, and idiosyncracies of the human memory system. The growing person could discover that immediate memory is of small span and limited duration, and that additional processing may be needed to optimize subsequent retrival. He could also induce from experience the related, sad fact that one cannot always count on retrieving later what was stored earlier, plus the happy fact that what cannot be remembered right now will often be remembered eventually. There is the further knowledge that the memory system can be untrustworthy as well as porous: It is possible to remember what did not happen and to misremember what did, in addition to outright forgetting (Flavell & Wellman, 1977, p.11).

This limited review on the developmental nature of memory strongly suggests that a clinical measure of children's memory should reflect the increase and improvement of memory with age. In addition, memory and intellectual integrity are often linked (Lezak, 1983; Squire, 1986). In fact, the Wechsler Intelligence Scales are suggested as a good "starting place" for testing memory functions, as they test span of immediate verbal retention and extent of remote memory stored in verbal form (Lezak, 1983). It would therefore appear that another consideration for the measurement of memory would be that the memory task results be related to results obtained from intelligence tests.

Neuropsychological Approach to the Study of Learning Disabilities in Children

One area of great interest within the field of child neuropsychology is that of learning disabilities. However, there are many issues complicating the research in this area. One such issue is that of definition. Kirk (1963) is credited with orignally coining the term "learning disability." However, the conceptualization of childhood learning disorders has spanned nearly 100 years, dating back to Morgan's (1896) case of congenital word blindness.

It was not until 1975 that the 94th U.S. Congress put forth the first widely accepted definition of learning disabilities. This definition stated that the learning disabled child experiences

> a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself in an imperfect ability to listen, think, speak, write, spell, or do mathematical calculations. The term includes such conditions as perceptual

> handicaps, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. (Federal Register, 1976, p. 56977)

However, at this time there is no single definition, with 22 states and the District of Columbia adopting the federal definition, 11 states using a definition written by themselves, one state supplementing the federal definition with the one proposed by the National Joint Committee for Learning Disabilities, and two states have taken a non-categorical approach and thus are not using the learning disabled (LD) label (Chalfant, 1985).

In 1984, a National Task Force was formed to analyze all the definitions being used by the state educational agencies (Chalfant, 1985). The analysis found the following five factors cited in various combinations: (a) a component referring to academic failure, (b) a component referring to psychological processes, (c) a component referring to exclusionary factors, (d) a component referring to etiology, and (e) a component referring to a discrepancy between aptitude and achievement. The task force concluded that "by using all of these factors...the probability of accurately identifying LD students will be increased" (Chalfant, 1985, p.12). So, while the 1984 National Task Force attempted to provide a unified way of describing the learning disabled child, it is obvious that any one or more of the criteria may be stressed or ignored in the differential diagnostic process (Adelman & Taylor, 1986). However, in discussing the definition of LD, it may be appropriate to assume that these five factors are important and somehow accurately describe and differentiate LD children from normal learning (NL) children.

Relationship Between Memory Skills and Learning Disabilities

There appears to be an implicit assumption that there is a cognitive processing problem which results in specific learning problems. This is reflected in the consensus among the various definitions requiring that there be both a processing deficit and a discrepancy between achievement and intelligence present in order to make the diagnosis of a learning disability. One of the processing skills which has been studied is memory.

Review of Current Literature

In reviewing the literature concerned with memory skills and/or problems of learning disabled children, several points are immediately apparent. First, there is a limited amount of research in this specific area. Second, while all the studies show significant differences between normal learning children and LD children, the research thus far has produced a variety of ambiguous results (Fletcher, 1985), with some investigators (e.g., Liberman, Mann, Shankweiler, & Werfelman, 1982; McManis, Figley, Richert, & Fabre, 1978) concluding that memory deficiencies reflect a fundamental difficulty with encoding and storing material in short-term memory. Other researchers (e.g., Bauer, 1977; Torgesen & Goldman, 1977) have argued that memory problems reflect more general difficulties with control processes such as selective attention, organization, and retrieval. Third, research in this area is quite problematic due to difficulty determining appropriate experimental tasks, and lack of uniform tests for either identification or experimentation.

In general, what appears to be one of the greatest problems with this body of literature is the selection of appropriate tasks to define the control population and the experimental population. Given the fact that the definition of a learning disability requires a discrepancy between intellectual level and achievement level, it would seem necessary to determine the intellectual level of both the control sample and the experimental sample, and then define the learning disabled sample as the one with a significant discrepancy on academic achievement tests. However, a review of the current literature focused on memory differences between normal learning (NL) children and LD children found that there exists a wide variation in the methods of determining the children's intellectual level.

Specifically, three different tests were used to determine the children's intelligence, with one study reporting the use of a variety of measurements, and no one tool being given to each child (Bauer, 1977). The three tests used to determine intellectual level were the Wechsler Intelligence Scales for Children-Revised (WISC-R) (Wechsler, 1974), the Peabody Picture Vocabulary Test (PPVT) (Siegel & Linder, 1984), and the Otis-Lennon Intelligence Tests (Swanson & Rathgeber, 1986). While the WISC-R was used to assess IQ level in all but six studies reviewed, methods of computing IQ's varied across studies with some administering the entire test (Fletcher, 1985; Liberman et al., 1982; McManis et al., 1978; Patton & Offenbach, 1978; Senf, 1969;

Vellutino, et al., 1975), and some administering only four subtests (Vocabulary, Similarities, Block Design, and Picture Completion) (Manis, Savage, Jorrison, Horn, Howell, Szeszulski, & Holt, 1987; Torgesen, 1977, 1979). In addition, two of these studies did not uniformly use the WISC-R with all subjects (Manis et al., 1987; Senf, 1969). Finally, in two of the studies, the researchers did not test for IQ, but rather relied on teacher reports or psychoeducational reports (Senf & Freundl, 1971; Steeves, 1983).

Another issue which is not addressed is what IQ level criteria for inclusion and exclusion should be applied. A common interpretation of the definition of learning disability includes the presence of "normal" IQ, which is generally considered to be within the range of 80 to 120 or 85 to 115. While twelve of the studies did apply a minimum IQ score, only four included a maximum IQ score. The eight without maximum cut-off levels utilized various minimum levels of 80 (Bauer, 1977; Siegel & Linder, 1984), 85 (Manis et al., 1987), and 90 (McManis et al., 1978; Patton & Offenbach, 1978; Vellutino et al., 1975) with two reporting that the IQ's were within normal limits (Senf, 1969; Torgesen & Goldman, 1977). The four studies with an IQ range for inclusion varied in that one had a WISC-R range from 80-115 (Fletcher, 1985), one had a range on the Otis-Lennon Intelligence Test from 90-115 (Swanson & Rathgeber, 1986), and two had a range of raw scores on four subtests from the WISC-R from 36-45 (Torgesen, 1977, 1979). Several of the studies reported differences between the control group's IQ scores and the LD group's IQ scores, with the control group always having the higher IQ mean (Bauer, 1977; Fletcher, 1985; Liberman et al., 1982; McManis et al., 1978; Patton & Offenbach, 1978; Senf, 1969; Siegel & Linder, 1984). In addition, two of the studies that may have had significant differences did not report any statistical comparison of the groups' IQ scores (Swanson & Rathgeber, 1986; Vellutino et al., 1975).

Given the diverse methods of obtaining intelligence scores, as well as the various exclusionary criteria utilized, one can begin to understand why the research in this area is limited and often referred to as "ambiguous" (Fletcher, 1985). Add to this the fact that among the studies reviewed, there were eight different tests used to determine academic achievement level. This certainly limits any attempts to compare results between studies. However, there are several results which merit discussion as they provide a starting point for the field to begin to build a more consistent and convergent fund of knowledge.

One consistent finding in each study was that learning disabled children do less well on a variety of memory tasks when compared to children without learning disabilities. This is consistent with what has been repeatedly found, namely, that learning disabled children have learning problems, which include memory deficits. This redundancy aside, what becomes important is to begin to understand the nature of the learning disabled child's memory difficulties.

Several of the studies reviewed concluded that reading disabled children have difficulties with short-term memory (STM) (Liberman et al., 1982; McManis et al., 1978; Siegel & Linder, 1984). Liberman and his associates (1982) found that while general memory abilities were normal in reading disabled children, their ability to remember linguistic items was impaired due to a failure of serial order memory and phonetic representation in STM. In the study conducted by McManis (1978) and his associates, the results supported the implication of STM inadequacies, plus difficulty in utilizing visual-perceptual information. Finally, in the Siegel and Linder (1984) study, it was suggested that the language processing difficulties experienced by learning disabled children were the result of STM deficits. This study also found differences between LD children with reading problems and LD children with arithmetic problems.

Another consistent finding across several studies was the failure of specific memory operations (i.e., storage, recall, rehearsal, or retrieval) (Bauer, 1977; Fletcher, 1985; Torgesen & Goldman, 1977) and/or the ability to organize memory efficiently (Senf & Freundl, 1971; Swanson & Rathgeber, 1986). Bauer (1977) found rehearsal processes in the LD children to be significantly inferior to normal children. The work conducted by Torgesen and Goldman (1977) found that reading disabled children failed to use the efficient mnenomic strategies that were exhibited by normal readers. Senf and Freundl (1971) found that LD children were disproportionately inferior in discriminating, encoding, or recalling visual material. This led to the conclusion that the LD children's problems might be the result of a deficit in memory organization. Further support for this hypothesis was found by Swanson and Rathgeber (1986). Finally, Fletcher (1985) found that children with different performance patterns on the Wide Range Achievement Test (WRAT) exhibited different performance patterns on verbal and nonverbal tasks. Specifically, he found that children with reading problems (_n_ = 10) only had retrieval difficulties on verbal tasks but not on the nonverbal tasks. On the other hand, children with arithmetic problems (_n_ = 13) had both storage and retrieval problems on nonverbal tasks but no problem on verbal tasks.

The emergence of subtypes of learning disabilities is of particular importance. Researchers within the field of learning disabilities (Adelman & Taylor, 1986; Kavale & Forness, 1987) as well as those more focused in the area of child neuropsychology (Rourke & Strang, 1983; Satz & Morris, 1981) have begun to study a specified subsample of children diagnosed as LD, rather than continuing to stress the problem of differentiating learning disabled children from children with other types of learning problems. This addresses the heterogeneity of learning disabilities and provides specific cognitive criteria for both the differentiation between reading, spelling and arithmetic disabilities, as well as subtypes within these subgroups (Rourke & Strang, 1983). (For a complete review of this literature, please refer to Appendix II).

Statement of Purpose

The present research was designed to address two separate but related issues concerning LD children and their memory skills. In order to do this, two studies were conducted. The first study entails the creation of a memory scale adapted from the WMS, with what was hoped would be appropriate changes to make the tool clinically useful in measuring children's memory. A small normal sample (N = 33) was collected which consisted of three age groups; 6-7 year-olds (n = 11), 8-9 year olds (n = 11), and 10, 11, and 12 year olds (n = 11). It was hypothesized that the results of this normal sample would reveal the developmental nature of memory. That is, that the older children would have better scores on the memory scale than the younger children. It was also hypothesized that children with higher IQ scores (measured on the WISC-R) would do relatively better on the memory scale than children with lower IQ scores.

The second study focuses on memory skills within an LD population. Memory is a complex cognitive function which has been shown to reflect the effects of a learning disorder (e.g., Bauer, 1977; Liberman et al., 1982; McManis et al., 1978; Torgeson & Goldman, 1977). In order to further explore this effect, the memory scale developed in Study 1 was administered to a small sample of learning disabled children. Given the consistent findings that LD children do less well on a variety of memory tasks than normal learning children, it was hypothesized that LD children would do less well on the memory scale than the children from the normal learning (NL) sample.

The second area of interest was the model presented by Rourke and his colleagues (see Appendix II), which has shown that learning disabled children are a heterogeneous group and that subtypes can be formed based on profiles derived from the WRAT. A series of studies (Rourke & Finlayson, 1978; Rourke & Strang, 1978; Strang & Rourke, 1983) clearly documented three subtypes within the LD population. These were identified through their profiles on the WRAT. The three groups that emerged were as follows: Group 1 consisted of children who were uniformly deficient on Reading, Spelling, and Arithmetic subtests of the WRAT; Group 2 children exhibited significantly better performance on the Arithmetic subtest relative to their performance on the Reading and Spelling subtests. The children in group 3 exhibited normal achievement on the Reading and Spelling subtests with marked impairment on the Arithmetic subtest.

The present study focused on one of these subtypes, which consisted of children who were significantly behind in Reading and Spelling compared with Arithmetic and who have a significant discrepancy between IQ and achievement performance. The model proposed by Rourke would suggest that these children would perform better on a visual-spatial memory task than on a verbal memory task (Rourke & Finlayson, 1978). Fletcher (1985) utilized this model, and found that children with this profile had poorer verbal skills in general and that they had problems with retrieval of verbal information. Therefore, it was hypothesized that the LD children who showed this pattern of Reading and Spelling lower than Arithmetic achievement would do relatively better on a task requiring the recall of visually presented material than on a task requiring the recall of verbally presented material.

CHAPTER 2

STUDY 1

This study employs a memory scale for children which is modeled after the Wechsler Memory Scale (WMS). This adapted memory scale (Wilson's Adapted Memory Scale for Children [WAMS-C]) was devised to address the developmental diversity of a population of children aged six through twelve.

Methods

Subjects

The criteria for selection of subjects was based on those utilized by Rourke (1975) in his research investigations. The criteria for inclusion was: (a) normal vision and hearing, (b) English as the primary language spoken in the home, (c) judged not to be "culturally deprived" or in need of psychiatric treatment for an emotional disorder (d) full-time attendance in school, (e) full scale IQ (measured by the WISC-R) between 80 and 120, (f) right-handed. (For the complete rationale underlying the use of this selection criteria, see Rourke [1975]). In addition, the children's ages for this study were between six years and twelve years.

The subjects were recruited from the Marana School District in Tucson, Arizona, through the distribution of letters (refer to Appendix III for a copy of this letter). Originally 42 subjects were tested. Of these, five subjects were dropped due to IQ scores above 120, and two additional subjects were dropped because of IQ scores below 80. Two more subjects were dropped because their achievement scores placed them in the LD range.

Instruments

The Wechsler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1974) was devised to provide scale point measures of intelligence for children between the ages of 6 and 16 years, 11 months, and 30 days. The WISC-R contains 12 subtests, 10 which comprise the IQ scores and 2 supplementary subtests. Within the Verbal Scale are Information, Comprehension, Arithmetic, Similarities, Vocabulary, and Digit Span, the supplementary verbal test. The Performance Scale includes Picture Completion, Picture Arrangement, Block Design, Object Assembly, Coding, and the supplementary test, Mazes. Besides separate scores for each subtest, the WISC-R provides a Verbal Intelligence Quotient (VIQ), a Performance Intelligence Quotient (PIQ), and a Full Scale Intelligence Quotient (FSIQ). The IQ scores are obtained by comparing each subject's test performance, not with a composite age group, but exclusively with scores earned by individuals of the same age. Therefore, the IQ score is a relative intelligence rating (Wechsler, 1974).

According to the WISC-R test manual (Wechsler, 1974), split-half reliabilities were obtained for each age group (e.g., 6½, 7½,...16½) on each of the subtests except Digit Span and Coding (which used the test-retest method to test for reliability), and for the three IQ scores, VIQ, PIQ, and FSIQ. The lowest coefficient found within the subtests was .57 for the Mazes subtest in the 15½ year old group. The highest coefficient was .90 for the Block Design subtest in the 16½ year old group. The average coefficients ranged from .72 to .86. There was much less variability found for the three IQ scores. The VIQ reliability coefficient averaged .95 with the range .91 to .96. PIQ averaged .90 with the range .89 to .91. And, FSIQ averaged .96 with the range .95 to .97.

The validity of the WISC-R is supported by intercorrelations among the twelve subtests, and between VIQ, PIQ, and FSIQ, as well as correlations with other Wechsler Scales and the Stanford-Binet Intelligence Scale (Terman & Merrill, 1937, 1973). The inter-correlations among the subtests were quite low, with many coefficients in the .20's or lower. However, the inter-correlations using the VIQ, PIQ, and FSIQ all exceeded .45. When the WISC-R was correlated with the Wechsler Adult Scale of Intelligence (WAIS) and the Wechsler Pre-School and Primary Scale of Intelligence (WWPSI), all coefficients were in the .80's and .90's. The correlations with the Stanford-Binet were also quite good with the majority of coefficients in the .60's and .70's (Kaplan & Sacuzzo, 1982). It can therefore be concluded that the WISC-R is a valid and reliable instrument.

The Wide Range Achievement Test (WRAT) (Jastak & Jastak, 1965) was devised to provide a tool for assessing achievement of the basic school subjects of reading (word recognition and pronunciation), written spelling, and arithmetic computation. It was designed as an adjunct to tests of intelligence. The three subtests are divided into Levels I and II. Level I is designed for use with children between the ages of 5 years, 0 months and 11 years, 11 months. Level II is intended for persons from 12 years, 0 months through adulthood.

Three types of scores are provided by the WRAT: (1) grade ratings, (2) percentiles, and (3) standard scores or deviation quotients based on grade ratings. The grade rating has the characteristics of the mental age used in such tests as the Stanford-Binet and is a statistical anchor of achievement rather than a precise grade placement measure. While the grade score is comparable to the mental age, the standard score is comparable to the IQ of standard tests (i.e., WISC-R). Persons at different ages may receive an identical grade score. Such a score, for example 5.5 grade, stands for superior achievement if achieved by a 7 year-old. It represents defective achievement if obtained by a 25 year-old person. Whether the grade rating is average, below or above average for any particular age level, is shown by the standard score. The WRAT standard score has a mean of 100 and a standard deviation of 15. It is statistically comparable to IQ's obtained from the Wechsler Scales (Jastak & Jastak, 1965).

The WRAT manual (Jastak & Jastak, 1965) reports split-half correlation coefficients and standard errors of measurement at each age group and the two test levels (I and II). They were determined on samples of 200 individuals selected in such a way as to represent probability distributions of achievement based on normative data. The split-half measures used were odd/even scores after the test items of each subject had been arranged in their exact order of difficulty. The order of difficulty of each subject was determined by an item analysis of 1400 records from Level I and 1300 records for Level II. The spelling and reading items are in the order established by this analysis. The arithmetic items deviate in minor ways from that order. The reliability coefficients of the reading subtests ranged from .98 to .99. The reliability coefficients on the spelling subtests ranged from .96 to .99. The reliability coefficient on the arithmetic subtests ranged from .94 to .97.

Validity of the WRAT is demonstrated in several ways. The results of the Reading subtest (1946 edition) were checked against an external criteria in a validity study performed by Wagner (1962). The reading scores of 29 students in a fifth grade were correlated by Wagner (1962) with teacher's ratings of their achievement on a 9 point scale. The correlation between the reading grades and the teachers ratings and grade levels was .78. The WRAT levels and mid-term grades correlated at .88. The WRAT has also been correlated with age (resulting in a significant positive relationship), with the WAIS (coefficients ranged from .28 to .80.), the WISC (coefficients ranged from .26 to .72), and other achievement tests (coefficients ranged from .81 to .93).

The Developmental Test of Visual-Motor Integration (VMI) (Beery, 1982) was designed primarily for preschool and early primary grade children, although the normative sample has an age range from 2 to 15 years. It was devised as a measure of the degree to which visual perception and motor behavior are integrated in children. The test consists of 24 forms that the child is directed to copy. The forms become progressively more difficult as the child proceeds through the test. The raw score is the total number of forms passed up to three consecutive failures. Raw scores are converted to age equivalent scores based on normative tables given in the manual (Beery, 1982). For this study, the age equivalent score was converted to an IQ equivalent score. This score then reflected the child's performance relative to other children his/her own age.

The VMI test manual (Beery, 1982) reports three tests of reliability: interjudge reliability, with coefficients ranging from .58 to .99 with a median of .93; test-retest reliability, which resulted in coefficients ranging from .63 (following a seven month interval) to .92 (following a two week interval); and, split-half coefficients ranging from .66 to .93, with the median .79. The VMI has also been subjected to validity analyses. In analyzing concurrent validity, the VMI was correlated with academic skills (coefficients ranged from .42 to .73), with age (coefficient = .89), with the Bender-Gestalt (coefficients ranged from .41 to .82), with motor skills (coefficient = .76), and visual skills (coefficient = .80). In analysis for predictive validity, it was found that the VMI is valuable when used in conjunction with other measures, and in fact it was the best predictor of achievement in kindergarten when used with a test of auditory-vocal association (Beery, 1982). However, its ability to predict achievement declines as children move up in the grades presumably, according to Beery (1982), because they learn to compensate for visual-motor weaknesses by using newly acquired verbal language skills.

The Wilson's Adapted Memory Scale for Children (WAMS-C) was constructed using the Wechsler Memory Scale (WMS) (Wechsler, 1945) as a model. The WMS was developed to provide a rapid, simple and practical memory examination. The adaptation for children consists of an attempt to provide questions more appropriate for ages 6 through 12, while maintaining the organization of the original memory scale. Similar to the original scale, the WAMS-C consists of seven subtests. Subtest 1 is labeled Information (I). This asks simple questions such as "How old are you?" "When is your birthday?" and "Who is your teacher?", etc. Subtest 2 is labeled Orientation (O). This asks the child for the year, month, day of the week, where s/he is, what city, and what time of day. Subtest 3 is labeled Mental Control (MC). On the original adult scale, there were three parts to this; counting backwards from 20 to 1, repeating the alphabet, and counting by three's. The adapted scale has added days of the week and months of the year. These additions were thought necessary to provide the younger children an opportunity to exhibit their attention and concentration skills.

Subtest 4 is labeled Memory Passages (MP) and is comparable to the Logical Memory subtest on the WMS, consisting of two memory passages. The first passage was taken from the Stanford-Binet Intelligence Test (Terman & Merrill, 1937, 1973), with minor changes (i.e., updating of the names). The second passage was constructed to provide text which contained words of equal meaningfulness and frequency (Christian, Bickley, Tarka, & Clayton, 1978). Children were asked to remember the stories immediately following the presentation and then again 30 minutes after the initial presentation (DMP).

Subtest 5 is labeled Digits (DS). This is equivalent to Memory Span on the WMS and is identical to Digit Span on the WISC-R. Subtest 6 is labeled Associate Learning (AL) and consists of 10 paired word associates, some easy and some hard, which the child is required to learn in three trials. The words are exactly the same as those on the original WMS. The items included were derived from the paired-associate list originally used by Wechsler in his study of the retention defect in Korsakoff psychosis (Wechsler, 1917).

The final subtest is Visual Reproduction (VR) and the task's demands are similar to those on the Visual Reproduction subtest of the WMS. However, the figures were derived from the Developmental Test of Visual-Motor Integration (VMI) (Beery, 1982), as it provides developmental norms for constructional skills. There are three sets of pictures; one for children aged 6 and 7; one for children aged 8 and 9; and, one for children aged 10, 11, and 12. Each set of pictures consists of two figures to be presented separately for 10 seconds and two figures presented together for 10 seconds. The children are asked to reproduce the figure or figures immediately following presentation and again thirty minutes later (DVR). (For the entire administration format as well as the WAMS-C protocol, please refer to Appendix I.)

Procedure

Seven research assistants were recruited for this study. All the research assistants were third or fourth year undergraduate psychology majors at the University of Arizona. The research assistants were required to attend weekly meetings during the Spring semester to receive credit for an Independent Study Project. The assistants were trained to administer all the instruments in the following manner. First, they were given manuals and copies of each test to study. Then they observed the WISC-R and WAMS-C being administered on video tape. Third, they watched, in pairs, the author administer all four tests to one subject. Fourth, they administered the test battery one or two times, with the author present for the entire administration. Finally, they were able to administer the battery on their own, but tape-recorded the administration of the WAMS-C to be reviewed by the author. The tape-recorded sessions were checked by the author for administration and scoring accuracy. The inter-rater reliability for 23 of the protocols was found to be $r = .99$, $p < .0001$. The other 10 subjects were tested only by the author.

Children who participated in this study were administered the WISC-R, WRAT, VMI, and WAMS-C. Both parents and children were given permission forms to sign (refer to Appendix III for copies of these forms). The children and their parents were told that they were participating in a dissertation project studying memory in children. The families were given the opportunity to receive a copy of the study upon completion. The parents were also told that their child's scores on the test measures could not be reported to them by the investigator, but that raw scores could be sent to their child's school psychologist. Twelve of the 42 parents requested this information be sent to the school psychologist at their child's school.

Results

The results obtained were analyzed using the Statistical Package for the Social Sciences (SPSS) computer program. The first set of analyses computed was descriptive statistics on each age group and then on the entire sample (N = 33) (refer to Tables 1, 2, 3, and 4). These tables reveal an interesting result. The Verbal IQ (VIQ) scores as well as the WRAT Reading and Spelling scores were higher in the older age groups. However, Performance IQ (PIQ) and the WRAT Arithmetic score were higher in the younger group.

The data for the WAMS-C was of particular interest, so descriptive analyses were computed to provide means and standard deviations for each subtest as well as for the Total Memory Score (TMS). This set of analyses was also conducted separately for each age group as well as on the entire sample (refer to Tables 5, 6, 7, and 8). These tables reveal an increase in scores from youngest to oldest group across subtests with the exception of the Visual Reproduction subtest (both immediate and delayed recall).

Correlation analyses were also conducted. First, the TMS was correlated with the WISC-R (FSIQ, VIQ, and PIQ), the WRAT (Reading, Spelling, and Arithmetic), the VMI, and Age. Again, this was done for

Table 1

Descriptive Data for WISC-R, WRAT, VMI, and Age

Six and Seven Year Olds (n = 11)

	MEAN	SD
Full Scale IQ	106.9	10.3
Verbal IQ	102.5	11.8
Performance IQ	111.8	9.6
WRAT Reading	108.6	10.6
WRAT Spelling	101.1	9.4
WRAT Arithmetic	103.0	6.7
VMI	92.3	9.3
Age	7.0	.6

Note WISC-R (Wechsler Intelligence Scale for Children-Revised), WRAT (Wide Range Achievement Test), VMI (Developmental Test of Visual-Motor Integration).

Table 2

Descriptive Data for WISC-R, WRAT, VMI, and Age

Eight and Nine Year Olds (n = 11)

	MEAN	SD
Full Scale IQ	107.4	9.4
Verbal IQ	107.7	12.1
Performance IQ	105.6	9.4
WRAT Reading	112.5	16.1
WRAT Spelling	104.8	15.3
WRAT Arithmetic	98.3	5.5
VMI	93.9	10.2
Age	9.0	.7

Note WISC-R (Wechsler Intelligence Scale for Children-Revised), WRAT (Wide Range Achievement Test), VMI (Developmental Test of Visual-Motor Integration).

Table 3

Descriptive Data for WISC-R, WRAT, VMI, and Age

Ten, Eleven, and Twelve Year Olds (n = 11)

	MEAN	SD
Full Scale IQ	106.2	9.1
Verbal IQ	107.2	10.3
Performance IQ	104.1	10.5
WRAT Reading	113.8	10.2
WRAT Spelling	109.8	17.9
WRAT Arithmetic	95.0	6.0
VMI	95.0	8.7
Age	11.4	1.1

Note WISC-R (Wechsler Intelligence Scale for Children-Revised), WRAT (Wide Range Achievement Test), VMI (Developmental Test of Visual-Motor Integration).

Table 4

Descriptive Data for WISC-R, WRAT, VMI, and Age

All Ages (N = 33)

	MEAN	SD
Full Scale IQ	106.8	9.3
Verbal IQ	105.8	11.3
Performance IQ	107.2	10.1
WRAT Reading	111.7	12.1
WRAT Spelling	105.2	14.6
WRAT Arithmetic	98.8	6.8
VMI	93.7	9.2
Age	9.1	2.0

Note WISC-R (Wechsler Intelligence Scale for Children-Revised), WRAT (Wide Range Achievement Test), VMI (Developmental Test of Visual-Motor Integration).

Table 5

WAMS-C[a] Means and Standard Deviations

Six and Seven Year Olds (n = 11)

	MEAN	SD
Information	4.2	0.9
Orientation	4.3	1.4
Mental Control	7.6	2.4
Memory Passages (immediate recall)	7.4	3.6
Memory Passages (delay recall)	5.6	2.8
Digits	7.5	0.8
Associate Learning	13.3	3.9
Visual Reproductions (immediate recall)	10.9	2.3
Visual Reproductions (delay recall)	9.1	2.7
Total Memory Score	55.1	8.3

[a]WAMS-C = Wilson's Adapted Memory Scale for children.

Table 6

WAMS-C[a] Means and Standard Deviations

Eight and Nine Year Olds (n = 11)

	MEAN	SD
Information	4.9	1.0
Orientation	5.5	0.7
Mental Control	10.3	3.0
Memory Passages (immediate recall)	8.7	3.8
Memory Passages (delay recall)	7.5	4.6
Digits	9.1	1.5
Associate Learning	15.9	2.7
Visual Reproductions (immediate recall)	9.5	2.7
Visual Reproductions (delay recall)	9.1	3.4
Total Memory Score	63.8	10.7

[a]WAMS-C = Wilson's Adapted Memory Scale for Children.

Table 7

WAMS-C[a] Means and Standard Deviations

Ten, Eleven, and Twelve Year Olds (n = 11)

	MEAN	SD
Information	6.0	0.0
Orientation	5.9	0.3
Mental Control	11.5	2.0
Memory Passages (immediate recall)	11.3	2.3
Memory Passages (delay recall)	10.2	2.6
Digits	10.6	1.3
Associate Learning	16.9	2.7
Visual Reproductions (immediate recall)	8.5	2.5
Visual Reproductions (delay recall)	7.1	2.8
Total Memory Score	70.6	7.2

[a]WAMS-C = Wilson's Adapted Memory Scale for Children.

Table 8

WAMS-C[a] Means and Standard Deviations

All Ages (N = 33)

	MEAN	SD
Information	5.0	1.1
Orientation	5.2	1.1
Mental Control	9.8	2.9
Memory Passages (immediate recall)	9.1	3.6
Memory Passages (delay recall)	7.8	3.9
Digits	9.1	1.8
Associate Learning	15.3	3.4
Visual Reproductions (immediate recall)	9.6	2.6
Visual Reproductions (delay recall)	8.4	3.1
Total Memory Score	63.2	10.7

[a]WAMS-C = Wilson's Adapted Memory Scale for Children.

each age group separately and then for the entire sample (see Table 9). These analyses help clarify the trends found in the descriptive data. Looking first at the results for the entire sample (TMS All), there are significant relationships found between Verbal IQ, WRAT Reading, WRAT Spelling and Age and the TMS. There is also a trend in the direction of better performance on the memory scale being related to higher Full Scale IQ scores. In general, these results show that as children's verbal skills improve, and as they grow older, their scores on this memory scale improve.

Contrary to this pattern, Performance IQ and WRAT Arithmetic are not related to the TMS for the entire group. In fact, the only significant relationship found between these variables was between WRAT Arithmetic and TMS in the 8-9 year old group. It is also interesting to note that this is the only age group that shows a significant relationship between FSIQ and TMS.

One final point concerning these results. As can be seen in Table 9, there are no significant relationships between the variables within the youngest group. And, only WRAT Spelling and Age are related to TMS in the oldest group. However, all the WRAT subtests, as well as FSIQ and age are related in the middle age group (8-9 year-olds).

The final analysis was a correlation matrix for the WAMS-C (subtests & TMS), FSIQ, VIQ, PIQ and Age for the entire sample (refer to Table 10). First, looking at the correlations between TMS and the subtests, it can be seen that all the subtests are highly correlated to TMS, with the exception of Visual Reproductions (both immediate and

Table 9

Correlations Between WAMS-C Total Memory Score (TMS) and the WISC-R, WRAT, VMI, and Age for Each Age Group and Entire Sample

	TMS 6-7	TMS 8-9	TMS 10-12	TMS all
Full Scale IQ	.365	.552**	.373	.330*
Verbal IQ	.207	.479	.277	.373**
Performance IQ	.402	.308	.263	.045
WRAT Reading	-.012	.738***	.474	.482***
WRAT Spelling	.177	.645**	.890***	.616***
WRAT Arithmetic	.201	.602**	.494	-.002
VMI	.318	.472	.342	.247
Age	.070	.718***	.516*	.694***

* = p < .10   ** = p < .05   *** = p < .01

Note WAMS-C (Wilson's Adapted Memory Scale for Children), WISC-R (Wechsler Intelligence Scale for Children-Revised), VMI (Developmental Test of Visual-Motor Integration).

Table 10

Correlation Matrix for WAMS-C, (TMS and Subtests) WISC-R, and Age

	I	O	MC	MP	DMP	DS	AL	VR	DVR
O	.61**								
MC	.61**	.46**							
MP	.55**	.37*	.50**						
DMP	.61**	.38*	.60**	.90**					
DS	.67**	.49**	.63**	.52**	.67**				
AL	.43*	.30	.52**	.46**	.59**	.60**			
VR	-.06	-.41*	-.12	-.10	-.11	-.13	-.09		
DVR	-.07	-.27	-.18	-.13	-.11	-.14	-.16	.77*	
TMS	.75**	.49**	.79**	.78**	.84**	.79**	.77**	.08	-.01
FSIQ	.17	.18	.20	.39*	.34*	.20	.11	.17	.06
VIQ	.28	.47**	.40*	.35*	.27	.28	.12	-.06	-.09
PIQ	-.04	-.27	-.20	.17	.18	-.05	-.04	.40*	.25
Age	.75**	.50**	.58**	.47**	.49**	.74**	.50**	-.13	-.08

* = p < .05 ** = p < .01

Note I (Information), O (Orientation), MC (Mental Control), MP (Memory Passages), DMP (Delayed Memory Passages), DS (Digits), AL (Associate Learning), VR (Visual Reproductions), DVR (Delayed Visual Reproductions), TMS (Total Memory Score), FSIQ (Full Scale IQ), VIQ (Verbal IQ), PIQ (Performance IQ).

delayed recall). In addition, all of the subtests are highly inter-related, if Visual Reproduction is excluded. In fact, the only non-significant relationship between the remaining subtests, is between Orientation and Associate Learning. When looking at Visual Reproduction and Delayed Visual Reproduction variables, the only significant relationships which emerge are between themselves, and between Visual Reproduction and Orientation.

Examination of the correlations between the subtests and the three IQ scores (FSIQ, VIQ, and PIQ) reveals a significant relationship between FSIQ and the Memory Passages, both immediate and delayed. Looking at the relationships between the subtests and Verbal IQ (VIQ), only Orientation, Mental Control and Memory Passages are significant. Finally, Performance IQ is significantly related to Visual Reproduction.

Discussion

This study supports the conclusion that the WAMS-C is a memory tool that in general provides evidence of both the developmental nature of memory as well as the link between intelligence and memory. There is clearly a strong relationship between increasing age and improved scores on the memory scale presented here. This is consistent with developmental studies of memory (Belmont & Butterfield, 1969; Flavell, 1985; Flavell & Wellman, 1977).

The link between memory and intelligence is less clear cut. Clearly higher Verbal IQ scores are related to higher scores on the WAMS-C. However, the lack of a relationship between Performance IQ and

TMS is also apparent. The inter-test correlations help clarify this finding.

The majority of subtests on the WAMS-C are verbal in nature and the entire test is heavily influenced by this. However, Visual Reproduction (immediate and delayed recall) may be measuring something quite different. That is, this subtest may be measuring visual memory. This type of memory could be considered part of the child's nonverbal intellectual repetoire, which is consistent with the relationship found between Performance IQ on the WISC-R and Visual Reproduction (Table 10). One reason there is no significant statistical results between Visual Reproduction and TMS may be that Visual Reproductions contributes only a small proportion to the overall TMS, which is primarily a score of verbal memory.

However, other methodological issues must also be considered. The lack of relationship between Visual Reproduction (immediately and delayed) and the other subtests, as well as TMS, may be an artifact of the test construction itself. The Visual Reproduction subtest was the only section of the test which varied the stimuli according to the age group. While this was done in hopes that the constructional skills of each age group would not interfer with test performance, the effect may have been to create a task with varying difficulty levels. If this were true, then it would appear that the younger children had an easier set of figures and that the figures became increasingly more difficult for the two older groups.

CHAPTER 3

STUDY 2

This study focuses on the WAMS-C and its ability to differentiate between a learning disabled sample of children and a normal learning sample of children. In Study 1 the WAMS-C was shown to generally reflect the developmental nature of memory and the relationship between intelligence (Verbal IQ) and memory. For study 2, it is hypothesized that LD children with reading and spelling deficits will evidence a verbal memory deficit and that their visual memory will be intact. In order to test this hypothesis, a subtype of LD children was identified utilizing the model set forth by Rourke (1975). The LD children who participated in this study had reading and spelling deficits, with relatively better arithmetic skills.

Methods

Subjects

The criteria for selection of subjects was based on the selection criteria utilized by Rourke (1975) in his subtyping of learning disabilities investigations. The criteria for inclusion was: (a) normal vision and hearing (b) English as the primary language spoken in the home (c) judged not to be "culturally deprived" or in need of psychiatric treatment for an emotional disorder (d) full-time attendance in school (e) full scale IQ (measured by the WISC-R) between 80 and 120 (f) right-handed. (For the rationale underlying the use of this selection criteria, see Rourke [1975].) In addition, the children's ages for this study were between eight years and twelve years.

The LD children were identified on the basis of their achievement scores on the WRAT Reading, Spelling and Arithmetic subtests. The control subjects scored above the 30th centile on all three subtests. The LD children chosen for this study had percentile scores below 25 on Reading and Spelling, with Arithmetic percentile scores above 25. This method of identification of a specific subtype of LD children conforms with the model developed by Rourke and his colleagues over the past few years (i.e., Petrauskas & Rourke, 1979; Rourke & Finlayson, 1978; Strang & Rourke, 1983). Rourke has claimed that subtypes of LD children can be reliably differentiated based on their WRAT profiles (For a complete review of this literature, please refer to Appendix II).

The LD subjects were drawn from three clinics in Southern California; UCLA's Learning Clinic; Kaiser Permanente's Pediatric Clinic; and, The Child Study Center. The clinic records of all children seen within the past year at the Learning Clinic and the Child Study Center were reviewed. Children who met the inclusion criteria and were thought to have a learning disability received either a telephone request to participate or a letter (see Appendix III for samples of these letters). Kaiser Permanent's Pediatric Clinic director made letters available to parents who brought their children to the clinic for learning problems. All LD children solicited for participation were screened for the possibility that they would have learning difficulties consistent with the specific profile under investigation, that is, to be significantly behind in Reading and Spelling achievement, with relatively better achievement in Arithmetic.

Originally, 22 subjects were found and tested. Of these, three subjects were dropped due to IQ scores below 80 and one subject was dropped because of an IQ score above 120. Four more subjects were lost during the matching process, generally due to differences in IQ scores (with the LD children being significantly lower than age-matched control children). Finally, six more subjects were excluded due to their WRAT profiles, which did not conform to the specific profile required for this study. Specifically, two children had percentile scores below 25 on all three WRAT subtests; one child had percentile scores above 25 on both Spelling and Arithmetic; one child had percentile scores above 25 on both Reading and Spelling, with Arithmetic below the 25th percentile; one child had percentile scores below 25 on Spelling and Arithmetic, with Reading above the 25th percentile; and, one child had Reading and Arithmetic scores below the 25th percentile, with Spelling above the 25th percentile.

The normal learning children were part of the sample collected from the Marana School District in Tucson, Arizona, and reported in Study 1. All these children met the inclusion criteria and did not evidence a learning disability. They were matched to the LD children on both IQ and age. In order to be considered a match, the Full Scale IQ's could not differ by more than eleven IQ points. The age difference could not be greater than six months between a matched pair.

Instruments

The instruments used were the same as reported in Study 1.

Procedure

Children who met inclusion criteria and were thought likely to meet requirements for the classification of learning disabled (based on an interview with parents who responded to the letter, and/or a review of clinic records) were administered the WISC-R, WRAT and the WAMS-C. Both parents and children were given permission forms to sign. The children and their parents were told that they were participating in a dissertation project studying memory in children. The families were given the opportunity to receive a copy of the study upon completion. The parents were also told that their child's scores on the measures could not be reported to them by the investigator, but that raw scores could be sent either to the child's school psychologist or the clinic from which they had received the letter. Four of the eight parents requested this information be sent to their clinic.

As discussed in the Subjects subsection for Study 2, the normal learning (NL) children were matched to the LD children on age and FSIQ. The children drawn from the NL sample had to be within six months of their matched LD pair, with a FSIQ score within 11 points of the same child. The cut-off for Full Scale IQ scores was based on information provided in the WISC-R manual (Wechsler, 1974). The three IQ scores provided by the WISC-R were constructed by transforming each sum of scaled scores for an age group to a new scaled score with a mean of 100 and a standard deviation of 15. This process was carried out for each age group. Therefore, a score of 100 defines performance of an average child of the same age. And, with the standard deviation of 15, two-thirds of the population of children will score between 85-115.

The method for determining whether a difference between scores is significant at some stated level of confidence, requires the computation of the standard error of measurement of the difference between the two scores that are compared. This statistic is a function of the standard error of measurement of each test in a pair. Wechsler (1974) reported that a seven point difference between the Verbal IQ and Performance IQ was significant at the 15 percent level and that a ten point difference was significant at the five percent level. He states in the manual that a diffference of 15 points or more is the level he would consider requiring further investigation. Therefore, while this study is not comparing the three IQ scores of an individual child, but rather FSIQ scores for different children, the same rational was thought appropriate to apply here and a conservative difference of 11 points was chosen.

Results

The results obtained on the WAMS-C were analyzed using the Statistical Package for the Social Sciences (SPSS) computer program. The first set of analyses involved descriptive statistics on each group (learning disabled [LD] children and normal learning [NL] children). Table 11 provides the comparison between FSIQ, VIQ, PIQ, and Age for the two groups. As can be seen, there is no difference in age between the

Table 11

FSIQ, VIQ, PIQ, and Age Means and Standard Deviations for Learning Disabled (LD) and Normal Learning (NL) Children

	LD Children (N = 8)	NL Children (N = 8)	t
FSIQ mean	102.5	108.1	3.19*
SD	10.9	7.6	
VIQ mean	99.6	110.5	2.72*
SD	11.0	7.7	
PIQ mean	106.5	104.0	.70
SD	11.8	12.0	
Age mean	9.8	9.8	.19
SD	1.4	1.4	

* = $p < .05$

Note FSIQ (Full Scale IQ), VIQ (Verbal IQ), PIQ (Performance IQ), SD (Standard Deviation.

two groups. Also, there is no difference between PIQ. However, both FSIQ and VIQ differ significantly between the groups. But, the point difference (FSIQ = 5.6; VIQ = 10.9) does not exceed 11 points and all means remain within the 85 to 115 range.

As can be seen by the results on Table 12 there are differences between the means on all the subtests. Dependent t-tests were conducted between the two groups subtest means and the Total Memory Score (TMS) means. The results of these analyses found significant differences on the following subtests: Mental Control (MC), Digits (DS), and Associate Learning (AL). A significant difference between the NL children's TMS mean score and the LD children's mean TMS score was also found. There were no other significant differences found between the subtest means.

Further analyses of the data were considered appropriate, given the significant differences between the two groups on the WAMS-C. To better understand the relationship between the TMS from the WAMS-C and the scale's subtests, a correlation matrix was created for each group. The delayed memory score for Memory Passages (DMP) and Visual Reproductions (DVR) were included. Age, Full Scale IQ (FSIQ), Verbal IQ (VIQ), and Performance IQ (PIQ) were also added to the matrix to see if the developmental trend found in the normal sample of Study 1 would emerge within these smaller samples.

First, looking at the pattern of results for the two groups on the subtests of the WAMS-C, it is apparent that the two matrices differ (see Tables 13 and 14). In general, the subtests appear to be more highly inter-related for the LD sample with Delayed Visual Reproductions (DVR)

Table 12

Descriptive Data for the Wilson's Adapted Memory Scale for Children (WAMS-C) With Comparisons between Normal Learning (NL) Sample and Learning Disabled (LD) Sample

	NL (N = 8)		LD (N = 8)		t
	$\bar{x}$	SD	$\bar{x}$	SD	
Information	5.6	.6	5.1	1.8	1.04
Orientation	5.9	.1	5.3	1.1	.74
Mental Control	11.4	2.2	7.0	2.3	3.62**
Memory Passages	10.3	3.2	9.1	3.4	.72
Delayed Memory Passages	8.7	3.4	8.3	3.8	.30
Digits	9.8	1.3	8.0	1.1	5.58**
Associate Learning	17.0	2.2	13.6	3.9	3.58**
Visual Reproductions	7.6	2.1	8.2	2.8	-.66
Delayed Visual Reproductions	6.9	3.6	6.9	3.1	.00
Total Memory Score	67.6	6.8	56.3	11.2	4.56**

* = $p < .05$ ** = $p < .01$

Table 13

Correlation Matrix for LD Children's Scores on WAMS-C

(TMS and Subtests), FSIQ, VIQ, PIQ, and Age

	I	O	MC	MP	DMP	DS	AL	VR	DVR	TMS
O	.69**									
MC	.09	.00								
MP	.36	-.13	.12							
DMP	.27	-.33	.25	.93***						
DS	-.20	-.39	.00	.45	.60**					
AL	.50*	.08	.56*	.43	.54*	.16				
VR	.63**	.07	.37	.86***	.86***	.38	.56*			
DVR	.21	-.12	.34	.84***	.86***	.69**	.63**	.74**		
TMS	.63**	.14	.55*	.78**	.81***	.33	.83***	.91***	.82***	
FSIQ	-.12	-.57*	.55*	.41	.48	.00	.34	.43	.32	.41

(table continues)

Table 13 (continued)

Correlation Matrix for LD Children's Scores on WAMS-C

(TMS and Subtests), FSIQ, VIQ, PIQ, and Age

	I	O	MC	MP	DMP	DS	AL	VR	DVR	TMS
VIQ	-.01	-.30	.42	.36	.29	-.09	.11	.43	.20	.32
PIQ	-.17	-.69**	.54*	.39	.58*	.16	.57*	.34	.42	.45
Age	.64**	.50*	.34	.17	.23	-.17	.37	.38	.10	.45

* = $p < .10$ ** = $p < .05$ *** = $p < .01$

Note I (Information), O (Orientation), MC (Mental Control), MP (Memory Passages), DMP (Delayed Memory Passages), DS (Digits), AL (Associate Learning), VR (Visual Reproductions), DVR (Delayed Visual Reproductions), TMS (Total Memory Score), FSIQ (Full Scale IQ), VIQ (Verbal IQ), PIQ (Performance IQ).

Table 14

Correlation Matrix for NL Children's Scores on WAMS-C

(TMS and Subtests), FSIQ, VIQ, PIQ, and Age

	I	O	MC	MP	DMP	DS	AL	VR	DVR	TMS
O	.34									
MC	.10	.44								
MP	.30	-.34	.10							
DMP	.48	-.30	.26	.87***						
DS	.49	-.08	.19	.30	.44					
AL	.13	.65**	.65**	.02	.18	.08				
VR	.34	-.26	.28	-.06	.23	.43	-.17			
DVR	.45	-.35	.36	.35	.63**	.48	-.03	.89***		
TMS	.54*	.18	.74***	.56*	.74***	.60**	.55*	.43	.68**	
FSIQ	.19	-.37	-.12	.36	.52*	.58*	.24	.25	.42	.39

(table continues)

Table 14 (continued)

Correlation Matrix for NL Children's Scores on WAMS-C

(TMS and Subtests), FSIQ, VIQ, PIQ, and Age

	I	O	MC	MP	DMP	DS	AL	VR	DVR	TMS
VIQ	-.21	-.18	.32	.41	.32	.62**	.31	-.04	.10	.47
PIQ	.38	-.26	-.37	.07	.36	.24	.08	.33	.41	.12
Age	.58**	.50*	.53*	.53*	.47	.03	.46	-.01	.22	.66**

* = p < .10 ** = p < .05 *** = p < .01

Note I (Information), O (Orientation),MC (Mental Control), MP (Memory Passages), DMP (Delayed Memory Passages), DS (Digits), AL (Associate Learning), VR (Visual Reproductions), DVR (Delayed Visual Reproductions), TMS (Total Memory Score), FSIQ (Full Scale IQ), VIQ (Verbal IQ), PIQ (Performance IQ).

significantly related to Memory Passages (MP), Delayed Memory Passages (DMP), Digits (DS), Associate Learning (AL), and Visual Reproductions (VR); VR was significantly related to Information (I), MP, DMP, and AL; DMP was significantly related to MP, DS, and AL; and, AL was significantly related to I, and Mental Control (MC). Within the NL sample, the subtests which were significantly related to one another were AL and MC; AL and Orientation (O); MP and DMP; DMP and DVR; and, VR and DVR.

The relationship between the TMS and the subtests was less variable between the two groups. Within the LD group, all subtests correlated significantly with TMS except O and DS. In NL group, only O and VR were not significantly related to TMS.

Finally, the patterns between the subtests and TMS of the WAMS-C and FSIQ and Age for the two groups also appear to be quite different. Within the LD group, the only significant relationship found between these variables was for FSIQ and MC (see Table 13). Within the NL sample of children, MC, MP, and TMS were significantly related to Age, while DMP and DS were significantly related to FSIQ.

Given the significant difference between the two groups on the TMS, as well as the differing patterns of correlations on the subtests, a discriminant analysis was performed to identify the subtests on which there was the most differences between the groups and the nature of the dimensions on which they differed. The analysis contained the five subtests, Mental Control (MC), Memory Passages (MP), Digits (DS), Associate Learning (AL), and Visual Reproductions (VR). The discriminant function equation which resulted was $Z_y = (.81z_{mc}) + (.11z_{mp}) + (.67z_{ds}) + .04z_{al}) + (-.69z_{vr})$ (refer to Table 15). Table 16 shows the reordering of the variables when they are ordered by size of correlation within the function. The mean discriminant score of the function for the NL sample was 1.41. The mean discriminant score of the function for the LD sample was -1.41.

Discussion

The results of the analyses support the hypothesis that LD children would significantly differ from NL children on the WAMS-C, and that this difference would be the result of lower performance by the LD children. However, the individual *t*-tests between the subtests of the WAMS-C, as well as the discriminant analysis, did not result in the predicted patter. That is, the LD children's performance was not significantly impaired on Memory Passages (MP) compared to the NL children's performance. In fact, neither MP or Visual Reproductions (VR) differentiated the groups. Instead, the lowered performance by the LD children appears to be the result of difficulty on the subtests Mental Control (MC), Digits (DS), and Associate Learning (AL). These results offer several interesting interpretations.

First, this cluster of subtests (MC, DS, and AL) all appear to have a high demand for attention and concentration. MC requires the children to recite rote information (i.e., counting backwards, ABC's, etc.) as quickly as possible. Good performance on this subtest requires the ability to maintain sequential order, which is, in part, an attentional

Table 15

Standardized Discriminant Function Coeffecients

	Function 1
	Coefficients
Mental Control (MC)	0.81
Memory Passages (MP)	0.11
Digits (DS)	0.67
Associate Learning (AL)	0.04
Visual Reproductions (VR)	-0.69

Table 16

Variables Ordered by Size of Correlation Within Function

	Function 1
	Correlations
Mental Control (MC)	0.69
Digits (DS)	0.53
Associate Learning (AL)	0.38
Memory Passages (MP)	0.13
Visual Reproductions (VR)	-0.09

task. And, counting by three's places additional demands on the child's ability to concentrate.

The Digits subtest is the same as Digit Span on the WISC-R, and has been considered one of three subtests within the WISC-R which measures attention (Kaufman, 1975). Kaufman (1975), in his factor analysis of the WISC-R, found three factors. He identified these as Verbal Comprehension (VQ) (consisting of Information, Similarities, Vocabulary, and Comprehension); Perceptual Organization (PQ) (consisting Picture Completion, Picture Arrangement, Block Design, and Object Assembly); and, Freedom from Distractibility (DQ) (consisting of Digits, Arithmetic, and Coding). Kaufman (1975) initially supported DQ as a measure of distractibility, but at the same time cautioned that it may instead simply be a measure of numberical ability. In subsequent work, Kaufman (1979) proposed that DQ may actually be measuring sequencing ability, anxiety, or symbolic reasoning.

Other researchers have supported some of these suggestions. Meeker (1969, 1975), using Guilford's three-dimensional theoretical model of intelligence, developed a comprehensive technique for interpreting the WISC-R. She found that only the subtests Coding, Digit Span, and Arithmetic have symbolic content and concluded that it is actually a measure of a child's ability to manipulate numerical symbols. Another method of reorganization of the WISC-R has been proposed by Bannatyne (1971, 1974). One category, which he labeled Sequencing Ability, coincides exactly with Kaufman's DQ factor. However, these interpretations are not inconsistent if one views freedom from distractibility as an attentional measure, and if one considers, as Lezak (1983) has stated, that problems in attention and/or concentration affect serial conceptual reasoning particularly required by arithmetic and sequencing tasks.

The suggestion of a link between attentional deficits and LD children is not new. In 1971, Dykman (1971) and his colleagues outlined a theory proposing that the difficulties experienced by the LD child in the learning situation are explained by "organically based deficiencies in attention" (Dykman, Ackerman, Clements, & Peters, 1971). And, a great deal of subsequent research supports the notion that LD children as a group, do differ from NL children on a variety of attention measures. Several reviews of the literature (Keogh & Margolis, 1976; Routh, 1979; Samuels & Edwall, 1981; Tarver & Hallahan, 1974) present evidence for LD versus control group differences on vigilance, reaction time, distractibility, and arousal. Other factors presumably related to the construct of attention have also been found within LD samples (e.g., overactivity, field dependence/independence, impulsivity, etc.). Therefore, given the repeated link between attention and learning disabilities (Copeland & Wisniewski, 1981; Senf & Freundl, 1971), the current results linking an attentional deficit to the lowered performance of the LD children on the WAMS-C are understandable.

This suggested interpretation supports the possibility that LD children with IQ's between 80 and 120, and with WRAT profiles exhibiting Reading and Spelling deficits, have difficulty on cognitively complex tasks such as memory because of attentional deficits. One way to further explore this would be to utilize the factor analytic approach Kaufman (1975) applied to the WISC-R to determine if there is a unique relationship between DQ and the WAMS-C within a sample of LD children.

An alternative explanation, which should not be considered to be mutually exclusive of the previous explanations (Farnham-Diggory & Gregg, 1975), would be a failure in the short-term memory (STM) system of the LD children (McManis et al., 1978). As with the literature linking attentional deficits with LD performance difficulties, there is a large body of research supporting this relationship (e.g., Cohen & Netty, 1978; Cummings & Faw, 1976; Ritchie & Aten, 1976; Shankweiler, Liberman, Mark, Fowler, & Fischer, 1979). However, the role of STM and/or the point of failure is controversial. Some researchers have concluded that memory deficits of LD children identified with reading problems, appear to be restricted to the domain of phonetic representation in STM (Liberman, et al., 1982; Farnham-Diggory & Gregg, 1975). Others view STM deficits of the LD child in the context of language processing, and are not limited to one cognitive function (i.e., reading), but believe the failure in STM affects learning in general (i.e., reading and arithmetic) (Lesgold & Perfetti, 1978; Perfetti & Lesgold, 1977; Siegel & Linder, 1984).

Finally, there are a number of researchers who propose that the problem in STM lies in the knowledge and use of efficient memory strategies (Bauer, 1977, 1979; Torgesen, 1977, 1979; Kee, Worden & Throckmorton, 1984; Ornstein & Naus, 1978). The consensus of these studies appears to be that LD children do not use rehearsal and/or elaborative encoding strategies spontaneously, which impairs their performance on most experimental tasks. A related conclusion is that LD children have inadequate metamemory development (Torgesen, 1979) which prohibits their use of appropriate memory strategies such as labeling, verbal rehearsal and clustering.

As stated above, the current results do not argue against the notion that the LD children participating in this study evidenced a STM deficit. However, the lack of significant group differences on either Memory Passages or Visual Reproductions is troublesome. Both MP and VR require an immediate memory response (consistent with the idea that this requires STM abilities) as well as a delayed memory response. However, neither subtest revealed differences between the groups. One possible explanation may be found in the conclusions reported by Lesgold and Perfetti (1982). They found that disabled readers made greater use of a semantic code in STM than did normal readers; that is, disabled readers appeared to have a greater tendency than did normal readers to code items in terms of meaning. The subtests MP and VR provide stimuli which are more meaningful (i.e., a story rather than numbers or word pairs; visually familiar shapes), which the LD subjects may be able to utilize in order to compensate for other STM memory deficits.

As mentioned earlier, the two explanations for the current results are not incompatible, and in fact the underlying process affecting the LD children's performance may be the intersection of these two processes. Intuitively, it seems necessary to have adequate attentional skills to obtain information to be held in STM. Lezak (1983) terms what resembles this intersection, "mental tracking" and defines it as the number of bits of information a person can attend to at once and repeat in order. It is easy to see how this process would be particularly necessary for Digits and Counting by three's.

CHAPTER 4

GENERAL DISCUSSION

The WAMS-C has been shown to be an instrument which reflects the developmental nature of memory. The relationship between intelligence and the memory skills measured by the WAMS-C suggests that the obtained total memory score (TMS) reflects predominantly verbal memory. There also appears to be a portion of the test, Visual Reproductions (VR) (immediate and delayed), which is not in general related to the other subtests of WAMS-C or TMS but is related to Performance IQ. This suggests that VR and DVR may be more related to nonverbal skills.

The WAMS-C also differentiated between a specific subtype of learning disabilities and NL children. However, the tasks which reflected the differences between these samples appear to reflect short term memory (STM) deficits and/or attentional problems. The hypothesis that a verbal memory task would differentiate the samples was not supported for the specific subtest (MP & DMP) thought to best assess verbal memory. But the three subtests, MC, DS, & AL, which did differentiate between the groups are all verbal in nature. And, the WAMS-C appears to be predominantly verbal, so the significant difference on TMS, may reflect a verbal deficit within this LD sample.

The above conclusions are very tentative due to the methodological limitation of this study. The first issue is the small number of subjects in both Study 1 & Study 2. Although the normative study which attempted to extend the age limits of the WMS was also small (Ivinskis et al., 1971 [n = 30]), the increased age span (6 to 12 versus 10 to 14), as well as the decision to divide the sample into three subgroups based on age, (6-7, 8-9, and 10,11 &12) prevents the present study's ability to provide normative data. Instead, Study 1 provides a comparison sample. Further research into the development of norms for the WAMS-C would require large representative samples for each age group.

The extremely small number of subjects in Study 2 also units the conclusions which can be drawn. The fact that significant differences were found provides encouragement for further research in this area. One area which might prove helpful would be to continue exploring the nature of the LD's deficit. Is it STM or attention, or is it a more general deficit in verbal processing?

Besides the small number of subjects, there also appears to be a bias within the NL sample of Study 1. Looking at the three IQ scores for each age group, it can be seen that the younger children have better nonverbal skills than verbal skills with a 9.3 point difference between VIQ and PIQ. The two older samples do not exhibit this difference (2.1 for 8 and 9 year olds; 3.1 for ten, eleven and twelve year olds). It would be important for future research to sample children more representatively so that the different age samples reflect similar IQ patterns to the general population. As it stands, any conclusions about an interaction between age and differential verbal/nonverbal abilities is inappropriate due to this problem in the sample.

A final problem which emerged within Study 1 is related to the test construction. As discussed earlier, the decision to vary the stimuli for VR may have produced an artificial division between verbal memory and what appears to be visual memory. While it can certainly be argued that VR has face validity a visual memory task, the varying of stimuli confounds the results and does not allow for this distinction to be made. There are several ways to address this problem. One way would be to use the same stimuli for VR with all children regardless of age. The choice of figures would need to consider including figures simple enough for the more limited constructional skills of the younger children as well as more complex figures for the oldest subjects. This would be necessary to avoid floor and ceiling effects for the youngest and oldest subjects. Perhaps including a figure appropriate for each age group (which might necessitate more figures) would address this issue. Another possible solution would be to maintain the age groups without any attempt to combine groups. This would require much larger samples for each age group.

Another way to address this problem would be to vary the Memory Passages stimuli for age appropriateness. It could be argued that all the verbal subtests should be varied for each age group, if the question is how to determine whether or not the WAMS-C measures both verbal and visual memory. MP requires both immediate and delayed memory, similar to VR. The difficulty with this method would be in the need for equivalency of difficulty both across ages for each subtest and then between the two subtests. Russell (1975) addressed the issue of equivalency between subtests by converting the scores to *t*-scores and then comparing the performance on both. However, this method requires a large enough sample to insure a normal distribution within the sample and this is rarely done. Further, the use of *t*-scores does not entirely correct for nonequivalency of difficulty across different tasks.

Given the above difficulties within the development of the WAMS-C, it makes the results of Study 2 tenuous, particularly due to the fact that the NL sample was drawn from the participants in Study 1. The exclusion of the youngest group eliminated the sample bias discussed earlier. However, the test construction difficulties remain, making any conclusions, which include VR inappropriate at this time. However, there remains the significant difference between the NL children and LD children on subtests which are 1) verbal in nature, 2) require attention and concentration, and 3) require STM abilities. Any further speculation concerning these results would be inappropriate at this time given the methodological issues discussed.

In conclusion, the WAMS-C is a new tool designed to measure memory in children aged six through twelve. The present research is a first attempt at providing a normative sample for comparison with other clinical populations. The small number of subjects as well as methodological problems limit the conclusions that can be made. However, there were intriguing significant results which warrant further study.

APPENDIX I: WILSON'S ADAPTED MEMORY SCALE FOR CHILDREN

ADMINISTRATION OF THE WILSON'S ADAPTED MEMORY SCALE FOR CHILDREN

SUBTEST I: INFORMATION

1. How old are you?

2. When is your birthday?
   (Younger children may be able to spontaneously give the month and day but not the year. Therefore try prompting the child with "And, do you know what year you were born?" Score correct only if child gives day, month and year.)

3. Who is the principal of your school?

4. Who is your teacher?

5. Who was your teacher last year?

6. Who is the President of the United States?
   (Younger children may respond "George Washington." If so, state, "Yes, he was the first President of the United States but who is the President now?")

Scoring: Score one point for each item correctly answered.
Check with the child's parent(s) to determine the accuracy of his/her answers to questions 3,4, and 5.

Maximum Score: 6 points.

SUBTEST II: ORIENTATION

1. What year is it?

2. What month is it?

3. What day of the week is it?

4. Where are we right now?
   (If the child responds concretely, i.e., "in your office," ask "Where is my office?")

5. What city are we in?

6. What time of the day is it now?
   (For younger children add "what part of the day is it now?" Score this correct if the child's response correctly identifies morning, afternoon, or evening.)

Scoring: Score one point for each item correctly answered.
Maximum Score: 6 points.

SUBTEST III: MENTAL CONTROL

1. Count backward from 20 to 1.
   Say, "I want to see how well you can count backward from 20 to 1, like this - 20, 19, 18 - all the way back to 1." The examiner may repeat directions but gives no aid whatsoever during subject's effort. Record errors and time (seconds).

Scoring: Score 2 points if no error.
Score 1 point if one error only.
Score 1 point extra if correct with no errors within 10 seconds.
(Spontaneous corrections are not counted as errors.)
Maximum Score: 3 points.

2. Alphabet.
   Say, "I want to see how quickly you can say the alphabet for me - A,B,C, all the way to Z - go ahead." Record errors and time (seconds).

Scoring: Score 2 points if no error.
Score 1 point if one error only.
Score 1 point extra if correct with no errors within 10 seconds.
Maximum Score: 3 points.

3. Days of the Week.
   Say, "Tell me the days of the week." Record errors and time (seconds).

Scoring: Score 2 points if no error.
Score 1 point if one error only.
Score 1 point extra if correct with no errors within 10 seconds.
Maximum Score: 3 points.

4. Months of the Year.
   Say, "Tell me the months of the year. Begin with January." Record errors and time (seconds).

Scoring: Score 2 points if no error.
Score 1 point if one error only.
Score 1 point extra if correct with no errors within 10 seconds.
Maximum Score: 3 points.

5. Counting by Three's.
Say, "I want to see how quickly you can count by 3"s, beginning with 1. Like this - 1 plus 3 is 4, plus 3 is what? That's right, now you try starting at 1." Stop the child when s/he reaches 40. Record errors and time (seconds). If the child continues to use the strategy of saying out loud "plus 3," give credit if correct.

Scoring: Score 2 points if no error.
Score 1 point if one error only.
Score 1 point extra if correct with no errors within 15 seconds.
Maximum Score: 3 points.

MAXIMUM SCORE FOR ENTIRE SUBTEST: 15 points.

SUBTEST IV: MEMORY PASSAGES

Memory Passage A:
Say, "I am going to read to you a short story. Listen very carefully because when I am through I want you to tell me everything you can remember about the story. And in a little while, about 30 minutes, I will ask you to remember the story again, so really pay attention." Then read the story. After reading the first story, say "Now what did I read to you? Tell me everything you remember." Record verbatim or by underlining the recalled words/passages in the story.

Scoring: Score 1 point for exact recall of entire section within dashes. Score .5 for partial passages or for similar idea without the exact word, i.e., horse rather than pony.

Memory Passage B:
After the recall of Story A is complete, say, "Now I am going to read you another story and see how much you can remember of this new story. Listen very carefully because when I am through I want you to tell me everything you can remember about the story. And again, in about 30 minutes, I will ask you to remember the story again, so really pay attention." Then read the story. Then say, "Now what did I read to you? Tell me everything you remember." Record verbatim or by underlining the recalled words/passages in the story.

Scoring: Score 1 point for exact recall of entire section within dashes. Score .5 for partial passages or for similar idea without exact word, i.e., pupils for students.

Final score is the average number of ideas correctly reproduces on both passages.

SUBTEST V: DIGITS

Digits Forward: Say, "I want to see how well you can pay attention. I am going to say some numbers and when I am through I want you to say them right after me. Listen." Give both series in each set, even if the child gets the first series correct. Discontinue when both series of a set are failed.

Scoring: Score is maximum number of digits repeated correctly; for example, if subject repeats 5 digits on either of 2 trials, his/her score is 5. As this is identical to the Digit Span on the WISC-R, only administer once and rescore appropriately for the WISC-R.
Maximum Score: 8 points.

Digits Backward: Begin with series of 2, after illustrating thus: "I want to see how well you can hold numbers in your mind. I am going to read to you a series of numbers and when I am through I want you to say them after me backward. For example, if I say 1 - 9, you should say (pause and wait to see if the child responds spontaneously) 9 - 1." If the child does not respond correctly, say, "that was not quite right, you should have said 9 - 1. Now listen again and remember to say them backward. Are you ready? "Give the first series. Give both series in each set, even if the child gets the first series correct. Discontinue when the child fails both series in a set.

Scoring: Score is maximum number of digits which child can repeat backward.
Maximum Score: 7 points.

MAXIMUM SUBTEST SCORE: 15 points.

SUBTEST VI: ASSOCIATE LEARNING

Say, "I am going to read to you a list of words, two at a time. Listen carefully because after I am through I will expect you to remember the words that go together. For example, if the words were EAST-WEST; GOLD-SILVER, then when I say the word EAST, I would expect you to answer (pause) WEST. And when I say the word GOLD, you would answer (pause) SILVER. Do you understand?" When the child is clear as to the directions continue as follows: "Now listen carefully to the list as I read it." Read the first presentation - METAL-IRON, BABY-CRIES, etc., at the rate of one pair every two seconds. After reading the first presentation, allow five seconds and test by presenting the first recall list. Give the first word of the pair. If the child gives the correct response say "That's right," and proceed with the next pair. If the child gives an incorrect reply say "No," and supply the correct association, and proceed with the next pair. If the child replies that s/he does not know, prompt him/her to guess and then supply the correct word if incorrect, then proceed with the next pair. After the first recall has been completed, allow a ten second interval and give the second presentation list proceeding as before. Repeat the recall a second time. Finally, allow a ten second interval and give a third presentation of the list followed by a third recall, proceeding as before.

Scoring: One point for each correct response. The final score results from adding all credits obtained on easy associations in left-hand column and dividing score by 2. Total points on hard associations in right hand column. Total the columns separately. Score on entire subtest is sum of both easy and hard association scores.
Maximum Score: 21 points.

SUBTEST VII: VISUAL REPRODUCTION

Directions: There are three sets of cards. One is for ages six and seven, one for ages eight and nine, and one for ages ten, eleven and twelve. The cards are marked by the ages and order of presentation.
For Cards I and II: Say, "I am going to show you a drawing. You will have just ten seconds to look at it; then I shall take it away and let you draw it from memory. And, just like the stories, in about 30 minutes, I will ask you to draw the pictures again. Don't begin to draw until I say 'go.' Ready?" After exposing the card for 10 seconds say, "Now draw it, go."

For Card III: Say, "Here is one that is a little harder. This card has two drawings on it. I want you to look at both of them carefully again you will have only ten seconds to look at the card, then I shall take it away and let you make both drawings; the one on the left side-here (pointing to space in which child is to make the drawing) and the right one-here (pointing). Also, you will do this again in thirty minutes too. Ready?" Expose for ten seconds and say, "Now draw it, go."

Scoring: Score one point for each of the following:

6/7 year olds:
Card I:
No more than slight separation of forms.
No major distortions of circle or open square.
Circle and two-cornered square of fairly equal size.
Bisector of circle passing through corner of square must project into square.
Maximum score: 4 points.

Card II: Three overlapping circles showing seven openings.
The triangle in the center must show.
One circle clearly below the others.
Three circles approximately the same size.
Maximum score: 3 points.

Card III: a. Absence of reversed or "floating" tips.
Sharp points on tips.
No indication of directional confusion.
Fairly equal length of "legs."
Maximum score: 4 points.

b. Six circles.
At least two straight sides.
Fairly equal spacing.
Baseline fairly horizontal.
Maximum score: 4 points.

<u>Maximum subtest score for 6/7 year olds</u>: 15 points.

8/9 year olds:

Card I: Four cornered square and circle.
Square touches circle with closed corner.
Little or no gap or overlap of forms.
Relatively equal size of circle and square.
Contact of corner within middle 1/3 of circle.
Maximum score: 5 points.

Card II: Two triangles.
Two corners of inner triangle cleanly touch near medians of outer triangle and third corner must be close.
Left outer angle approximately 90 degrees.
Maximum score: 3 points.

Card III: a. Four good corners.
Only slight "dog ears" allowed.
No "kite" shapes.
Opposing corners (especially horizontal).
Maximum score: 4 points.

b. Eight dots.
Circularity (one dot may fall somewhat outside the pattern.)
Fairly regular spacing.
Maximum score: 3 points.

<u>Maximum subtest score for 8/9 year olds</u>: 15 points.

10-12 year olds:

Card I: All sides indicated (one of the most obtuse angles may be rounded).
No evidence of directional confusion.
Overlap clearly shown, but not extreme.
Maximum score: 3 points.

Card II: Correct number of parts.
Correct orientation.
No evidence of confusion.
Correct number of corners (8).
Maximum score: 4 points.

Card III: a. Eight dots.
Circularity (one dot may fall somewhat outside the pattern).
Fairly regular spacing.
Maximum score: 3 points.

b. Four good corners.
Both acute angles 60 degrees or less.
Horizontal axis between 170 degrees and 190 degrees.
No obvious "kites."
Opposing corners.
Maximum score: 5 points.

<u>Maximum subtest score for 10-12 year olds</u>: 15 points.
For additional scoring aid, please refer to the appropriate figures in the Developmental Test of Visual Motor Integration (VMI).

Administration and scoring of the delayed portions of the test are identical to the immediate recall procedures. To obtain the percentage retained following the 30 minute delay, divide the delayed score by the initial score. The scores from the delayed portions of the scale are <u>not</u> included in the Total Memory Score (TMS).

WILSON'S ADAPTED MEMORY SCALE FOR CHILDREN

NAME________________ DATE________ EXAMINER________

REFERRAL SOURCE____________ AGE________ SEX________

		Score	Delay
I.	Information	____	
II.	Orientation	____	
III.	Mental Control	____	
IV.	Memory Passages	____	____
V.	Digits Total	____	
VI.	Associate Learning	____	
VII.	Visual Reproductions	____	____
	Total Raw Score	____	

I. PERSONAL AND CURRENT INFO.	SCORE	II. ORIENTATION	SCORE
1. AGE	____	1. YEAR	____
2. BIRTHDAY.	____	2. MONTH.	____
3. PRINCIPAL	____	3. DAY OF WEEK. .	____
4. TEACHER	____	4. WHERE NOW. . .	____
5. TEACHER BEFORE.	____	5. CITY IN. . . .	____
6. PRESIDENT	____	6. TIME OF DAY. .	____
SCORE	____	SCORE	____

III. MENTAL CONTROL (Circle omits; cross out errors)

		TIME	ERRORS	SCORE
1.	20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1	____	____	____
2.	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z	____	____	____
3.	MON TUES WED THUR FRI SAT SUN	____	____	____
4.	JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC	____	____	____
5.	1 4 7 10 13 16 19 22 25 28 31 34 37 40	____	____	____

IV. MEMORY PASSAGES

(A) Once there was/ a little girl/ named Amy./ She lived on a farm/ with her brother/ John./ One day/ their father gave them/ a Shetland pony./ They had/ lots of fun/ with the pony./ One day/ when John was riding on it/ the pony/ became frightened/ and ran away./ Poor John/ fell in a ditch./ How Amy laughed/ when she saw him./ He was covered/ with mud/ from head to foot./

(B) The last day/ of school/ was very exciting./ The teachers/ and students/ were all/ happy to begin/ their summer vacation./ Each class/ had planned/ something special for the day./ The sixth graders/ went on a picnic./ The rest/ of the students/ had their lunch/ at school./ Everyone/ had a party/ in the afternoon/ with lots of cake and ice cream. What a wonderful/ way to end/ the year./

(A) No. of memories_____ (B) No. of memories_____ TOTAL ($\frac{A+B}{}$) = _____

V. (A) DIGITS FORWARD / (B) DIGITS BACKWARD

DIGITS FORWARD	SCORE	DIGITS BACKWARD	SCORE
3-8-6	3	2-5	2
6-1-2	3	6-3	2
3-4-1-7	4	5-7-4	3
6-1-5-8	4	2-5-9	3
8-4-2-3-9	5	7-2-9-6	4
5-2-1-8-6	5	8-4-9-3	4
3-8-9-1-7-4	6	4-1-3-4-7	5
7-9-6-4-8-3	6	9-7-8-5-2	5
5-1-7-4-3-2-8	7	1-6-5-2-9-8	6
9-8-5-2-1-6-3	7	3-6-7-1-9-4	6
1-6-4-5-9-7-6-3	8	8-5-9-2-3-4-2	7
2-9-7-6-3-1-5-4	8	4-5-7-9-2-8-1	7
FORWARD SCORE	_____	BACKWARD SCORE	_____

Draw a line through any series failed. Circle maximum number repeated correctly. FORWARD + BACKWARD scores = TOTAL _____

VII. ASSOCIATE LEARNING

First Presentation		Second Presentation		Third Presentation	
Metal	-Iron	Rose	-Flower	Baby	-Cries
Baby	-Cries	Obey	-Inch	Obey	-Inch
Crush	-Dark	North	-South	North	-South
North	-South	Cabbage	-Pen	School	-Grocery
School	-Grocery	Up	-Down	Rose	-Flower
Rose	-Flower	Fruit	-Apple	Cabbage	-Pen
Up	-Down	School	-Grocery	Up	-Down
Obey	-Inch	Metal	-Iron	Fruit	-Apple
Fruit	-Apple	Crush	-Dark	Crush	-Dark
Cabbage	-Pen	Baby	-Cries	Metal	-Iron

Recall 1	Easy	Hard	Recall 2	Easy	Hard	Recall 3	Easy	Hard
North	____		Cabbage		____	Obey		____
Fruit	____		Baby	____		Fruit	____	
Obey		____	Metal	____		Baby	____	
Rose	____		School		____	Metal	____	
Baby	____		Up	____		Crush		____
Up	____		Rose	____		School		____
Cabbage		____	Obey		____	Rose	____	
Metal	____		Fruit	____		North	____	
School		____	Crush		____	Cabbage		____
Crush		____	North	____		Up	____	
TOTAL	____	____	TOTAL	____	____	TOTAL	____	____

(A) TOTAL EASY = ______

(B) TOTAL HARD = ______

SCORE = $\frac{A}{2} + B$ = ______

VII. VISUAL REPRODUCTION

(A) ______ (B) ______ (C-1) ______ (C-2) ______

TOTAL - A + B + C-1 + C-2 = ______

Fold under on broken line before giving paper to subject for drawing.

- -

IV. MEMORY PASSAGES

(A) Once there was/ a little girl/ named Amy./ She lived on a farm/ with her brother/ John./ One day/ their father gave them/ a Shetland pony./ They had/ lots of fun/ with the pony./ One day/ when John was riding on it/ the pony/ became frightened/ and ran away./ Poor John/ fell in a ditch./ How Amy laughed/ when she saw him./ He was covered/ with mud/ from head to foot./

(B) The last day/ of school/ was very exciting./ The teachers/ and students/ were all/ happy to begin/ their summer vacation./ Each class/ had planned/ something special for the day./ The sixth graders/ went on a picnic./ The rest/ of the students/ had their lunch/ at school./ Everyone/ had a party/ in the afternoon/ with lots of cake and ice cream./ What a wonderful/ way to end/ the year./

(A) No. of memories____ (B) No. of memories____ TOTAL $\left(\frac{A+B}{2}\right)$ = ____

PERCENTAGE RETAINED = ______

VII. VISUAL REPRODUCTION

(A) ______ (B) ______ (C-1) ______ (C-2) ______

TOTAL = A + B + C-1 + C-2 = ______ PERCENTAGE RETAINED = ______

Fold under on broken line before giving paper to subject drawing.

- -

APPENDIX II: NEUROPSYCHOLOGICAL APPROACH TO THE STUDY OF LEARNING DISABILITIES

Interest in brain-behavior relationships, from both experimental and clinical points of view, is not a recent development in psychology. However, formal assessment techniques concerning evaluation of the status of brain functions in individual persons have a rather recent history, dating back only approximately 50 years. Perhaps the best known American pioneer in the study of human brain-behavior relationships is Ward Halstead (1908-1969). Based on naturalistic observation, Halstead developed a battery of behavioral indicators designed to differentiate individuals with cerebral damage from those without cerebral damage (Halstead, 1947). Halstead recognized that brain damage in its various forms can affect sensory, central processing, or motor functions, and so included measures of these three stages of the behavioral cycle in his original battery.

Ralph Reitan, who began his neuropsychological research in Halstead's laboratory, went on to develop a research approach oriented essentially toward systematic subdivisions of the term brain-damage (Reitan, 1955). He understood the potential contribution of a standardized battery approach, which served as the basis of his research. Reitan's first study utilizing this approach compared the results obtained using Halstead's tests by a group of 50 subjects with documented cerebral damage or dysfunction to a group of 50 subjects who showed no past or present signs or symptoms of cerebral damage or dysfunction. The results showed "striking" differences between the two groups (Reitan, 1955). Reitan (1955) concluded that "Halstead's battery was sufficiently sensitive to the effects of organic brain damage to provide an objective and quantitative basis for detailed study of relationships between brain function and behavior" (p. 35).

Reitan's work in this area resulted in a modification and expansion of Halstead's original battery, which is now known as the Halstead-Reitan Neuropsychological Test Battery. This is appropriate for adults and adolescents 15 years and older. During the 1960's, Reitan and his colleagues at the Indiana University Medical Center, expanded their work to include children (Reed, Reitan, & Klove, 1965; Reitan, 1964; Reitan & Klove, 1968). This resulted in the development of two batteries for children; the Halstead Neuropsychological Test Battery for Children (ages 9-14), and the Reitan-Indiana Neuropsychological Test Battery for Children (ages 5-8).

In the refinement and validational research conducted on the neuropsychological batteries, Reitan initially demonstrated that the neuropsychological test battery was able to differentiate between adult subjects with and without brain lesions (Reitan, 1955). Subsequent studies related test findings using the adult battery to such conditions as site of lesion, casual effects, age of onset, premorbid condition, and severity and extent of lesion (Doehring & Reitan, 1962; Reitan, 1958; Reitan & Davison, 1974; Reitan & Fitzhugh, 1971). Some of the issues addressed by these early adult studies, e.g., whether the neuropsychological approach could differentiate between normal subjects and brain damaged subjects, could also be applied to children, but questions unique to children began to emerge. The first such issues were: Does cerebral damage to developing abilities in children have effects similar to damage to acquired abilities in adults? And, are there neuropsychological deficits in children who have negative neurological findings, but whose behavior is in some ways similar to that of children with structural brain damage? The research pertinent to these issues will be briefly reviewed, as the answers to these initial questions were necessary before the more sophisticated questions pertaining to learning disabilities could be formulated.

In 1965, Reed, Reitan, and Klove matched 50 brain-damaged children between the ages of 10 and 14 years with 50 normally functioning controls and compared the performance of each pair on 27 measures from the Wechsler-Bellevue Scale and the neuropsychological battery. The results of this analysis found that the brain-damaged subjects were most frequently impaired in language functions. Since brain damage in adults tend to markedly impair adaptive and problem-solving abilities rather than language skills, these initial results suggested that brain damage sustained in childhood may have a different effect than brain damage sustained in adulthood. In a replication and extension of this study, Boll (1974) found comparable results, supporting the validity of the Wechsler scales and neuropsychological measures as tests for brain damage in older children.

Boll and Reitan (1970) found significant differences on the performance of motor and sensory-perceptual tasks when they compared a sample of brain-damaged children with a control sample. Specifically, one measure of sensory-perceptual function, (Tactile Finger Localization) and three measures of motor functions (Finger Tapping

Test, Tactual Performance Test, and Grip Strength Test) were able to differentiate between the two groups.

In regard to the younger children's battery, Reitan (1975) compared 29 brain-damaged children between five and eight years of age with 29 controls on the Wechsler Intelligence Scale for Children (WISC) and neuropsychological measures. He found significant differences between the groups on all but one of 41 measures (the insignificant comparison involved grip strength using the dominant hand). Consistent with the results obtained by Reed et.al. (1965), the measures of verbal functions frequently showed the largest group differences. In an earlier study utilizing the same groups of subjects, Reitan (1971) found that motor and sensory-perceptual measures alone were able to classify subjects according to group membership with 70-80 percent accuracy.

Once the validation studies began providing evidence that the neuropsychological analysis could successfully differentiate between brain-damaged children and normal children, researchers began applying this method to other childhood disorders. One area which seemed particularly appropriate was that of learning disabilities. One of the first studies designed to test this method of analysis was conducted by Doehring in 1968. He compared 39 boys between the ages of 10 and 14 years of age who were retarded in reading but otherwise normal, with a control group of 39 boys with normal reading skills. Doehring found that the normal readers were significantly superior to the retarded readers on 62 out of 103 measures, and that the pattern of deficit included visual and verbal impairment. The retarded readers were superior to the normal readers on several measures using somesthetic input. Two experienced neuropsychologists gave subjects blind ratings of "no cerebral dysfunction" or "definite cerebral dysfunction." The trend for the judges to rate the normal subjects as having no cerebral impairment and the retarded readers as having definite cerebral impairment was significant.

Reitan and Boll (1973) evaluated the neuropsychological correlates of minimal brain dysfunction in children five to eight years of age. Their study included four groups of approximately 25 children each. The categories were: normal; brain-damaged; minimally brain dysfunctional children whose primary referral was due to academic problems; and, minimally brain dysfunctional children who were described as having mainly behavioral problems in the classroom. The test results were subjected to two types of analysis; an analysis of variance supplemented by _t_-tests, and a blind overall judgement of whether each child appeared to have normal, mildly impaired, or abnormal brain functions. Using statistical methods to analyze the level of performance, the authors found that the normal subjects generally achieved the best scores and the brain-damaged subjects the lowest scores, with the two minimally brain dysfunctional (MDB) groups usually scoring in between. The brain-damaged groups consistently performed significantly more poorly than the other three groups but the differences between the two MBD groups and the control subjects generally failed to reach significance. The blind judgement analysis achieved finer distinctions between the groups. Using only the test protocols, Reitan identified 64 percent of the normal children as having normal brain functions, approximately 85 percent of the MBD subjects as having mildly impaired brain functions (averaging the two groups), and 96 percent of the brain-damaged children as having abnormal brain functions.

Finally, in research designed to specifically address the neuropsychological difference between normal, learning-disabled, and brain-damaged children in the 9 to 14 year age groups, Selz (1977) found significant differences between these three groups. Using analysis of variance on the three summary IQ scores obtained on the WISC and 10 neuropsychological measures, there were significant differences between the groups beyond the .01 level on 11 of the 13 measures, and a significant difference beyond the .015 level on one measure. The *t*-test comparisons indicated that the learning disabled subjects performed in a relatively normal manner on measures with a strong motor component. The performance of the disabled learners resembled that of the brain-damaged subjects on tests with strong cognitive or attentional demands. A discriminant analysis that utilized the 13 measures classified subjects according to group membership with 80 percent accuracy. The 20 percent classification errors tended to be in the direction of classifying subjects as less impaired than their group membership implied, e.g., assigning a learning-disabled subject to the control category (Selz & Reitan, 1979).

Once the evidence supporting the ability to differentiate learning disabled children from normal children using neuropsychological analysis was found, researchers began developing new applications for this method of assessment. Just as Reitan had begun his career by developing an approach to aid in systematic subdivision of the term brain damage, the most recent application of neuropsychological methods centers upon attempts to subdivide learning disabilities into discrete categories. This next section will focus on the research from the Neuropsychology Laboratory of Windsor Western Hospital Centre, one of the major laboratories involved in this effort. This work was chosen for its comprehensive treatment of learning disabilities, and is an example of the work being done in several different settings (e.g., Bakker, 1979; Lyon, 1982; Satz & Morris, 1981).

One of the Neuropsychology Laboratory's major contributors to research utilizing neuropsychological assessment of children with learning disabilities is Byron Rourke, who has provided evidence supporting the division of learning disabled into distinct subgroups. He has also provided the rationale for these distinctions, in that the classifications provide information pertinent to both prognosis and rehabilitation. Rourke's work will be presented in three parts: reading disorders, spelling disorders, and arithmetic disorders.

Initially Rourke began his research program based on the theoretical question of whether it was the case that some or all of the deficits exhibited by children who are classified as "learning disabled" are the result of cerebral impairment (Rourke, 1975). The investigation of this question led to the utilization of neuropsychological assessment as well as the implementation of Reitan's four methods of inference. The first important application of this method of investigation was a four year longitudinal study of reading disability. Due to its importance as an early demonstration of the use of neuropsychological methodology in the study of learning disabled children, this work will be presented in some detail.

In the intial phase of the investigation, there were 30 subjects in the normal-reading (NR) group and 29 subjects in the retarded-reading (RR) group. Subjects were assigned to their respective groups based on their performance on two subtests of the Metropolitan Achievement Test (MAT). Subjects were matched for age; their ages were between seven years, two months to eight years, four months. The study included testing at intervals of two years, three years, and four years after the initial assessment. By the final testing period, 24 NR and 20 RR subjects from the original groups participated in the retesting.

One of the important deviations of this study from previous work in the area was Rourke's decision to include only subjects with Full Scale WISC scores between 91 and 117 with the NR group and the RR group having equivalent Performance IQs. Rourke defended this decision on the basis that it would be reasonable to assume that "dull" and "bright" children would differ markedly on a large number of variables, rather than just on reading ability, and that the results of this investigation were intended to apply to groups of "average" children.

The overall results of this study showed that in general, the children in the RR group were further behind the children in the NR group at the time of the final assessment than they had been initially. This was attributed to the fact that most of the NRs made more than four years of progress in reading over the four year period, while the retarded readers made less than two years progress. Several subjects originally classified as RR made significant advances in reading performance during this four year period, but it was found that there were variables that reliably differentiated between these RRs and those who made little, if any progress. These included 11 of the 13 subtests of the Underlining Test (Doehring, 1968) and Verbal IQ. This investigation provided important methodological support for the utilization of Reitan's four methods of inference (level of performance, difference scores, comparisons of performance on the two sides of the body and pathognomic signs). These plus developmental analyses provided important information which may not have been available if such rigorous methods had not been practiced (Rourke, 1976a).

Another issue addressed in this investigation by Rourke was the relative merits of the positions in the controversy between the "developmental lag" model and the "deficit" model. Satz and Van Nostrand (1972) had postulated an underlying "lag mechanism" in brain maturation which they thought forecast the later onset of dyslexia. Based on this, they conceptualized dyslexia within the framework of a developmental model rather than that of a "deficit" model. They suggested that the underlying lag in brain maturation causes a delay in the rate of acquisition of developmental skills rather than a loss or impairment in these skills.

The "deficit" model, supported by Doehring (1968), Reed (1968), and Reitan (1964), suggests that there is some sort of cerebral dysfunction underlying the acquisition of age appropriate reading skills. The "deficit" view differs from the "developmental lag" position in that there is no necessary expectation that the children who suffer from the deficit(s) will ever catch up with their normal age mates in those skills which are required for age-appropriate reading, but is similar to the "developmental lag" view in that it also predicts a less than age appropriate level of reading performance throughout the elementary school years. The "deficit" position supports the possibility that children will exhibit a deficit in the cerebral structures of systems which subserve some of the abilities necessary for reading, but allows for adaptation and/or compensation for the deficits in question. Drawing from the work of Luria (1966) and Wepman (1964), the possibility of enlisting other neuronal structures or systems which, in the ordinary course of events would not subserve these abilities is entertained.

In order for Rourke (1975) to relate this investigation to the assessment of these two positions, seven developmental lag-deficit paradigms were constructed. Then the results of the Satz, Friel, & Rudegair (1974) study as well as Rourke's (1975) longitudinal study were compared in the light of these paradigms (Rourke, 1976b). In general, it was found that there was some support for the "developmental lag" position in the case of fairly simple, early-emerging abilities. Specifically, the position presented by Satz and Van Nostrand (1972) postulates a particular lag in the development of the left cerebral hemisphere. Both Rourke's (1975) study as well as the Satz et.al. (1974) study lent support to the notion that dysfunction of the left cerebral hemisphere is particularly involved in the genesis of reading retardation. However, Rourke did not find that retarded readers, as a group, eventually "caught up" in those abilities thought to subserve the reading function, nor did they "catch up" in the ability to read. Thus, the weight of the evidence of the Rourke (1975) study favors a "deficit" rather than a "developmental lag" position.

Another study which grew out of this longitudinal investigation used measures of reading, spelling, and psychomoteric intelligence as well as the Underlining Test (Doehring, 1968), in an attempt to determine their relative predictive accuracy for both the NR group and the RR group (Rourke & Orr, 1977). The results indicated that performance on the Underlining Test was the best predictor of eventual achievement levels in reading and spelling when compared to the other tests utilized (i.e., reading, spelling or psychometric intelligence), with two subtests found which were particularly sensitive to the two groups of RRs. These were the subtests that involved target and distractor items which were nonverbal (sequences of geometric forms and gestalt figures). It appeared that the ability to utilize a strategy of verbal labeling of the fairly complex figures did lead to better overall performance, suggesting that the development of verbal mediation was an important component of improved reading skills (Rourke & Orr, 1977).

Although the results of this study were exciting, Rourke and Orr (1977) advised caution in the drawing of clinical inferences (including prognosis) for individual cases. This caution was necessary because of the restricted range of IQs and the truncated and restricted distributions of initial MAT subtests scores. Also, to be considered are the restricted age span and fairly small number of measures chosen for comparison (Rourke, 1976c).

The final study to be discussed in this section constitutes Rourke's first attempt to design a study specifically to identify subgroups of reading disabled children (Petrauskas & Rourke, 1979). The study used a multivariate classification procedure (Q-type factor analysis) similar to that employed by Doehring and Hoschko (1977). The sample was comprised of 150 children between seven and eight years of age. There were 133 retarded readers chosen from a clinic population and 27 normal readers who were tested in the original longitudinal investigation.

The results indicated three types of retarded readers which could be differentiated from normal readers and one another. Following is a brief description of each subtype (including the subtype containing the normal readers).

<u>Subtype 1</u>

Subtype 1 could be characterized as having relatively well-developed visual-spatial and eye-hand coordination skills; average or near-average tactile-kinesthetic abilities, abstract reasoning, and nonverbal concept formation; near-average word definition ability; mildly impaired word blending ability, immediate memory for digits, and store of general information; and moderate to severe impairment in verbal fluency and sentence memory.

Subtype 2

Subtype 2 could be characterized as having average or near-average kinesthetic, psychomotor, visual-spatial constructional and word-defining abilities, and nonverbal problem-solving and abstract reasoning skills within a context that provides immediate positive and negative feedback; borderline to mildly impaired immediate memory for digits and other "sequencing" skills, store of general information, sound blending verbal fluency, and concept formation when substantial verbal coding is required and/or when no positive and negative feedback is provided; and, moderate to severe impairment in finger recognition, immediate visual-spatial memory, and memory for sentence.

Subtype 3

Subtype 3 could be characterized as having average or near-average finger recognition (left hand), kinesthetic, visual-spatial constructional, vocabulary and sound-blending abilities, and nonverbal concrete formation within a context of immediate positive and negative feedback; borderline to mildly impaired finger recognition (right hand), immediate memory for digits, eye-hand coordination under speeded conditions, store of general information, and nonverbal abstraction and the shifting of set without the benefit of positive and negative feedback; mild to moderate impairment in verbal fluency, sentence memory, and immediate visual-spatial memory; and moderate to severe impairment in concept formation which involved substantial verbal coding.

Subtype 4

Subtype 4 could be characterized as having average or above-average finger recognition, kinesthetic, sequencing, eye-hand coordination, visual-spatial constructional, visual memory, auditory-verbal receptive, and concept-formation abilities. This subgroup was comprised primarily of normal readers (seven of the eight children in this group).

The results of the Petrauskas and Rourke (1979) study illustrated the complex nature of the neuropsychological dimensions of the groups of clinical disorders known primarily as "reading disability." At the very least, this analysis provided evidence to indicate that reading disabled children do not constitute a homogeneous group. It is also clear that deficiencies in psycholinguistic skills play a major role in reading difficulties at this age level. Further work (Fisk & Rourke, 1983) found that psycholinguistic disabilities are also the source of major problems for different subtypes of learning disabled children ages ranging from 9 to 14 years of age.

These results suggest important clinical applications. If the various subtypes of reading disability are related to different cognitive skills, then perhaps reading-disabled children will respond differentially to various forms of teaching and intervention. Investigations designed to address this issue are needed and are part of Rourke's ongoing research strategy (Rourke & Strang, 1983). Also, Rourke and his colleagues have been able to provide speculations regarding the likelihood of dysfunction maximally involving different systems, suggesting a relationship between the left temporal lobe and reading disability associated with subtype 1; a relationship between the left temporo-parieto-occipital area and reading disability associated with subtype 2; and, a relationship between the left frontal lobe and reading disabiity associated with subtype 3 (Rourke & Strang, 1983). Of course, these attempts at localization are only speculative at this time, but they provide a basis for further validation and research.

Several studies conducted by Rourke and his colleagues have attempted to analyze spelling errors from the point of view of their degree of phonetic accuracy. The impetus for this line of research emerged from clinical practice with learning disabled children (Rourke, 1976c) and research evidence derived from studies of adults with well-documented lesions (e.g., Kinsbourne & Warrington, 1963). Both sources have found consistent evidence indicating the relative "intactness" of children (and adults) whose misspelling was essentially phonetically accurate (e.g., gelusy for the word jealousy). This is contrasted to misspellings which are phonetically inaccurate (e.g., htvowe for the word jealousy). In particular, research has documented that adults with lesions of the so-called "language areas" of the left cerebral hemisphere exhibit a tendency to spell in a phonetically inaccurate way (e.g. Kinsbourne & Warrington, 1963). Rourke began a line of research based on these findings which was designed to investigate the existence of two types of spelling disability.

In the first study (Burgher & Rourke, 1976), the spelling production of the subjects from the longitudinal investigation of reading retardation (Rourke, 1975) was examined. It was found that retarded readers had significantly fewer phonetically accurate spelling errors than normal readers. Also, there was a "leveling off" in the degree of phonetic accuracy of the misspellings after the second year of testing (i.e., ages 9-10).

The next study (Sweeney & Rourke, 1978) was cross-sectional in nature and was based on two groups of studies. The first group of studies was conducted by Newcombe (1969) and Nelson and Warrington (1974) and found a positive relationship between spelling retardation characterized by phonetically inaccurate errors and a general impairment in language functioning. The second group of studies was conducted by Boder (1973) and demonstrated a positive relationship between spelling performances characterized by an excess of phonetic accuracy and poor memory for how words looked.

The subjects for the study conducted by Sweeney and Rourke (1978), were children at age levels corresponding to grades four and eight. There were three groups, one a control group consisting of normal spellers (NS) and two experimental groups of disabled spellers. One of the experimental groups consisted of phonetically inaccurate (PI) spellers, while the other was composed of phonetically accurate (PA) spellers.

It was found that the PI spellers were inferior to the PA spellers and the normal spellers on most measures of psycholinguistic ability at the older (grade eight) age level. Upon closer examination, it was discovered that the PA spellers performed at levels similar to those of NS on tests in which the correct responses could be brief, single word answers, while the PI spellers were inferior to both the PA spellers and the NS. In contrast, the levels of performance of PA spellers could not be distinguished from those of PI spellers and were inferior to NS on those measures which required a fairly complex formulation of an answer to a question, and when the correct answer could not be determined exclusively by utilizing the information contained in the question itself. Sweeney & Rourke (1978) concluded that the older PA spellers experienced significant difficulty in associating spoken language with the analysis of visual-spatial information; in relating the verbal information provided with other information; and, encoding relatively complex word strings in response to verbal information provided.

Returning to the younger group, it was found that the arithmetic subtest of the Wide Range Achievement Test (WRAT) differentiated the three groups, with the PI spellers exhibiting the poorest performance. This suggested that one important deficiency in the PI spellers at this age level might be their ability to benefit from formal instruction in the use of rules and consequently, in logical-grammatical reasoning. This prompted further analysis of these subjects at the fourth grade level (Sweeney, McCabe & Rourke, 1978) in which the subjects' performance on the Logico-Grammatical Sentence Comprehension Test (Wiig & Semel, 1974) was compared. The results of this study indicated that while PI spellers were significantly inferior to normal spellers in their logical-grammatical reasoning, PA spellers were not inferior. It therefore appeared that PIs encountered significant difficulty in carrying out relatively rudimentary operations on language, and this hampers their capacity to benefit from formal academic instruction in the processing of verbal information.

In general, these studies indicate the heuristic value of a qualitative analysis of the spelling errors of children if the nature of the underlying deficiencies of spelling retardation is to be explicated. Also, it is clear that the age at which children were tested was a very important consideration with respect to the relationship between degree of phonetic accuracy of misspellings and performance on the dependent variables (Rourke, 1978).

There is a notable lack of research pertaining specifically to arithmetic disability when compared to studies of retarded reading and spelling (Rourke, 1978). One reason for this may be the lack of educational concern due to the emphasis in Western culture on reading and spelling (Rourke & Strang, 1983). The fact that arithmetic is often viewed as a type of language activity, (e.g., the Arithmetic subtest of the WISC-R is considered part of the verbal scale) may also contribute to the neglect of this area of learning. Rourke and his colleagues at the Neuropsychology Laboratory have conducted important work in this area.

The first of these important studies was that of Rourke and Finlayson (1978) in which they attempted to determine if children who exhibited arithmetic retardation within the context of differing patterns of reading and spelling performances would also exhibit differing patterns of brain-related abilities. For this study, children between the ages of 9 and 14 who had been classified as learning disabled were divided into three groups on the basis of their patterns of performance in arithmetic. The children in Group 1 were uniformly deficient in reading, spelling, and arithmetic. The children in Group 2 exhibited significantly better performance in arithmetic (which was still below age expectation) relative to reading and spelling. The children in Group 3 exhibited normal reading and spelling with marked impairment in arithmetic. Also, Group 2 and Group 3 did not differ in their level of arithmetic performance, while they were superior to the arithemtic performace of Group 1. The three groups were equated for age and Full Scale IQ on the WISC. There were 16 dependent measures which provided the basis of comparison.

The analysis of the three groups' performance on the dependent measures found; 1) the performance of Group 1 and Group 2 were superior to Group 3 on measures of visual-perceptual and visual spatial abilities, and 2) Group 3 performed at a superior level to Groups 1 and 2 on measures of verbal and auditory-perceptual abilities. These results were interpreted as being consistent with the view that the children in Group 3 may have a relatively dysfunctional right cerebral hemisphere, and that children in Groups 1 and 2 were suffering from the adverse effects of a relatively dysfunctional left cerebral hemisphere (Rourke & Finlayson, 1978). Of particular interest within this context was the fact that the two groups who had been equated for deficient arithmetic performance (i.e., Groups 2 and 3), exhibited vastly different performances on verbal and visual-spatial tasks. These differences were clearly related to their patterns of reading, spelling, and arithmetic, rather than being limited to only their arithmetic performance.

A second study pertaining to this question was conducted shortly after the first by Rourke and Strang (1978), utilizing level of performance comparisons as well as comparison of performance on the two sides of the body to determine differences between the three groups of children from the first study (Rourke & Finlayson, 1978). Rourke and Strang (1978) were specifically interested in the ability of motor, psychomotor, and tactile-perceptual tests to differentiate between the two groups and they found that there were no significant differences evident on the simple motor tasks. However, on more complex psychomotor measures as well as on a composite tactile-perceptual measure, the children in Group 3 exhibited marked impairment. Finally, there was evidence consistent with the view that Group 3 children were suffering from the adverse effects of a relatively dysfunctional right cerebral hemisphere within the context of satisfactory left hemispheric functioning. Opposed to this was the evidence that Group 2 children exhibited indications that would be consistent with the opposite pattern of hemispheric integrity.

A third study (Strang & Rourke, 1983) using the same children from Group 2 and Group 3 compared their performance on the Halstead Category Test (Reitan & Davison, 1974). The results of this investigation found that children in Group 3 made significantly more errors on the test. Also, while the level of performance of the Group 2 children was age appropriate on this nonverbal problem-solving task, Group 3 children's performance was approximately one standard deviation below the mean. Specifically, these children had particular difficulty on the subtests requiring "higher-order" visual-spatial analysis.

The overall consistency of these three studies (Rourke & Finlayson, 1978; Rourke & Strang, 1978; Strang & Rourke, 1983) is striking. All three studies indicated that learning-disabled children who are better on the Arithmetic subtest of the WRAT compared to the Reading and Spelling subtests (i.e., Group 2) performed poorly on tests thought to tap abilities primarily subserved by the left cerebral hemisphere. Children whose only deficit appeared on the Arithmetic subtest of the WRAT, with Reading and Spelling within normal limits (i.e., Group 3) did poorly on measures of abilities thought to be subserved primarily by the right hemisphere. Rourke and his colleagues have conducted qualitative analyses on the performance of Group 3 children on the WRAT Arithmetic subtest, in an attempt to gain further insight into this neglected disability. The results and implications of this approach will not be discussed here; the reader is referred to Strang & Rourke (1983) for a detailed description.

A relatively new approach to the study of learning disabilities is from a neurobiological perspective, which supports the neuropsychological etiology of some childhood learning disorders (Gaddes, 1980, 1981; Geschwind & Galaburda, 1985; Hynd & Cohen, 1983; Obrzut & Hynd, 1983). Electrophysiological and neuropathological evidence is accumulating which supports the existence of the clinical syndrome, "learning disability." While this line of investigation is beginning to provide some gross differentiation within this syndrome (i.e., language versus spatial difficulties), the research is unable at this time to provide the fine distinctions found in the neuropsychological research.

One of the current methods in this line of research has focused on developing and refining electrophysiological procedures to investigate the basis of learning disabilities. Initial work in this area used electroencephalographic (EEG) data as indices of cortical dysfunction. Major difficulties encountered have been concerned with the intepretation of the temporal and spatial relationship of vast arrays of electrode patterns in ongoing brain activity. To deal with this problem, Duffy, Burchfield, and Lombroso (1979) developed the brain electrical activity mapping (BEAM) technique, which can summarize, reduce and visually display spectral, spatial and temporal information of brain activity from 20 different scalp locations. This information is then statistically compared to a control group (Torello & Duffy, 1985).

The BEAM recording technique has demonstrated diagnostic utility within a well-defined population of dyslexics, finding that dyslexia is a neurophysiological problem with topographically specific brain areas of dysfunction (Duffy, Denckla, Bartels, & Sandini, 1980). Discrete brain areas were identified in the "pure" dyslexic subjects as being significantly different from the age-matched control subjects. These areas have been classically associated with speech and reading in normal individuals as measured by more invasive techniques such as sodium amytal testing (Wada & Rasmussen, 1960) and regional cerebral blood flow (RCBF) (Lassen, Ingvar, & Skinhoj, 1978).

Another electrophysiological procedure often used to investigate the basis of learning disability has been the evoked potential (EP). This procedure has encountered the same type of difficulties encountered by the EEG studies, but the difficulties have similarly been somewhat ameloriated by the BEAM technique (Duffy et.al., 1979). Further refinement of this procedure has resulted in finding that brain stem evoked responses (BSER) appear to be a viable electrophysiological procedure to assess learning disability (Obrzut, Morris, Wilson, Lord, & Caraveo, 1987). Until recently, auditory brain stem responses have been evoked by the biaural presentation of a brief, discrete sound stimulus and recording of the polyphasic change in the electrical activity of the brain stem during the first 10 milliseconds following the stimulus. These BSERs are thought to be the far-field reflection of sequential electrical events at successively higher levels of the brain stem auditory pathway.

Recent refinement in this approach involved presenting the auditory stimulus monaurally to the left or right ear, and determining any asymmetry in the BSER which occurs in response to the monaural stimulus. To date only a few attempts in assessing learning disabled populations by use of this procedure have been made and these reveal a marked symmetry in neurologically normal persons and characteristic asymmetry in a special population (stutterers) (Decker & Howe, 1981). The limited research in evoked responses in learning disabled populations has focused upon abnormalities in laterality or asymmetry in the cerebral cortex. This rather gross approach has not yet provided any useful diagnostic taxonomy for the various subtypes of learning disability, including disabilities involving confusion in the processing of auditory information.

While the emphasis of the electrophysiological research has been on differentiating normal learners from disabled learners, other research has focused upon studying the developmental process of the brain. Specifically, it has been found recently that investigation into the asymmetrical development of the brain may lead to new hypotheses concerning the etiology of learning disabilities (Geschwind & Galaburda, 1985).

In their recent review, Geschwind & Galaburda (1985) present evidence for the following: 1) anatomic asymmetry of the brain; 2) asymmetry of the fetal brain; 3) male-female differences in the brain; 4) laterality in developmental disorders; 5) abnormal cytoarchitectues in childhood dyslexia; 6) patterns of maturation of the brain; 7) cell death in the developing brain; 8) reorganization of the brain after intrauterine lesions; 9) hormonal influences on brain structures; 10) genetic studies of handedness; 11) chemical asymmetry of the brain; 12) evolution of asymmetry; 13) associations of left handedness; and, 14) relationships of laterality to special talents. As can be seen from this list, the review by Geschwind & Galaburda (1985) was quite comprehensive. It is not the intention of this review to attempt a summary of the findings; the discussion will be limited to those findings dealing directly with developmental disorders and childhood dyslexia. The interested reader is referred to the original article for greater detail.

Geschwind & Galaburda (1985) postulate that the brain abnormalities in dyslexia are developmental in nature and can be attributed to alterations in the cortex and connectionally related subcortical structures resulting from disturbances in neuronal migration and assembly. Further, they state it is likely that in some individuals the postulated slowing of the rate of migration of neurons to the left cortex is even more marked than in the normal state; this excessive delay can lead to lateralized developmental arrest and malformation, thus leading to childhood dyslexia and possibly to other developmental disorders. This hypothesis is based on the case studies of five patients (Drake, 1968; Galaburda, 1983; Galaburda & Eidelberg, 1982; Galaburda & Kemper, 1979).

As can be seen, the emphasis of this type of research is finding the neurological basis for learning disabilities. At this time, it appears that the normal asymmetrical development with left dominance for language and right dominance for spatial processing is somehow arrested in the dyslexic, resulting in increased symmetry. Further, there has been a connection between learning disabilities and nonright-handedness (Geschwind & Behan, 1982). But as the authors note, the findings in these studies do not imply that nonright-handedness causes learning disabilities. Rather nonright-handedness is simply a marker of an alteration in dominance. Geschwind and Galaburda (1985) further state that there is a strong genetic component associated with learning disabilities, which is sex-limited (a gene is expressed less often in one sex). They propose that learning disorders are more common in males because of some male-related factor in development, possibly testosterone (e.g., Dorner, 1980, Gorski, Harlan, & Jacobson, 1980; MacLusky & Naftolin, 1981; McEwen, 1981; Pfaff, 1966; Raisman & Field, 1973). When one considers the consequences of these speculations, it would appear that learning disorders may not be preventable, making the need for greater understanding of the etiology as it pertains to remediation even more important.

This line of study provides an important link between the neurological integrity of the brain and learning disabilities. As Adelman & Taylor (1986) argue, the label "learning disabled" should be applied to children whose learning difficulties are primarily due to minor central nervous system dysfunction. While many children have learning problems, not all are learning disabled. Perhaps the present difficulty with definition and classification arises because many in the field have failed to make this distinction.

At this time it seems that there is enough mounting evidence to support the neuropsychological basis of learning disability. Also there is mounting evidence that this can no longer be considered a homogenous entity. Recent research efforts have focused primarily on empirical classification of homogenous subtypes (Fisk & Rourke, 1983). While the present classification efforts provide a positive addition to research, there is a growing concern in the field on the lack of a conceptual framework to drive the research. This framework would serve to unify the field and the efforts of the researchers and provide more commonality and consensus in measurement and methodology (Adelman & Taylor, 1986; Kavale and Forness, 1987; Morris, Blashfield, & Satz, 1986). While this review has only presented the neuropsychological perspective, there are several other approaches, each utilizing separate test batteries and data analysis strategies (Feagans, & Appelbaum, 1985; Wolfus, Moscovitch & Kinsbourne, 1980). As Kavale and Forness (1987) state, "imagine the powerful outcomes if the major individuals involved in sbutype research would pool their efforts into producing a <u>single</u> classification scheme for the field." (p. 381).

APPENDIX III: FORMS

Sheryl L. Wilson
4881 W. Ferret
Tucson, AZ 85741
Day telephone: 626-7416
Evening telephone: 744-1670

Dear Parents:

I am a graduate student in the Clinical Psychology program at the University of Arizona. As part of my dissertation project, I am looking for volunteer children between the ages of 6 and 12 years. I am devising a memory scale for children in this age range. The children will be given four tests; the Wechsler Intelligence Scale for Children-Revised, the Developmental Test of Visual-Motor Integration, the Wide Range Achievement Test, and my memory scale. The results from these tests will be used anonymously to provide information as to whether or not my memory scale is a useful clinical tool.

Children who participate may be tested in their homes (evenings Monday through Friday) or may be tested in my home on weekends. The children's test results will be available to be sent to each child's school psychologist for reporting and interpretation. The testing will last approximately 2-3 hours.

If you are interested in allowing your child/children to participate, please fill out the attached form and return it to me or call me at the telephone numbers listed above.

Thank you for your time in considering this project.

Sincerely,

Sheryl L. Wilson (Barnier)

Sheryl L. Wilson
4881 W. Ferret
Tucson, AZ 85741
Day telephone: 626-7416
Evening telephone: 744-1670

Yes, I would like my child/children, ______________________________

to participate in your study. My child/children is/are aged__________.

I would prefer the testing to be done in (circle one):

In my home on week nights.

In your home on weekends.

Other (please specify)__________________________

I understand that the test results will be used anonymously to study memory skills in children.

I can be contacted at _________________________day/evening.

Signed_______________________________ Date____________________

[ ] Please send my child/children's test results to his/her school psychologist at ____________________ school.

[ ] Please send a copy of the completed study to us.

____
Address

Sheryl L. Wilson
4881 W. Ferret
Tucson, AZ 85741
Day telephone: 626-7416
Evening telephone: 744-1670

YOUR MOTHER/FATHER HAS TOLD ME IT WAS OKAY FOR YOU TO HELP ME WITH MY STUDY OF CHILDREN'S MEMORY. THIS MEANS THAT YOU WILL SPEND A FEW HOURS DOING SOME FUN TESTS. THE TEST RESULTS CAN BE EXPLAINED BY YOUR SCHOOL PSYCHOLOGIST IF YOU AND YOUR PARENTS WANT. DO YOU UNDERSTAND? IS IT OK?

______________________________ ______________________

child's signature date

Sheryl L. Wilson
340 S. Huntington
San Dimas, CA 91773
(714) 592-7135 or (714) 861-8034

Dear Parents:

I am a graduate student in the Clinical Psychology program at the University of Arizona. As part of my dissertation project I am looking for volunteer children between the ages of 6 and 12 years who have been identified by the school as having a learning problem. I have devised a memory scale for children in this age range. The children will be given four tests; the Wechsler Intelligence Scale for Children-Revised, the Developmental Test of Visual-Motor Integration, the Wide Range Achievement Test, and my memory scale. The results from these tests will be used anonymously to provide information as to whether or not my memory scale is a useful clinical tool.

Children who participate may be tested in their homes or may be tested in my home, whichever is more convenient. The children's test results will be available to be sent to each child's school psychologist for reporting and interpretation. The testing will last approximately 2-3 hours.

If you are interested in allowing your child/children to participate, please fill out the attached form and return it to me or call me at the telephone numbers listed above.

Thank you for you time in considering this project.

Sincerely,

Sheryl L. Wilson

Sheryl L. Wilson
340 S. Huntington
San Dimas, CA 91733
(714) 592-7135 or (714) 861-8034

Yes, I would like my child/children, ______________________________

to participate in your study. My child/children is/are aged ________.

I would prefer the testing to be done in (circle one):

in my home.

in your home.

other (please specify) ______________________________

I understand that the test results will be used anonymously to study memory skills in children.

I can be contacted at ______________________________ day/evening.

Signed ____________________________ Date ______________________

Please send my child/children/s test results to his/her school psychologist at ______________________________ school.

Please send a copy of the completed study to me.

____
Address

Sheryl L. Wilson, M.A.
340 S. Huntington Ave.
San Dimas, CA 91773
(714) 592-7135

Dear Parents:

I am a graduate student in the Clinical Psychology program at the University of Arizona. I have completed all my clinical training requirements and am now working to complete my dissertation. As part of my dissertation project, I am looking for volunteer children between the ages of 8 and 12 years. Dr. Papazian has given me permission to have these letters distributed through this clinic. I am specifically interested in children who have been identified as having learning difficulties.

I have devised a memory scale for children. Current psychological literature suggests that children with learning problems may have specific memory problems. However, thre is no standard test of memory for children. While in Tucson, I collected a sample of "normal" learning children, to better understand how their memory works. Now, I am hoping to compare this information with that of children with learning problems.

All children who participate will be given my memory scale. In addition, I will need current (within the past three years) IQ scores (from the Wechsler Intelligence Scale for Children-Revised) and current (within the past six months) achievement scores from the Wide Range Achievement Test-Revised. If these scores are available in your child's records, I would like permission to use them. If not, I can administer these tests, too.

The results from these tests will be used anonymously. All scores will be reported as averages, with no individual scores included in the study. A completed copy of this study will be available to you. Also, the test results will be available for interpretation by your care-provider at Kaiser.

If you are interested in allowing your child to participate, please call me so we can make arrangements for the testing. If you have any questions, please feel free to call and discuss these with me.

Thank you for your time in considering this project.

Sheryl L. Wilson, M.A.
340 S. Huntington Ave.
San Dimas, CA 91773
(714) 592-7135

Yes, I give permission for my child, ______________________________

to participate in your study. In addition, I give my permission to use any testing results to obtain my child's scores on the Wechsler Intelligence Scale for Children-Revised and/or the Wide Range Achievement Test-Revised. If these scores are not current or unavailable, you may administer these tests in addition to your memory scale.

I understand that the test results will be used anonymously to study the memory skills of children with learning problems.

Signed_________________________________ Date___________________

[ ] Please send a copy of the completed study to our family.

Sheryl L. Wilson, M.A.
340 S. Huntington
San Dimas, CA 91773
(714) 592-7135

YOUR MOTHER/FATHER HAS TOLD ME IT WAS OKAY FOR YOU TO HELP ME WITH MY STUDY OF CHILDREN'S MEMORY. THIS MEANS THAT YOU WILL SPEND SOME TIME WITH ME DOING SOME FUN TESTS. THE TEST RESULTS CAN BE EXPLAINED BY YOUR SCHOOL PSYCHOLOGIST IF YOU AND YOUR PARENTS WANT. DO YOU UNDERSTAND? IS IT OK? IF IT IS, PLEASE SIGN YOUR NAME.

________________________________ ____________
Child's Signature Date

REFERENCES

Adelman, H.S., & Taylor, L. (1986). The problems of definition and differentiation, and the need for a classification scheme. Journal of Learning Disabilities, 19, 514-520.

Bakker, D.J. (1979). Hemispheric differences and reading strategies: Two dyslexias? Bulletin of the Orton Society, 29, 84-100.

Bannatyne, A. (1971). Language, reading and learning. Springfield, Illinois: Charles C. Thomas.

Bannatyne, A. (1974). Diagnosis: A note on recategorization of the WISC-R scaled scores. Journal of Learning Disabilities, 7, 272-274.

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

Bauer, R.H. (1979). Memory, acquisition, and category clustering in learning disabled children. Journal of Experimental Child Psychology, 27, 365-387.

Beery, K.E. (1982). Revised administration, scoring and teaching manual for the Developmental Test of Visual-Motor Integration. Chicago: Follett.

Beery, F.M., & Baumeister, A.A. (1973). Paired-associate learning by normal children and retardates with relevant redundant compound stimuli. Journal of Experimental Child Psychology, 15, 63-76.

Belmont, J.M., & Butterfield, E.C. (1969). The relations of short-term memory to development and intelligence. In L.P. Lipsitt & H.W. Reese (Eds.), Advances in child development and behavior (Vol. 4, pp. 29-32). New York: Academic Press.

Benton, A.L. (1979). Visuoperceptive, visuospatial, and visuoconstructive disorders. In K.M. Heilman & E. Valenstein (Eds.), Clinical neuropsychology (pp. 115-130). New York: Oxford University Press.

Boder, E. (1973). Developmental dyslexia: A diagnostic approach based on three atypical reading-spelling patterns. Developmental Medicine and Child Neurology, 15, 663-687.

Boll, T.J. (1974). Behavioral correlates of cerebral damage in children aged 9 through 15. In R.M. Reitan & L.A. Davison (Eds.), Clinical neuropsychology: Current status and applications (pp. 91-120). Washington, D.C.: V.H. Winston & Sons.

Boll, T.J., & Reitan, R.M. (1970). Motor and sensory-perceptual deficits in brain-damaged children. Paper presented at the meeting of the Midwestern Psychological Association.

Bretherton, I., McNew, S., & Beegley-Smith (1981). Early person knowledge as expressed in gestural and verbal communication: When do infants acquire a "theory of mind"? In M.C. Lamb & L.R. Sherrod (Eds.), Infant social cognition (pp. 67-91). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Brinkman, S.D., Largen, J.W., Gerganoff, S., & Pomaro, N. (1983). Russell's revised Memory Scale in the evaluation of dementia. Journal of Clinical Psychology, 39, 989-993.

Brown, A.L. (1975). The development of memory: Knowing, knowing about knowing, and knowing how to know. In H.W. Reese (Ed.), Advances in child development and behavior (Vol. 10, pp. 131-154). New York: Academic Press.

Brown, A.L., Bransford, J.D., Ferrara, R.A. & Campione, J.C. (1983). Learning, remembering and understanding. In J.H. Flavell & E.M. Markman (Eds.), Handbook of Child Psychology: Cognitive Development (Vol. 3, pp. 211-237). New York: Wiley.

Burgher, P.L., & Rourke, B.P. (1976). Comparison of the phonetic accuracy of spelling errors of normal and retarded readers: A four year follow-up. Unpublished study, University of Windsor.

Chalfant, J.C. (1985). Identifying learning disabled students: A summary of the National Task Force Report. Learning Disabilities Focus, 1, 9-20.

Christian, J., Bickley, W., Tarka, M., & Clayton, K. (1978). Measure of free recall of 900 English nouns: Correlations with imagery, concreteness, meaningfulness and frequency. Memory and Cognition, 6, 379-390.

Cohen, R.L., & Netey, C. (1978). Cognitive deficits, learning disabilities, and WISC verbal performance consistency. Developmental Psychology, 14, 624-634.

Copeland, A.P., & Wisniewski, N.M. (1981). Learning disability and hyperactivity: Deficits in selective attention. Journal of Experimental Child Psychology, 32, 88-100.

Cummings, E.M., & Faw, T.T. (1976). Short-term memory and equivalence judgements in normal and retarded readers. Child Development, 47, 286-289.

Dean, R.S. (1984). Interaction of cerebral laterality and paired associate learning in young children: A dual processing model. Paper presented at the annual meeting of the National Academy of Neuropsychologists, San Diego.

Decker, T.N., & Howe, S.W. (1981). Auditory tract asymmetry in brain stem electrical responses during binaural stimulation. Journal of the Acoustical Society of America, 69, 1084-1090.

Doehring, D.G. (1968). Patterns of impairment in specific reading disability. Bloomington: Indiana University Press.

Doehring, D.G., & Hoschko, I. (1977). Classification of reading problems by the Q-technique of factor analysis. Cortex, 13, 281-294.

Doehring, D.G., & Reitan, R.M. (1962). Concept attainment of human adults with lateralized cerebral lesions. Perceptual and Motor Skills, 14, 27-33.

Dorner, G. (1980). Sexual differentiation of the brain. Vitamins and Hormones, 38, 325-381.

Drake, W.E. (1968). Clinical and pathological findings in a child with a developmental learning disability. Journal of Learning Disabilities, 1, 9-25.

Duffy, F.H., Burchfield, J.L., & Lombroso, C.T. (1979). Brain electrical activity mappping (BEAM): A method for extending the clinical utility of EEG and evoked potential data. Annals of Neurology, 5, 309-321.

Duffy, F.H., Denckla, M.B., Bartels, P.H., & Sandini, G. (1980). Dyslexia: Regional differences in brain electrical activity by topographic mapping. Annals of Neurology, 7, 412-430.

Dykman, R., Ackerman, P., Clements, S., & Peters, J. (1971). Specific learning disabilities : An attentional deficit syndrome. In H. Myklebust (Ed.), Progress in learning disabilities (Vol. 23, pp. 56-93). New York: Grune & Stratton.

Erickson, R.C. (1978). Problems in the clinical assessment of memory. Experimental Aging Research, 4, 255-272.

Erickson, R.C., & Scott, M.L. (1977). Clinical memory testing: A review. Psychological Bulletin, 84, 1130-1149.

Ervin, S.M. (1961). Changes with age in the verbal determinants of work-association. American Journal of Psychology, 74, 361-372.

Estes, R.E., & Huizinga, R.J. (1974). A comparison of visual and auditory presentations of a paired-associate learning task with learning disabled children. Journal of Learning Disabilities, 7, 44-51.

Farnham-Diggory, S., & Gregg, L.W. (1975). Short-term memory function in young readers. Journal of Experimental Child Psychology, 19, 279-298.

Feagans, L., & Appelbaum, M. (1986). Language subtypes and their validation in learning disabled children. Journal of Educational Psychology, 78, 358-364.

Federal Register. (1976). Education of handicapped children and incentive grant program. U.S. Department of Health, Education and Welfare, Vol. 41, p. 569-577.

Fisk, J.L., & Rourke, B.P. (1983). Neuropsychological subtyping of learning-disabled children: History, methods, implications. Journal of Learning Disabilities, 16, 529-531.

Flavell, J.H. (1970). Developmental studies of mediated memory. In H.W. Reese & L. Lipsitt (Eds.), Advances in child development and behavior (Vol. 5, pp. 181-211). New York: Academic Press.

Flavell, J.H. (1985). Cognitive development. Englewood Cliffs, New Jersey: Prentice-Hall.

Flavell, J.H., Beach, D.H., & Chinsky, J.M. (1966). Spontaneous verbal rehearsal in a memory task as a function of age. Child Development, 37, 283-299.

Flavell, J.H., & Wellman, H.M. (1977). Metamemory. In R.V. Kail & J.W. Hagen (Eds.), Perspectives on the development of memory and cognition (pp. 89-121). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Fletcher, J.M. (1985). Memory for verbal and nonverbal stimuli in learning disability subgroups: Analysis by selective reminding. Journal of Experimental Child Psychology, 40, 244-259.

Gaddes, W.H. (1980). Learning disabilities and brain function: A neuropsychological approach. New York: Springer-Verlag.

Gaddes, W.H. (1981). An examination of the validity of neuropsychological knowledge in educational diagnosis and remediation. In G.W. Hynd & J.E. Obrzut (Eds.), Neuropsychological assessment of the school-age child: Issues and procedures (pp. 27-84). New York: Grune & Stratton.

Galaburda, A.M. (1983). Developmental dyslexia: Current anatomical research. Annals of Dyslexia, 33, 41-53.

Galaburda, A.M., & Eidelberg, D. (1982). Symmetry and asymmetry in the human posterior thalamus: II. Thalamic lesions in a case of developmental dyslexia. Archives of Neurology, 39, 333-336.

Galaburda, A.M., & Kemper, T.L. (1979). Cytoarchitectonic abnormalities in developmental dyslexia: A case study. Annals of Neurology, 6, 94-100.

Geschwind, N., & Behan, P.O. (1982). Left-handedness: Association with immune disease, migraine, and developmental learning disorder. Protocol of the National Academy of Science, USA, 79, 5097-5100.

Geschwind, N., & Galaburda, A.M. (1985). Cerebral lateralization: Biological mechanisms, associations, and pathology: A hypothesis and a program for research. Archives of Neurology, 42, 428-459.

Gilleard, C.J. (1980). Wechsler Memory Scale performance of elderly psychiatric patients. Journal of Clinical Psychology, 36, 958-960.

Gorski, R.A., Harlan, R.E., & Jacobson, C.D. (1980). Evidence for the existence of a sexually dimorphic nucleus in the preoptic area of the rat. Journal of Comprehensive Neurology, 193, 529-539.

Halstead, W.C. (1947). Brain and intelligence. Chicago: University of Chicago Press.

Hulicka, I.M. (1966). Age differences in Wechsler Memory Scale scores. Journal of Genetic Psychology, 109, 135-145.

Hynd, G.W., & Cohen, M. (1983). Dyslexia: Neuropsychological theory, research and clinical differentiation. New York: Grune & Stratton.

Ivinskis, A., Allen, S., & Shaw, E. (1971). An extension of Wechsler Memory Scale norms to lower age groups. Journal of Clinical Psychology, 27, 354-357.

Jastak, J.F., & Jastak, S.R. (1965). The Wide Range Achievement Test Manual. Wilmington, Delaware: Guidance Associates.

Johnson, C.N., & Wellman, H.M. (1980). Children's developing understanding of mental verbs: Remember, know and guess. Child Development, 51, 1095-1102.

Kail, R.G., & Hagen, J.W. (1977). Perspectives on the development of memory and cognition. Hillsdale, NJ: Erlbaum.

Kaplan, R.M., & Sacuzzo, D.P. (1982). Psychological testing: Principles, applications, and issues. Monterey, CA: Brooks/Cole Publishing Co.

Kaszniak, A.W. (1986). The neuropsychology of dementia. In I. Grant & K.M. Adams (Eds.), Neuropsychological assessment of neuropsychiatric disorders (pp. 172-220). New York: Oxford University Press.

Kaufman, A.S. (1975). Factor analysis of the WISC-R at 11 age levels between 6½ and 16½ years. Journal of Consulting and Clinical Psychology, 43, 135-147.

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

Kavale, K.A., & Forness, S.R. (1987). The far side of heterogeneity: A critical analysis of empirical subtyping research in learning disability. Journal of Learning Disabilities, 20, 374-382.

Kee, D., Worden, P.E., & Throckmorton, B. (1984). Sentence demonstration ability in reading disabled vs. normal college students. Bulletin of the Psychonomic Society, 22, 183-185.

Keeney, T.J., Cannizzo, S.R., & Flavell, J.H. (1967). Spontaneous and induced verbal rehearsal in a recall task. Child Development, 38, 953-966.

Keogh, B., & Margolis, J. (1976). Learn to labor and to wait: Attentional problems of children with learning disorders. Journal of Learning Disabilities, 9, 276-286.

Kinsbourne, M., & Warrington, E.K. (1963). The developmental Gerstmann syndrome. Archives of Neurology, 8, 490-501.

Kirk, S.A. (1963). Behavioral diagnosis and remediation of learning disabilities. In S.A. Kirk & J.M.McCarthy (Eds.), Learning disabilities: Selected ACLD papers (pp. 25-43). Boston: Houghton Mifflin.

Lassen, N.A., Ingvar, D.H., & Skinhoj, E. (1978). Brain function and blood flow. Scientific American, 239, 62-71.

Lesgold, A.M., & Perfetti, C.A. (1978). Interactive processes in reading comprehension. Discourse Processes, 1, 323-336.

Lezak, M.D. (1983). Neuropsychological assessment. New York: Oxford University Press.

Liben, L.S. (1982). The developmental study of children's memory. In T.M. Field (Ed.), Review of human development (pp. 103-125). New York: Wiley.

Liberman, I.Y., Mann, V.A., Shankweiler, D., & Werfelman, M. (1982). Children's memory for recurring linguistic and nonlinguistic material in relation to reading ability. Cortex, 18, 367-375.

Logue, P., & Wyrick, L. (1979). Initial validation of Russell's revised Wechsler Memory Scale: A comparison of normal aging versus dementia. Journal of Consulting and Clinical Psychology, 47, 176-178.

Luria, A.R. (1966). Higher cortical functions in man. New York: Basic Books.

Lyon, R. (1982). Subgroups of LD readers: Clinical and empirical identification. In H. Myklebust (Ed.), Progress in learning disabilities (Vol. V, pp. 86-104). New York: Grune & Stratton.

MacLusky, N.J., & Naftolin, G. (1981). Sexual differentiation of the central nervous system. Science, 211, 1294-1303.

Malloy, P.F., & Nadeau, S.E. (1986). The neurological examination and related diagnostic procedures in behavioral neurology and neuropsychology. In D. Wedding, A.M. Horton, & J. Webster (Eds.), The neuropsychology handbook (pp. 105-133). New York: Springer Publishing Co.

Mandler, J.M. (1984). Representation and recall in infancy. In M. Moscovitch (Ed.), Infant memory (pp. 24-39). New York: Plenum Press.

Manis, F.R., Savage, P.L., Jorrison, F.J., Horn, C.C., Howell, M.J., Szeszulski, P.A., & Holt, L.K. (1987). Paired associate learning in reading-disabled children: Evidence for a rule-learning deficiency. Journal of Experimental Child Psychology, 43, 25-43.

McEwen, B.S. (1981). Neural gonadal steroid actions. Science, 211, 1301-1311.

McManis, D.L., Figley, C., Richert, M., & Fabre, T. (1978). Memory-for-Designs, Bender-Gestalt, Trail Making Test, and WISC-R performance of retarded and adequate readers. Perceptual and Motor Skills, 46, 443-450.

Meeker, M.N. (1969). The structure of intellect. Columbus, Ohio: Charles E. Merrill.

Meeker, M.N. (1975). Glossary for SOI factor definitions. Available from SOI Institute, 214 Main St., El Segundo, CA.

Miller, W.G. (1986). The neuropsychology of head injuries. In D. Wedding, A.M. Horton, & J. Webster (Eds.), The neuropsychology handbook (pp. 347-375). New York: Springer Publishing Co.

Morgan, W.P. (1896). A case of congenital word blindness. British Medical Journal, 2, 1378.

Morris, R., Blashfield, R., & Satz, P. (1986). Developmental classification of reading-disabled children. Journal of Clinical and Experimental Neuropsychology, 8, 371-392.

Naus, M.J., & Ornstein, P.A. (1983). Development of memory strategies: Analysis, questions and issues. In M.T.C. Chi (Ed.), Trends in memory development research (pp. 71-105). Basel Switzerland: Karger.

Nelson, H., & Warrington, E.K. (1974). Developmental spelling retardation and its relation to other cognitive abilities. British Journal of Psychology, 65, 265-274.

Nelson, K., Fivush, R., Hudson, J., & Lucariello, J. (1983). Scripts and the development of memory. In M.T.C. Chi (Ed.), Trends in memory development research (pp. 106-121). Basel, Switzerland: Karger.

Newcombe, F. (1969). Missile wounds to the brain. London: Oxford University Press.

Obrzut, J.E., & Hynd, G.W. (1983). The neurobiolgical and neuropsychological foundation of learning disabilities. Journal of Learning Disabilities, 16, 515-520.

Obrzut, J.E., Morris, G.L., Wilson, S.L., Lord, J.M., & Caraveo, L.E. (1987). Brain stem evoked response in the assessment of learning disabilities. International Journal of Neuroscience, 32, 811-823.

Olson, G.M., & Sherman, T. (1983). Attention, learning, and memory. In M.M. Haith & J.J. Campos (Eds.), Handbook of child psychology: Infancy and developmental psychobiology (Vol. 2, pp. 131-156). New York: Wiley.

Olson, G.M., & Strauss, M.S. (1984). The development of infant memory. In M. Moscovitch (Ed.), Infant Memory (pp. 23-41). New York: Plenum Press.

Ornstein, P.A., & Naus, M.J. (1985). Effects of the knowledge base on children's memory strategies. In H.W. Reese (Ed.), Advances in child development and behavior (pp. 113-148). New York: Academic Press.

Paris, S.G. (1975). Integration and inference in children's comprehension and memory. In F. Restle, R. Shiffrin, J. Castellan, & D. Pisoni (Eds.), Cognitive Theory (Vol. 1, pp. 32-56). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Paris, S.G., & Lindauer, B.K. (1977). Constructive processes in children's comprehension and memory. In R.V. Kail & J.W. Hagen (Eds.), Perspectives on the development of memory and cognition (pp. 153-176). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Patton, J.E., & Offenbach, S.I. (1978). Effects of visual and auditory distractors on learning disabled and normal children's recognition memory performance. Journal of Educational Psychology, 70, 788-795.

Pellegrino, J.W., Rosinski, R.R., Chiese, H.L., & Siegel, A. (1977). Picture-word differences in decision latency. Memory and Cognition, 5, 383-396.

Perfetti, C.A., & Lesgold, A.M. (1977). Discourse comprehension and sources of individual comprehension skill. In M. Just & P. Carpenter (Eds.), Cognitive processes in comprehension (pp. 141-183). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Petrauskas, R.J., & Rourke, B.P. (1979). Identification of subtypes of retarded reading: A neuropsychological multivariate approach. Journal of Clinical Neuropsychology, 1, 17-37.

Petrey, S. (1977). Word associations and the development of lexical memory. Cognition, 5, 57-71.

Pfaff, E.W. (1966). Morphological changes in the brains of adult male rats after neonatal castration. Journal of Endocrinology, 36, 415-416.

Piaget, J., & Inhelder, B. (1973). Memory and intelligence. New York: Basic Books.

Prigatano, G.P. (1978). Wechsler Memory Scale: A selective review of the literature. Journal of Clinical Psychology, 34, 816-832.

Psychological Corporation (1987). Wechsler Memory Scale-Revised Manual. New York: Harcourt Brace Javonovich, Inc.

Raisman, G., & Field, P.M. (1973). Sexual dimorphism in the neuropil of the preoptic area of the rat and its dependence on neonatal androgen. Brain Research, 54, 1-29.

Reed, H.B.C., Reitan, R.M., & Klove, H. (1965). Influence of cerebral lesions on psychological test performance of older children. Journal of Consulting Psychology, 29, 247-251.

Reed, J.I. (1968). The ability deficits of good and poor readers. Journal of Learning Disabilities, 2, 134-139.

Reitan, R.M. (1955). Investigation of the validity of Halstead's measures of biological intelligence. AMA: Archives of Neurology and Psychiatry, 73, 28-35.

Reitan, R.M. (1958). Qualitative versus quantitative mental changes following brain damage. Journal of Psychology, 45, 339-346.

Reitan, R.M. (1964). Manual for administering and scoring the Reitan-Indiana Neuropsychological Battery for Children (Aged 5 through 8). Indianapolis: University of Indiana Medical Center.

Reitan, R.M. (1971). Sensorimotor functions in brain-damaged and normal children of early school age. Perceptual and Motor Skills, 33, 655-664.

Reitan, R.M. (1975). Assessment of brain-behavior relationships. In P. McReynolds (Ed.), Advances in psychological assessment, (Vol III, pp. 186-242). San Francisco: Josey-Bass Inc.

Reitan, R.M., & Boll, T.J. (1973). Neuropsychological correlates of minimal brain dysfunction. Annals of the New York Academy of Sciences, 205, 65-68.

Reitan, R.M., & Davison, L.A. (1974). Clinical neuropsychology: Current status and application. Washington, D.C.: V.H. Winston and Sons.

Reitan, R.M., & Fitzhugh, K.B. (1971). Behavioral deficits in groups with cerebral vascular lesions. Journal of Consulting and Clinical Psychology, 37, 215-223.

Reitan, R.M., & Klove, H. (1968). Identifying the brain-injured child. In H.M. Robinson & H.K. Smith (Eds.), Clinical studies in reading III (pp. 72-87). Chicago: University of Chicago Press.

Ritchie, D.J., & Aten, J.L. (1976). Auditory retention of nonverbal and verbal sequential stimuli in children with learning disabilities. Journal of Learning Disabilities, 9, 312-318.

Ritter, K., Kaprove, B.H., Fitch, J.P., & Flavell, J.H. (1970). The development of retrieval strategies in young children. Cognitive Psychology, 5, 310-321.

Rourke, B.P. (1975). Brain-behavior relationships in children with learning disabilities: A research program. American Psychologist, 30, 911-920.

Rourke, B.P. (1976a). Issues in neuropsychological assessment of children with learning disabilities. Canadian Psychological Review, 17, 89-102.

Rourke, B.P. (1976b). Reading retardation in children: Developmental lag or deficit? In R.M. Knights & D.J. Bakker (Eds.), Neuropsychology of learning disorders: Theoretical approaches (pp. 125-137). Baltimore: University Park Press.

Rourke, B.P. (1976c). Interactions between research and assessment. Journal of Pediatric Psychology, 1, 7-11.

Rourke, B.P. (1978). Neuropsychological assessment of children with learning disabilities. In S.B. Filskov & T.J. Boll (Eds.), Dyslexia: An appraisal of current knowledge (pp. 173-215). New York: Oxford University Press.

Rourke, B.P., & Finlayson, M.A.T. (1978). Neuropsychological significance of variations in patterns of academic performance: Verbal and visuo-spatial abilities. Journal of Abnormal Child Psychology, 6, 121-133.

Rourke, B.P., & Orr, R.R. (1977). Prediction of the reading and spelling performances of normal and retarded readers: A four year follow-up. Journal of Abnormal Child Psychology, 5, 9-20.

Rourke, B.P., & Strang, J.D. (1978). Neuropsychological significance of variations in patterns of academic performance: Motor, psychomotor, and tactile-perceptual abilities. Journal of Pediatric Psychology, 3, 62-66.

Rourke, B.P., & Strang, J.D. (1983). Subtypes of reading and arithmetic disabilities: A neuropsychological analysis. In M. Rutter (Ed.), Developmental neuropsychiatry (pp. 473-488). New York: Guilford Press.

Routh, D. (1979). Activity, attention, and aggression in learning disabled children. Journal of Clinical Child Psychology, 8, 183-187.

Russell, E.W. (1975). A multiple scoring method for the assessment of complex memory functions. Journal of Consulting and Clinical Psychology, 43, 800-809.

Samuels, S., & Edwall, G. (1981). The role of attention in reading with implications for the learning disabled student. Journal of Learning Disabilities, 14, 353-361.

Satz, P., Friel, J., & Rudegair, F. (1974). Differential changes in the acquisition of developmental skills in children who later become dyslexic: A three year follow-up. In D. Stern, J. Rosen, & N. Butters (Eds.), Plasticity and recovery of function in the central nervous system (pp. 175-202). New York: Academic Press.

Satz, P., & Morris, R. (1981). Learning disability subtypes: A review. In F.J. Pirozzola & M.C. Wittrock (Eds.), Neuropsychological and cognitive processes in reading (pp. 109-141). New York: Academic Press.

Satz, P., & Van Nostand, G. (1972). Developmental dyslexia: An evaluation of a theory. In P. Satz & J. Ross (Eds.), The disabled learner: Early detection and intervention (pp. 121-148). Rotterdam, The Netherlands: Rotterdam University Press.

Senf, G.M. (1969). Development of immediate memory for bisensory stimuli in normal children and children with learning disorders. Developmental Psychology Monograph, Vol. 1, No. 6, Part 2.

Senf, G.M., & Freundl, P.C. (1971). Memory and attention factors in specific learning disabilities. Journal of Learning Disabilities, 4, 94-106.

Selz, M. (1977). A neuropsychological model of learning disability: Classification of brain function in 9-14 year old children. Unpublished doctoral dissertation, University of Washington.

Selz, M., & Reitan, R.M. (1979). Neuropsychological test performance of normal learning-disabled and brain-damaged older children. Journal of Nervous and Mental Disease, 167, 298-302.

Shankweiler, D., Liberman, I., Mark, L., Fowler, C., & Fischer, F. (1979). The speech code and learning to read. Journal of Experimental Psychology: Human Learning and Memory, 5, 531-545.

Shatz, M., Wellman, H.M., & Silker, S. (1983). The acquisition of mental verbs: A systematic investigation of the first reference to mental state. Cognition, 14, 301-321.

Siegel, L.S., & Linder, A. (1984). Short-term memory processes in children with reading and arithmetic disabilities. Developmental Psychology, 20, 200-207.

Spence, D.L., McKinney, J.D., & Appelbaum, M. (1985). Classification and validation of behavioral subtypes of learning disabled children. Journal of Educational Psychology, 77, 67-77.

Squire, L.R. (1986). The neuropsychology of memory dysfunction and its assessment. In I. Grant & K.M. Adams (Eds.), Neuropsychological assessment of neuropsychiatric disorders (pp. 268-299). New York: Oxford University Press.

Steeves, K.J. (1983). Memory as a factor in the computational efficiency of dyslexic children with high abstract reasoning ability. Annals of Dyslexia, 33, 141-152.

Strang, J.D., & Rourke, B.P. (1983). Concept-formation/nonverbal reasoning abilities of children who exhibit specific academic problems with arithmetic. Journal of Clinical Child Psychology, 12, 33-39.

Strub, R.L., & Black, F.W. (1977). The mental status examination in neurology. Philadelphia: F.A. Davis.

Swanson, H.L. & Rathgeber, A.J. (1986). The effects of organizational dimension on memory for words in learning-disabled and nondisabled readers. Journal of Educational Research, 79, 155-162.

Sweeney, J.E., McCabe, A.E., & Rourke, B.P. (1978). Logico-grammatical abilities in retarded spellers. Unpublished study, Windsor Western Hospital Centre and University of Windsor.

Sweeney, J.E., & Rourke, B.P. (1978). Neuropsychological significance of phonetically accurate and phonetically inaccurate spelling errors in younger and older retarded spellers. Brain and Language, 6, 212-225.

Tarver, S., & Hallahan, D. (1974). Attention deficits in children with learning disabilities: A review. Journal of Learning Disabilities, 7, 560-569.

Terman, L.M., & Merrill, M.A. (1937). Measuring Intelligence. Boston: Houghton Mifflin.

Terman, L.M., & Merill, M.A. (1973). Stanford-Binet Intelligence Scale: Manual for the Third Revision, Form L-M. Boston: Houghton Mifflin.

Torello, M.W., & Duffy, F.H. (1985). Using brain electrical activity mapping to diagnose learning disabilities. Theory into Practice, 24, 95-99.

Torgesen, J.K. (1977). Memorization processes in reading-disabled children. Journal of Educational Psychology, 69, 571-578.

Torgesen, J.K. (1979). Factors related to poor performance on memory tasks in reading disabled children. Learning Disability Quarterly, 2, 17-23.

Torgesen, J.K., & Goldman, T. (1977). Verbal rehearsal and short-term memory in reading-disabled children. Child Development, 48, 56-60.

Vellutino, F.R., Steger, J.A., Harding, C.J., & Phillips, F. (1975). Verbal versus nonverbal paired-associates learning in poor and normal readers. Neuropsychologia, 13, 75-82.

Wada, J., & Rasmussen, T. (1960). Intracarotid injection of sodium amytal for the lateralization of cerebral speech dominance. Journal of Neurosurgery, 17, 266-282.

Waters, H.S., & Andreassen, C. (1983). Children's use of memory strategies under instruction. In M. Pressley & J.R. Levin (Eds.), Cognitive strategies: Developmental, educational, and treatment-related issues (pp. 67-91). New York: Springer-Verlag.

Wechsler, D.A. (1917). Retention defect in Korsakoff's psychosis. Psychiatry Bulletin, 2, 403-451.

Wechsler, D.A. (1945). A standardized memory scale for clinical use. Journal of Psychology, 19, 87-95.

Wechsler, D.A. (1974). Wechsler Intelligence Scale for Children-Revised. New York: The Psychological Corp.

Wepman, J.M. (1964). Discussion of "The modality concept." In H.A. Robinson (Ed.), Meeting individual differences in reading (pp. 19-36). Chicago: University of Chicago Press.

Wiig, E.H., & Semel, E.M. (1974). Development of comprehension of logico-grammatical sentences by grade school children. Perceptual and Motor Skills, 18, 171-176.

Wolfus, B., Moscovitch, M., & Kinsbourne, M. (1980). Subgroups of developmental language impairment. _Brain and Language_, _10_, 152-171.