University of Alberta

Developmental Norms and Clinical Utility of the Wechsler Memory Scale-Revised for 9-15-Year-Olds

by

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A thesis
submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of
Master of Education

in

School Psychology

Department of Educational Psychology

Edmonton, Alberta

Fall 1995

ISBN 0-612-06574-X

University of Alberta

Library Release Form

Name of Author: Mary E. Lee

Title of Thesis: **Developmental Norms and Clinical Utility of the Wechsler Memory Scale-Revised for 9-15-Year-Olds**

Degree: Master of Education

Year This Degree Granted: 1995

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Abstract

This study was undertaken to introduce normative data for children aged 9 through 15 on the Wechsler Memory Scale-Revised (WMS-R) Logical Memory and Visual Reproduction subtests and to compare clinical and control groups of children on these subtests. Subjects for the normative sample consisted of 716 children aged 9 through 15. The comparison of clinical and control groups utilized a clinical group of 26 subjects with traumatic brain injuries and two control groups of 26 subjects each selected from the normative sample.

The results of two three-way MANOVAs on data for the normative group revealed significant main effects for age on both Logical Memory and Visual Reproduction variables of the WMS-R. Significant effects for gender on these variables were not found. There were significant effects for CCAT verbal scores on Logical Memory variables and CCAT nonverbal scores on Visual Reproduction variables. Univariate F-test results showed a significant effect for age on Logical Memory I, II, and recognition scores; and Visual Reproduction I, II, savings, and recognition scores.

The analysis of data comparing the clinical group and two control groups of children showed the clinical group to perform significantly poorer on immediate and delayed recall of verbal material compared to a control group matched on age and gender. Differences in immediate and delayed recall of verbal material were not found between the clinical and control group matched on age and WISC-R or WISC-III vocabulary scores, suggesting that immediate and delayed recall of verbal material is related to verbal intelligence. The clinical group performed significantly poorer than either control group on their ability on the delayed recall of visual material; however, they did not differ significantly from control subjects on their ability on the immediate recall of visual material. Logical Memory and Visual Reproduction savings (i.e., percentage retention) scores effectively discriminated

between mean clinical- and control-group performance, whereas recognition trials did not discriminate between these groups.

Acknowledgements

I wish to acknowledge the many individuals who have contributed to the completion of this thesis.

My sincere appreciation is expressed to Dr. Janzen for serving as my supervisor. I would also like to express my gratitude to Dr. Paterson, Dr. Richards, and Dr. Paniak for serving as committee members.

Thanks are also extended to Dr. Paniak and the staff of the Glenrose Rehabilitation Hospital for their assistance.

Finally, I would like to thank my husband, Rodney, for his interest and support in my academic endeavors.

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CHAPTER 1

INTRODUCTION

Statement of Problem

"The assessment of memory functions is an essential part of the diagnostic evaluation of persons experiencing psychological problems ranging from dementia in older persons to disabilities in children" (Curry, Logue, & Butler, 1986, p. 214). The Wechsler Memory Scale-Revised (WMS-R) is an instrument designed to assess verbal and nonverbal memory functions. The age range of the WMS-R normative database is 16 to 74 years of age. Although there have been attempts to provide child and adolescent norms for the Wechsler Memory Scale (WMS; Curry et al., 1986; Ivinskis, Allen, & Shaw, 1971), a normative database for children under 16 years of age has not yet been established for the WMS-R. Curry et al. reported that "a major rationale for construction of age-related norms for the WMS-R is the hypothesis that memory functions vary with age" (p. 217).

To be useful clinically, the WMS-R must also be able to detect memory problems in subjects reported to have memory problems. Elwood (1991) contended that the effectiveness of a test in detecting memory deficits is reflected in how accurately it can discriminate between control subjects and those with presumed memory deficits. A comparison of control and clinical subjects can help to determine if an instrument such as the WMS-R can detect memory problems in subjects reported to have these problems.

This study consists of the following population samples: a normative sample of school children aged 9 through 15 and a sample of 26 children with head injuries matched with two control groups of 26 subjects each. The study has two major purposes. The first is to develop a clinically useful normative database for the Logical Memory I and II (i.e., story recall) and Visual Reproduction I and II (i.e., figural reproduction) subtests of the WMS-R for children aged 9 through 15. The second purpose of this study is to determine differences on these subtests between clinical and control groups of children.

Questions Addressed in the Current Study

1. Are there differences in performance according to age for a normative population on the WMS-R variables of Logical Memory I, II, savings, and recognition trial scores and Visual Reproduction I, II, savings, and recognition trial scores?

2. Are there differences in performance according to gender for a normative population on the WMS-R variables of Logical Memory I, II, savings, and recognition trial scores and Visual Reproduction I, II, savings, and recognition trial scores?

3. Is there a correlation between Canadian Cognitive Ability Test (CCAT) verbal scores and Logical Memory variables, and CCAT nonverbal scores and Visual Reproduction variables for a normative population?

4. Is there a correlation between WISC-III Vocabulary scores and Logical Memory variables for a normative population?

5. Do clinical and control groups differ in performance on the WMS-R variables?

Delimitations and Limitations of the Study

This study is delimited by the decision of the researcher to utilize data from the Glenrose Rehabilitation Hospital. The nature of these data, and therefore this thesis, is limited by several factors. This is not a representative sample by urban-rural location, geographic location, or ethnicity. All subjects for the normative database were from one Edmonton, Alberta, public school system. Subjects for part 2 of the study were also limited by location. The control groups were selected from the aforementioned normative sample. The subjects for the clinical sample were patients at one hospital, the Glenrose Rehabilitation Hospital in Edmonton, Alberta.

The sample size for the analysis of the recognition data was small, limiting the generalizability of these findings.

Overview of the Study

Chapter 2 of this thesis is a review of the literature regarding research on recent models of memory, the WMS-R and its predecessor, the WMS. Chapter 3 includes a description of the methodology and design of this study. The results of this study are presented in Chapter 4. Chapter 5 includes a discussion of the findings of each hypothesis, the implications of the study, and suggestions for further research.

CHAPTER 2

LITERATURE REVIEW

Introduction

The selective review of literature in this chapter consists of three main areas. The first includes a discussion of models of memory. The second examines the development of memory in children. The last section addresses the Wechsler Memory Scale-Revised (WMS-R) and its predecessors, the Wechsler Memory Scale (WMS) and Russell's Revision of the Wechsler Memory Scale (RWMS).

The importance of memory to humans is described by Goethals and Soloman (1989) as "the enabling capacity of human existence. Without memory's capacity to store information in the remarkable quantities we generally take for granted, human behavior, human consciousness, and human identity would bear no relation to their present form" (p. 1).

The study of memory is not a simple and straightforward process. Nelson (1993) pointed out that "students of memory have been faced with the persistent problem of what it is that they are studying and whether it comes in different types or whether there is a single structure or process called memory" (p. 1). There is a tendency to study memory as though it involves a single process when in fact it "is an outcome of the functioning of a complex set of neurobiological processes" (McGaugh, 1989, p. 34).

Klatzky (1980) said that memory has an abundance of meanings and that it "is not readily captured in a single phrase" (p. 1). Wechsler (1987) contended that the concept of memory is broad and in discussing it said that memory encompasses many functions that may be considered mutually distinct. One of these is the distinction between memory for verbal and that for figural material. The meanings and explanations of memory and how it works have varied depending on where and when it has been used and the perspective of the person using it. Differing models of memory have attempted to explain the process of memory.

Models of Memory

Many models have been developed over the course of time to explain the memory process. Searleman and Herrmann (1994) stated that "it is clear that memory is highly organized, but there is an ongoing debate over whether there is a single memory system or multiple memory systems" (pp. 72-73).

Although thought and discussion about memory may date back to the time of Aristotle, it is Herman Ebbinghaus' work beginning in the 1880s that is considered to be the start of the scientific study of memory. His study of memory using an experimental approach was a deviation from the work of his contemporaries, who favored natural observation and conjecture (Searleman & Herrmann, 1994).

During the first half of the 20th century, memory was viewed as a unitary system. Learning occurred when a stimulus and a response were paired. Remembering was believed to occur when a response was recollected when presented with a stimulus (Searleman & Herrmann, 1994). Memory failure was believed to be caused by interference.

By the late 1950s the unitary view had fallen from favor, and the multiple-memory-system approach rose in popularity. Searleman and Herrmann (1994) felt that this was due to the information-processing approach used by computer scientists, the Brown-Peterson Distractor Technique, and the work of Sperling (cited in Searleman & Herrmann, 1994) on iconic memory. The Brown-Peterson Distractor Technique postulates that forgetting of information can occur in seconds if people do not rehearse the information. Sperling's work dealt with memory decay. It influenced later theorists such as Atkinson and Shiffrin (1965, 1968, 1971; cited in Searleman & Herrmann, 1994), and Neisser (1967; cited in Searleman & Herrmann, 1994). The multiple-memory-system approach promotes the idea of memory being organized into separate components (Searleman & Herrmann, 1994).

In the mid-1960s the Atkinson-Shiffrin model gained prominence. This model uses an information-processing approach called the multistore model. In their model, information coming from sense receptors (eyes, nose, ears) passes through three components: a sensory register, a short-term store, and a long-term store (Moshman, Glover, & Bruning, 1987, p. 337). Moshman et al. described the functions of each of the three components. The function of the sensory register is to hold information received from the sense receptors until it can be processed by the information-processing system. The short-term store is where incoming information is held, thought about, and rehearsed. The long-term store is the permanent store of unlimited size holding the new information which was transferred from the short-term store.

By the early 1970s increased dissatisfaction with the Atkinson-Shiffrin model led to other models of memory being proposed as alternatives to it. Other ideas of the memory process included the working memory model, which proposed that short-term memory is composed of the central executive, the phonological loop, and the visuo-spatial sketch pad; the connectionist models that were patterned after the way the human brain works; and the levels-of-processing model that was initially proposed by Fergus Craik and Robert Lockhart in 1972 (Searleman & Herrmann, 1994).

Craik and Lockhart (1972) proposed that a depth or levels-of-processing model of memory was an alternate framework from the multistore theory of memory. Their proposed framework differed from aspects of the multistore theory of memory in that they "believed that memory depends on what people do when they process information. Storage mechanisms, as emphasized by the multistore model, are less critical" (Moshman et al., 1987, p. 342).

Craik and Lockhart (1972) proposed that incoming stimuli may be processed at different levels. Stimuli may be processed at a shallow level where physical or sensory analysis occurs onto a deep level where semantic properties of the stimuli are of concern. This series or hierarchy of processing stages is what Craik and Lockhart referred to as *depth of processing*. They contended that deeper analysis will lead to a more enduring memory trace. Craik and Lockhart felt that stimuli may be maintained by recirculating information at one level of processing. This type of maintenance in primary memory is what they referred to as *Type I processing*. It does not lead to improved subsequent retention, however, because when the attention of the individual is diverted, information is lost. *Type II processing* involves more elaborate or deeper analysis of information and can lead to the long-term storage of information (Craik & Lockhart, 1972). Searleman and Herrmann (1994) stated that an example of Type I processing is repeating a phone number to keep it in conscious awareness, whereas relating a phone number to things that are more meaningful to remember it for the future is an example of Type II processing.

Berk (1991) stated that, according to this model, our limited capacity to handle large numbers of stimulus inputs at once is not due to a fixed-size memory container but is rather due to the limit imposed by the extent to which we can distribute our attention to different activities. The level of skill and types of strategies employed are influential. As our age increases to maturity, strategy use for most people improves. Berk contended that

> level of processing theorists attribute the limited capacity of working memory entirely to attentional resources. With age, cognitive operations become more automatic and efficient because of practice and improved use of strategies. As a result, attention is freed for other concurrent activities. (p. 294)

Craik and Tulving (1975) and Bellezza, Cheesman, and Reddy (1977) utilized written material when investigating Craik and Lockhart's (1972) levels-of-processing model of memory. The study of this model of memory on visual material was done by Bower and Karlin (1974). A series of 10 experiments by Craik and Tulving were designed to explore the levels-of-processing framework for human memory. Although they found support for the basic ideas of the levels-of-processing framework, they felt that many ideas suggested by Craik and Lockhart (1972) needed modification. Bellezza et al. looked at whether the use of an organizational strategy influences free-recall performance more than the degree of semantic elaboration does. The levels-of-processing model of memory asserts that deeper "semantic" levels of processing lead to better memory than superficial or more shallow processing does. Bellezza et al.'s findings supported the premise that semantic processing of a word improves its recall over situations where only nonsemantic aspects are attended to; however, they also found that increased organization leads to better recall when further increases in semantic processing do not. Bower and Karlin stated that studies supporting the depth-of-processing hypothesis used only words as learning materials; thus, they felt the need to explore the effects with other stimuli. In exploring the depth of processing on pictures of faces, they found that performance on a later-recognition memory test was high for pictures judged for likableness or honesty ("deep") and low for pictures judged by sex ("superficial").

Support for the levels-of-processing framework included investigations of the self-reference effect. In the study by Rogers, Kuiper, and Kirker (1977), subjects not only made semantic, structural, and phonemic ratings of words, but they also decided whether the word described themselves. Rogers et al. stated that the data suggest that "self-reference is a very potent encoding device" (p. 687). This tendency for people to remember words which have been related to themselves is presumably due "to the deep levels of encoding the words underwent" (Searleman & Herrmann, 1994, p. 96).

Searleman and Herrmann (1994) stated that "the generation effect (that self-generated items are better remembered than other nongenerated items) can also be seen as being consistent with the levels-of-processing framework" (p. 96). This effect has been observed in tasks of free and cued recall and recognition. They stated that it was found in both intentional and incidental situations.

Whereas the initial levels-of-processing theory's only definition for *depth of analysis* involved the progression from the physical through the semantic levels, later more comprehensive definitions for levels of hierarchical analysis were given (Snart, 1979). Snart explained that later definitions included an increase in the accessibility of an item within a level, with incoming information being analyzed either laterally or vertically within three domains, rather than necessarily going through the levels of the hierarchical analysis. In discussing the levels-of-processing model of memory, Moshman et al (1987) stated that

> although the original levels-of-processing model has been refined as a result of new research (Craik, 1973, 1977; Craik & Lockhart, 1972; Craik & Tulving, 1975; Eich, 1985; Fisher & Craik, 1980; Jacoby & Craik, 1979; Jacoby, Craik, & Begg, 1979), the basic idea of this model remains that memory is a byproduct of perceptual analyses of incoming stimuli. The 'deeper' the processing, the more likely the recall. (p. 343)

Although the levels-of-processing theory was met with enthusiasm by some, it has received criticism from others. Searleman and Herrmann (1994) supported Baddeley's (1978) criticism of the lack of an independent measure of processing depth. Searleman and Herrmann contended that the inability to measure processing depth separately from the amount of retention makes the whole concept circular. For example, material that has been well remembered has been encoded or processed deeply, but there is no way of knowing how deeply it has been encoded without examining its performance. In addressing this criticism, Craik (1990) stated that "there is agreement among judges as to what types of processing are deeper than others, and that other concepts in psychology (such as 'reinforcement') have proved valuable although they cannot be measured independently of their effects" (p. 214).

Another criticism of the levels-of-processing theory deals with maintenance rehearsal and long-term retention. Although the model proposes that only elaborative rehearsal can result in long-term retention of information, Searleman and Herrmann (1994) identified studies by Mechanic (1964), Woodward, Bjork, and Jongeward (1973), Melson (1977), Glenberg, Smith, and Green (1977), Glenberg and Adams (1978), and Maire (1983) as having shown that maintenance rehearsal leads to enhanced retention.

A third criticism leveled against the theory concerns the tenet that superficial processing will not be remembered as well as information processed deeply. Research has shown that this assumption is not always true (Searleman & Herrmann, 1994). Morris, Bransford, and Franks (1977) contended that shallower levels of processing such as rhyming will not necessarily lead to poorer retention. They explained that transfer-appropriate processing could replace the concept of levels of processing. Transfer-appropriate processing emphasizes the value of acquisition activities being defined relative to particular goals and purposes. Morris et al. argued that particular acquisition activities are never inherently superficial; instead, "task meaningfulness must be defined relative to particular learning goals" (p. 519). Craik (1990) stated that

> although transfer-appropriate processing is an important principle of memory, it does not negate the usefulness of a systematic taxonomy for encoding; a semantic encoding paired with an appropriate semantic retrieval cue typically yields higher performance than a rhyme encoding paired with a rhyme cue. (p. 214)

When evaluating the levels-of-processing framework, Searleman and Herrmann (1994) defended it from criticism by stating that "it has been suggested that the circularity issue is not as important as some people claim and that the transfer-appropriate processing work doesn't really cause problems for the model" (p. 96). Moshman et al. (1987) supported the value of the levels-of-processing approach when they claimed that "perhaps the greatest contribution of the levels-of-processing model is the idea that memory for information is determined by what children and adults do with that information when they encounter it" (p. 345).

Development of Memory in Children

Studies on how memory develops in humans have been conducted for the past 100 years.

> In the past 25 years, no other area in developmental psychology has increased more dramatically than the study of memory. . . . Some of the clearest insights into human memory and thinking have come from understanding developmental changes in memory and memory processes. Moshman et al., 1987, p. 334)

Piaget's theory of cognitive development proposes that a child progresses through four stages of development: the sensorimotor (birth to 2 years), the preoperational (2-7 years), the concrete operational (7-11 years), and the formal operational (11-15 years). There are many aspects of a child that develop when the child progresses through these stages, including memory.

The investigation of memory during the sensorimotor stage of a child's life has not been easy for researchers. Mitchell (1990) contended that during the first year of life, a child's limited attention span, lack of verbalization, and underdeveloped body control make the task of investigating memory difficult. Although difficult, the task is not impossible, because "studies of infant memory indicate that some aspects of memory functions operate in the first few months of life and that memory has improved by the age of 1 year" (Papalia & Olds, 1982, p. 232). Habituation experiments with newborns have shown that they have some memory skills (Kail, 1990; Moshman et al., 1987; Parkin, 1993). Searleman and Herrmann (1994) explained that a typical habituation-dishabituation procedure involves presenting an attentive infant with the same picture over a series of trials and observing the amount of time the infant fixates on the stimulus. A decrease in the amount of time spent looking at the stimulus is thought to reflect habituation: the recognition of the stimulus from previous trials and the resultant looking at it for less time. By the age of 3 months infants will usually begin to recognize familiar objects, by 6 months a child can recognize visual stimuli after a two-week delay, and by 12 months a child can remember routine events and past experiences (Campbell, 1990).

During the preoperational stage a child has an increasing ability to remember and to use their memories. Papalia and Olds (1982) discussed recognition and recall abilities during early childhood. *Recognition memory* may be defined as "the realization that some perceptually present stimulus or event has been encountered before" (Vasta, Haith, & Miller, 1995, p. 305). Recognition ability can be measured by showing a child a number of objects, putting them away, and then showing them again along with other objects that the child has not yet seen. The child is then asked which he or she has seen before and which ones are new. Papalia and Olds stated that 2-year-olds averaged 81% correct and 4-year-olds averaged 92% correct.

Recall memory was defined by Vasta et al. (1995) as "the retrieval of some past stimulus or event that is not perceptually present" (p. 305). Recall abilities were tested by showing a child a number of objects, putting them away, and asking the child to name the objects seen. Two-year-olds averaged 23% correct, and 4-year-olds averaged 35% correct. Myers and Perlmutter (1978; cited in Papalia & Olds, 1982) found that "in general, in early childhood, recognition ability is good, recall is poor and both improve between the ages of 2 and 5" (p. 308). Although recall is generally harder than recognition at all ages, during early childhood it is even harder to recall material from memory because a child has less knowledge in general, is familiar with fewer items, has poorer vocabulary, and has not figured out strategies for remembering information (Papalia & Olds, 1982).

Freiberg (1987) felt that the amount that a person can memorize at one time is limited by the development and functioning of brain cells. She said that on average a 6-year-old can remember and repeat 5 digits presented verbally, whereas a 10-year-old usually can remember 7 digits, and some adults have immediate recall of 10 digits. Six-year-olds may have the ability to remember and repeat two unrelated words presented verbally; 10-year-olds, three or four; and adults, up to six. Mitchell (1990) claimed that, whereas some children have impressive number memories but average or weak concept memories, others have gifted visual memories but poor auditory memories. He stated that most children have memory skills which are comparatively uniform.

"A person's understanding and knowledge about the whole concept of memory is called metamemory" (Papalia & Olds, 1982, p. 440). Vasta et al. (1995) contended that "most researchers remain convinced that the growth of metamemory is one source of developmental improvement in memory" (p. 316). Vasta et al. and Searleman and Herrmann (1994) concurred that even young children have some knowledge that memory exists; however, metamemory in young children is limited. Searleman and Herrmann claimed that "even children of 3 or 4 demonstrate some metamemory" (p. 279). Although children as young as kindergarten may have some idea of the concept of metamemory, it tends to develop through the fifth grade. Schneider and Pressley (1989) pointed out, however, that knowledge of memory is not complete by the end of childhood. They stated that knowledge of memory strategies tends to increase with increasing age.

During Piaget's stage of concrete operations (ages 7 to 11), a person's ability to remember information increases for both short- and long-term memory. Papalia and Olds (1982) contended that advances in memory during this age are due to general cognitive development, which allows one to use different strategies for remembering. Three memory strategies often used are rehearsal, clustering, and chunking.

Rehearsal, a short-term memory strategy, involves the repetition of information. In discussing a study by Flavel, Beach, and Chinsky (1966), Parkin (1993) stated that "the results showed a very clear developmental trend with only 10 per cent of 5-year-olds employing rehearsal, but 60 per cent of 7-year-olds and 85 per cent of 10-year-olds" (p. 152). Ornstein and associates (1975, 1978, 1985; cited in Moshman et al.,

1987) examined rehearsal from 7 years through adulthood and stated that the amount of rehearsal stayed the same, but the nature of it changed. Children rehearsed at a shallow level, whereas older children and adults rehearsed and processed information more creatively.

Papalia and Olds (1982) contended that *clustering* is a strategy used to help convert material from short-term to long-term memory. An example of clustering is the grouping of items into categories to aid memory.

Chunking occurs when one breaks material to be remembered into smaller pieces. Remembering the chunks or pieces allows the total to be recalled. An example of chunking is the method of remembering a telephone number. Typically, the seven-digit telephone number is divided into a separate three- and four-digit code.

The stage that Piaget referred to as *formal operations* encompasses the age range between 11 and 15 years of age. The beginning of adolescence is a primary feature of this age range. Adolescence is a time when processing speed continues to increase and old strategies such as rehearsal continue to develop and are used more flexibly (Schneider & Pressley, 1989). *Elaboration,* "the process whereby existing mental contents (units) are related to one another" (Madler, 1989, p. 85), is more likely to be used by adolescents than by younger children.

Developmental changes in memory begin in childhood and continue through adolescence and into adulthood unless something occurs to halt development. Memory development or the use of memory may be slowed or halted if injury to the brain occurs. According to Haut, Franzen, and Rogers (1992), "memory dysfunction is one of the most common residuals from insult to the brain" (p. 451). Deficits to the memory can be manifested in varying degrees of verbal and/or visual memory impairments (Reid & Kelly, 1993). Boll and Barth (1981) commented that

> brain damage during childhood has different effects at each age,and these differences interact with type, severity, and location at lesion. The generalization of knowledge from adults to children is limited by the different and more rapidly changing psychological state of the organism. (p. 427)

Boll and Barth stated that the increased difficulty in measuring the effects of brain damage in children serves to highlight the need for valid assessment techniques which reflect the complexity of the biology and psychology of the patient. In reviewing clinical memory assessment techniques, Haut et al. stated that no one measure is best suited for all rehabilitation patients. They said that memory evaluation for rehabilitation purposes should include a number of measures to allow for an adequate sampling of learning and memory strengths and weaknesses. The WMS and WMS-R are two instruments designed to assess memory functions which may be used in the evaluation and rehabilitation of patients.

Wechsler Memory Scale (WMS)

The WMS, introduced by David Wechsler in the *Journal of Psychology* in 1945, was used to provide "a rapid, simple, and practical memory examination" (p. 87). This instrument, consisting of seven subtests, was described by Wechsler as advantageous because of its (a) 15-minute administration time, (b) satisfactory standardization, (c) allowance for memory variations with age, and (d) memory quotients that he felt were comparable to the subject's intelligence quotient.

Although normative data for adults were provided, Wechsler (1945) did not include normative data for individuals less than 16 years of age. A study by Ivinskis et al. (1971) extended the WMS norms to include lower age groups. Their study consisted of 74 subjects, 30 in the 10- to 14-year age group and 44 in the 16- to 18-year age group. They found that the subjects aged 10-14, when compared to older subjects (16-18, 20-29 years), scored lower on most WMS subtests. One exception occurred when younger subjects scored better in Associate Learning than did any other age group.

Although the WMS has been cited by Erickson and Scott (1977) and D'Elia, Satz, and Schretlen (1989) as a widely known test of memory functioning, Curry et al. (1986) pointed out that this scale was developed before many recent advances in the study of memory processes, such as the clarification of differences between immediate and delayed recall. The WMS did not include an assessment for delayed memory. A review by Prigatano (1978) described the strengths and weaknesses of the WMS. Prigatano felt that the strengths of the WMS were (a) an observed decline in total WMS scores with age in an adult population, (b) a relatively constant factor structure, (c) evidence that Memory Quotient (MQ) scores were below Full Scale IQ in patients with amnestic disturbances, and (d) experimental support for the construct validation of the WMS as a test of short-term verbal memory. The weaknesses he found with the test included (a) no scaled or standard scores; (b) problems with the scoring of the Logical Memory subtest; (c) a lack of norms for a large representative sample including children, adolescents, and the aged; (d) a lack of good numerical determinations of the test-retest reliability of the MQ scores in normals; and (e) a lack of information of the distribution of Full Scale IQ minus MQ scores, especially with those of superior IQ scores. He also felt that there was a need to restandardize the MQ scores with the Wechsler Adult Intelligence Scale (WAIS) or WAIS-R Full Scale IQ instead of the Wechsler-Bellevue IQ Scale. Prigatano concluded that "the WMS needs to be improved substantially if it is to continue as a viable measure of memory function" (p. 828).

Revised Wechsler Memory Scale (RWMS)

Because of what Russell (1975) referred to as "recent advances in the understanding of memory processes" (p. 800), he presented a preliminary report on a memory-scoring method for the WMS. Russell's version of the WMS utilized the Logical Memory and Visual Reproduction subtests of the original WMS. His revision allowed the assessment of verbal and figural and immediate and delayed memory. The first administration of the Logical Memory and Visual Reproduction tests provided immediate verbal and figural memory scores. After a half-hour delay of the first administration of each test, a second recall of the memory material from each test was requested. The scores from each test yielded the delayed verbal and figural memory scores. In response to criticism that the Verbal (Logical) Memory norms were too high, Russell (1988) produced renorming "by developing new scale scores and age-education correlations" (p. 235).

In a study by Curry et al. (1986), it was acknowledged that the WMS was widely used, and Russell's (1975) revision permitted the assessment of semantic and figural and immediate and delayed functions. Curry et al. pointed out, however, that "no norms have been developed for use with adolescents and older children" (p. 214). Their study consisted of 247 subjects between the ages of 9 years 7 months and 15 years 6 months. Tests administered included the RWMS and Peabody Picture Vocabulary Test (PPVT). The PPVT standard score was used as an estimate of verbal intelligence and served to screen out exceptional students. The relationship between sex, age, and verbal intelligence and RWMS memory scores was examined. Curry et al. found that the relationship between memory functioning, age, and verbal intelligence appeared to differ as a function of age. For females, five of six RWMS memory measures improved as a function of age; however, none were significantly related to age for males. For males, three of six memory measures were related to verbal intelligence; however, for females, none were related to verbal intelligence as measured by the PPVT. Curry et al. stated that the results of their study show that normal preadolescents and adolescents generally score in a range that would be considered impaired by Russell's rating system for adults. They contended that "in itself, this finding shows the need to have age-related norms for late childhood and early adolescence" (p. 218). Curry et al. pointed out the need for age-appropriate norms, and their study sought to extend the normative database for the WMS and RWMS to include a child population.

Wechsler Memory Scale-Revised (WMS-R)

The WMS-R, a revision of the WMS, is an individually administered clinical instrument for appraising major dimensions of memory functions (Wechsler, 1987). It attempted to overcome some of the shortcomings of the original test. According to the WMS-R manual, the changes included (a) the provision of norms stratified at nine age levels, (b) the replacement of a single global summary score (the Memory Quotient) with five composite scores, (c) the addition of new subtests measuring figural and spatial memory, (d) the addition of measures of delayed recall, and (e) the revisions of the scoring procedures for several subtests to improve scoring accuracy.

The WMS-R is intended as a diagnostic and screening device for use as part of a clinical examination of the assessment of memory functions. It consists of a series of subtests, each measuring a different aspect of memory. Wechsler (1987) stated that the function assessed include memory for verbal and figural stimuli, meaningful and abstract material, and delayed as well as immediate recall. He continued: "The Scale is not suitable for making fine discriminations at high levels of memory functioning" (p. 7).

Loring (1989), Bowden and Bell (1992), and Haut et al. (1992) concurred that the WMS-R attempted to overcome the shortcomings of the WMS. Haut et al. contended that the WMS-R is a good test for memory assessment. He said that it is a relatively quick screening procedure that allows the identification of a range of memory impairments in a varied population of patients. Loring stated that although it is not without shortcomings, "due to its relatively strong psychometric grounding and representative normative sampling, the WMS-R will likely obtain a prominent position in many neuropsychology batteries" (p. 59).

"Evidence of a test's validity helps to establish the nature of what the test measures" (Wechsler, 1987, p. 65). Studies have shown the validity of the WMS-R in discriminating between clinical and normal populations. In examining the issue of validity, Wechsler summarized WMS-R scores for 14 clinical groups and compared each group to the normal standardization sample. The diagnoses of the 14 clinical groups were alcoholism, Alzheimer's, brain cancer, closed head injury, dementia, depression, Huntington's, Korsakoff's, multiple sclerosis, psychiatric groups, schizophrenia, seizure disorder, stroke, and neurotoxins. Wechsler stated that the consistency of significant differences across clinical groups provided evidence of criterion-related validity for the WMS-R. He said that although the data of the clinical groups is to be illustrative and suggestive, not necessarily representative of the different clinical groups, "the data do support the utility of the WMS-R in assessing memory impairment" (p. 86). In a study by Reid and Kelly (1993), which was designed to assess the validity of the WMS-R in a group of subjects with recent head injury, the WMS-R differentiated a group of head-injured subjects from normal controls in terms of different memory components. In investigating the validity of the WMS-R with individuals with head injuries, Boyer (1991) found the WMS-R to be "a valid and useful instrument for assessing the memory deficits in head injured patients in the early post injury period" (p. 3). Although Elwood (1991) concurred that "numerous studies have shown that the WMS-R is able to grossly discriminate various clinical samples from groups of normal individuals" (p. 190), he also pointed out that available studies "do not demonstrate that the WMS-R can distinguish between clinical populations" (p. 191).

Although the WMS-R has been valid in discriminating between clinical and normal populations, it is also important to look at the extent to which a test measures a theoretical construct or trait. Anastasi (1982) referred to this as *construct validity*. Anastasi stated that age differentiation is a technique which may contribute to construct validity. Some abilities, such as intelligence or memory, are expected to increase during childhood to maturity. A test measuring an ability such as intelligence or memory should have test scores which show such an increase. This study examined WMS-R test scores in a pediatric population.

Although it is generally agreed that the WMS-R is an improvement over the WMS, it has also received criticism. Loring (1989) and Elwood (1991) have criticized the lack of inclusion of all ages in the standardization sample. Whereas normative data are available between the ages of 16 and 74, the norms for three age groups—18-19, 25-34, and 45-54—were derived by using an estimated procedure (Wechsler, 1987). Wechsler explained that 50 subjects were included in each of six age groups—16-17, 20-24, 35-44, 55-64, 65-69, and 70-74. The norms for ages 18-19, 25-34, and 45-54 were derived by interpolation. Loring contended: "One must temper criticism of normative data by acknowledging that any systematically collected database attempting to adequately sample the population of interest is of value, particularly when considering memory tests" (p. 60). Bowden and Bell (1992) stated that

> while observed data are always preferable to interpolated scores, there is no reason to assume that the interpolated Index scores do not faithfully reflect the population parameters at every age band. . . . There is no strong reason to avoid using the WMS-R with any age group. (pp. 341-345)

Mittenberg, Burton, Darrow, and Thompson (1992) designed a study to provide empirical norms for individuals between 25 and 34 years of age. They claimed that when these normative data were compared to the estimated norms for this age group in the WMS-R manual, statistically significant differences between the observed and the published index scores were present. They stated that data published in the WMS-R manual appear to underestimate performance on the Attention/Concentration index at the lower end of the score distribution and overestimate that at the higher end of Visual Memory and Delayed Recall indexes. They felt that these norms may be used as an alternative to those in the WMS-R manual.

Wechsler (1987) stated that the *reliability* of a test refers to its consistency or precision of measurement. He said that users of the WMS-R should use appropriate caution when interpreting subtests with low reliabilities. This may include Visual Reproduction I and Visual Reproduction II, with reliability coefficients of .59 and .46, respectively.

Butters et al. (1988), Haut et al. (1992), and Reid and Kelly (1993) concurred that the lack of recognition tests for verbal and nonverbal tasks is a shortcoming of the WMS-R. They pointed out that the lack of recognition tasks prevents comparisons between recall and recognition memory. Haut et al. stated that the lack of recognition testing makes it difficult to differentiate a basic problem with encoding from a retrieval problem. They claimed that including a recognition component in the Logical Memory and Visual Reproduction subtests would assess an aspect of memory that they felt had been ignored in this test battery. They further contended that testing for recognition performance would "yield practical information for the development of compensation strategies" (p. 459). The present thesis presents information regarding recognition performance on the WMS-R.

Whereas the WMS-R normative database covers the age range of 16 to 74 years, it does not extend to children under 16 years of age. A normative database is essential because it provides a frame of reference with which to compare a person's test scores. The use of an appropriately normed testing instrument helps to provide reliable and valid assessments. Wechsler (1987) contended that "future research with larger samples, different clinical groups, and more exactly defined groups is needed to further understand how the WMS-R may be most useful in the assessment of memory impairment" (p. 86). The present study will help to further the use of the WMS-R with a late-childhood and early-adolescent population.

CHAPTER 3

METHOD AND DESIGN

Subjects

Because this thesis consists of two studies, each will be described separately.

Study 1: Normative Study

The 716 children comprising the normative database were part of a study by Miller, Paniak, and Murphy (1993). These children were recruited from schools in the Edmonton Public School District. An information letter sent to parents or guardians containing the purpose of the study and requesting consent to participate contained questions to help to limit the sample to subjects with no biasing conditions. Children were excluded from the study if English was not the main language used at home or if the child was enrolled in an English as a Second Language (ESL) class. The criteria for exclusion also included attendance in a self-contained special-education class or grade failure. Children who received special help for learning difficulties had their school records examined to determine if a documented brain injury or major psychiatric disorder was associated with the learning problem. If this was the case, the child was excluded from the study. Children who had been hospitalized because of brain injury or behavior problems were excluded from the study. Children who had been diagnosed with Attention Deficit Hyperactivity Disorder were excluded only if they had required hospital treatment for it or if there was a documented brain injury. The group of 716 subjects consisted of 326 males and 390 females, with a mean age of 11.80 (*SD*=3.97). The mean Wechsler Intelligence Scale for Children-III (WISC-III) Vocabulary Scaled score was 10.34 (*SD*=2.66) for the normative sample, suggesting normative estimated verbal intelligence. The mean Canadian Cognitive Abilities Test (CCAT) verbal score was

111.17 (*SD*=14.00). The mean CCAT quantitative and nonverbal scores were 113.73 (*SD*=13.75) and 110.38 (*SD*=14.52), respectively. Table 1 presents the means and standard deviations by age for the Wechsler Memory Scale-Revised (WMS-R) variables, the WISC-III Vocabulary scaled score, and the three CCAT scores.

Table 1

Descriptive Statistics for the Normative Sample

		Age						
Variable		9	10	11	12	13	14	15
Subjects	*N*	81	140	132	123	96	116	28
Males	*n*	36	64	76	50	40	45	15
Females	*n*	45	76	56	73	56	71	13
Age (in mos.)	*M*	114.56	125.82	137.09	149.78	161.93	173.31	181.25
	SD	3.10	3.55	3.41	3.63	3.43	3.33	1.69
Vocscale	*M*	10.36	9.84	9.90	10.55	10.61	10.79	10.61
	SD	2.82	2.80	2.85	2.74	2.72	2.05	1.41
CCATVS	*M*	114.30	109.43	111.03	110.13	110.71	112.52	108.24
	SD	13.89	15.00	14.57	13.50	14.49	12.67	8.69
CCATQS	*M*	119.40	113.43	114.12	113.15	111.00	113.05	107.88
	SD	9.29	14.12	12.60	13.77	14.99	15.06	13.80
CCATNVS	*M*	110.10	110.87	108.02	111.53	112.26	112.34	109.32
	SD	14.71	14.57	13.74	13.36	16.45	14.54	13.25

Note. CCATVS = Canadian Cognitive Abilities Test verbal score
CCATQS = Canadian Cognitive Abilities quantitative score
CCATNVS = Canadian Cognitive Abilities Test nonverbal score
Vocscale = WISC-III Vocabulary scaled score

Study 2: Clinical and Matched Group Comparisons

Subjects for the second part of this study consisted of a clinical group of 26 subjects with traumatic brain injuries and two control groups of 26 subjects each. The clinical-group subjects had been assessed at the Glenrose Rehabilitation Hospital.

Table 2 illustrates the diagnoses of the subjects in the clinical group. The control-group subjects were selected from the aforementioned normative group.

Table 2

Diagnoses of Subjects in the Clinical Group by Glenrose Rehabilitation Hospital

Diagnosis	Frequency
Head injury of unspecified cause without fracture	1
Head injury—motor-vehicle accident—without fracture	13
Head injury—motor-vehicle accident—with fracture	5
Head injury—fall—without fracture	6
Head injury—pedestrian—without fracture	1
Total	26

The 26 subjects in the clinical group consisted of 14 males and 12 females. Glasgow Coma Scale (GCS) scores and Post Traumatic Amnesia (PTA) scores were used to measure the severity of brain injury of the subjects. The GCS evaluates three components of consciousness independently of one another: (a) the stimulus required to induce eye opening, (b) the best motor response, and (c) the best verbal response (Bigler, 1990). Based on these criteria, a score to a maximum of 15 is accorded to a patient, which means that an individual can spontaneously open his or her eyes, follow simple motor commands, and demonstrate normal orientation to time, place, and person (Bigler, 1990). PTA can also be used as an indicator of brain injury. Post-traumatic amnesia may be characterized by confusion and an inability to consolidate information about ongoing events in memory (Ewing-Cobbs & Fletcher, 1990). Subjects selected for the clinical group had a moderate traumatic brain injury (GCS score of 9-12) or a severe traumatic brain injury (GCS score of 3-8). Table 3 presents post-injury Glasgow Coma Scale results for this group. The mean was 6.28 (*SD*=2.27). For subjects where a GCS score was unavailable, a PTA of greater than or equal to one day (1,440 minutes) was required, indicating a moderate or greater traumatic brain injury (Bigler, 1990). Table 4 shows PTA scores for the clinical group. The mean was 19.34 days (*SD*=22.09). Table 5 illustrates the chronicity or time interval from injury to testing of the WMS-R for each clinical group subject. The mean was 24.48 months (*SD*=27.31). The mean WISC-III Vocabulary scaled score was 7.31 (*SD*=2.71).

Table 3

Glasgow Coma Scale (out of 15) Results

GCS	Frequency
3	2
4	2
5	3
6	3
7	3
8	3
9	1
12	1
Not available	8
Total	26

Table 4

Post-Traumatic Amnesia for the Clinical Group

Days	Frequency
< 1 day	2
1	1
4	1
4.5	1
6	1
9	1
21	1
24.5	1
28	2
56	1
69.5	1
Not available	13
Total	26

Table 5

Chronicity (Time From Injury to WMS-R Testing)

Months	Frequency
1	2
3	2
4	1
9	2
10	1
12	4
13	1
14	1
17	1
18	1
24	1
25	1
28	1
30	1
48	1
52	1
58	1
85	1
112	1
Missing	1
Total	26

Two control groups of 26 subjects each were selected from the normative data. They each consisted of 14 males and 12 females.

The subjects in control group 1 were matched with the clinical group on age and gender. The criterion of age was selected because of the finding that memory changes with age. The size of the normative group from which the control subjects were chosen was sufficiently large to allow their selection on the basis of gender. Matching of subjects in this manner allows the postulation that possible significant differences found between the clinical and the control group may be due to factors other than age or gender. It also facilitates possible comparisons to other studies matched on these variables.

The subjects in control group 2 were matched with the clinical group on age and WISC-R or WISC-III vocabulary scores. All subjects in the control group had WISC-III vocabulary scores. Clinical-group subjects had either WISC-R or WISC-III vocabulary scores. Sattler (1992) stated that correlations between WISC-R and WISC-III Verbal Scales were .86 for a sample of 104 children with learning difficulties and .90 for a sample of 206 normal children. The WISC-III tends to provide lower IQs than the WMS-R does by about 5 to 9 points (Sattler, 1992). Matching was done in this manner to ascertain that any significant effects found would be due to differences on the WMS-R and not due to age or verbal intelligence. Subjects were not individually matched on sex because MANOVA test results indicated that there was no main effect for sex on WMS-R variables.

Appendix A illustrates the matched samples. The mean WISC-III Vocabulary scaled score was 10.27 (*SD*=2.65) for control group 1 and 7.69 (*SD*=2.02) for control group 2.

Testing Instruments

The results of the CCAT and selected results of the WMS-R, WISC-R, and WISC-III were used in this study.

The WMS-R is an instrument designed to assess verbal and nonverbal memory functions. The Logical Memory I and II and Visual Reproduction I and II subtests were used in this study. Logical Memory I, a test of immediate verbal recall, has the examinee listen to each of two stories and, after hearing them, immediately retell them from memory. The Logical Memory II, a test of delayed recall, is administered 30 minutes after the Logical Memory I subtest has been completed. The examinee is asked to tell the examiner about the stories previously heard. The Visual Reproduction I subtest, a test of immediate visual recall, has the examinee look at four geometric designs in sequence for 10 seconds each and then draw them immediately from memory. The Visual Reproduction II subtest, a measure of delayed recall, has the examinee draw the designs from subtest 1 from memory after a delay of 30 minutes. Savings scores were calculated for Logical Memory and Visual Reproduction by utilizing both immediate and delayed recall scores. The savings scores for Logical Memory and Visual Reproduction were each calculated by dividing the score on delayed recall by the immediate recall performance and multiplying this by 100.

Wechsler (1987) stated that the average internal consistency reliability coefficients for the WMS-R subtests utilized in this study, as shown in Table 6, are:

Table 6

Reliability Coefficients

	Age 16-17	Average for all adult age groups
Logical Memory I	.71	.74
Logical Memory II	.71	.75
Visual Reproduction I	.71	.59
Visual Reproduction II	.38	.46

In addition to the administration of the Logical Memory and Visual Reproduction subtests, Miller et al. (1993) added recognition trials to both subtests. The Logical Memory recognition trial was administered after the Logical Memory II test. Five questions were posed on each story. These questions were of a three-option multiple-choice format. The Visual Reproduction recognition trial was administered after the Visual Reproduction II test. For each of the four original subtest pictures, a sheet with three distractors and one correct answer was presented to the subject with the task being to choose the correct response. See Appendix B for Logical Memory and Visual Reproduction recognition items.

The WISC-R and WISC-III Vocabulary subtests are tests of word knowledge. The vocabulary subtest can provide an estimate of intellectual ability because the number of words known by a child correlates with the ability to learn and accumulate information (Sattler, 1992, p. 1086). The average internal consistency reliability coefficient for the WISC-R Vocabulary subtest is .86 and is .87 for the WISC-III Vocabulary subtest (Sattler, 1992).

The CCAT was designed to assess the development of cognitive abilities related to verbal, quantitative, and nonverbal reasoning and problem solving (Thorndike & Hagen, 1982). This instrument was normed with students in Canadian schools where

English was the major language used in instruction. Kuder-Richardson Formula #20 reliability estimates range from .910 to .948 for the Verbal Battery, .882 to .898 for the Quantitative Battery, and .881 to .922 for the Nonverbal Battery (Thorndike & Hagen, 1982).

Procedure

Permission to conduct this study was obtained from the Department of Educational Psychology Ethics Committee at the University of Alberta, and permission for use of data from the Glenrose Rehabilitation Hospital was granted by the Glenrose Rehabilitation Hospital Research Ethics Committee. The 716 subjects for the normative database were drawn from subjects in a study by Miller et al. (1993). The children, aged 9 through 15, in the Miller et al. study were volunteers from Edmonton Public Schools. Permission was obtained from Edmonton Public Schools for the utilization of schools, and permission was also obtained from the parents and guardians of the children tested. The Logical Memory I and II and Visual Reproduction I and II subtests of the WMS-R and the WISC-III Vocabulary subtest were administered as part of a larger test battery over a one-hour time period. CCAT scores for 624 of the 716 subjects were obtained from school files. Test scores from Grade 3 (for subjects aged 9-11) and Grade 6 (for subjects aged 12-15) were used in this study.

The analyses consisted of comparing the performance of control and clinical groups on the aforementioned subtests of the WMS-R. The clinical group of 26 subjects who had received head injuries had undergone neuropsychological assessment at the Glenrose Rehabilitation Hospital. These subjects received testing on the Logical Memory I and II and Visual Reproduction I and II subtests of the WMS-R and either the WISC-R or WISC-III as part of this assessment. The two control groups of 26 subjects each were selected from the normative group.

The WMS-R has been criticized for the lack of recognition tests for verbal and nonverbal tasks (Butters et al., 1988; Haut et al., 1992; Reid & Kelly, 1993). In addition to administering the Logical Memory and Visual Reproduction subtests to subjects, Miller et al. (1993) added recognition trials to both subtests. Ten subjects in the clinical group received the recognition trials. All subjects in the normative group were administered the recognition trials, which followed the procedure outlined in the "Testing Instruments" section of this chapter.

Variables

The following test variables were analyzed in this study:

Wechsler Memory Scale-Revised (WMS-R) Test Variables
- Logical Memory I (LMI)
- Logical Memory II (LMII)
- Logical Memory Savings Score (LMSAV)
- Logical Memory Recognition (LMREC)
- Visual Memory I (VMI)
- Visual Memory II (VMII)
- Visual Memory Savings Score (VMSAV)
- Visual Memory Recognition (VMREC)

Wechsler Intelligence Test for Children-Revised (WISC-R)
- Vocabulary Subtest

Wechsler Intelligence Test for Children-Third Edition (WISC-III)
- Vocabulary Subtest

Canadian Cognitive Abilities Test (CCAT) Variables
- CCAT Verbal Test
- CCAT Nonverbal Test

Hypotheses

This study was conducted to investigate the following statistical hypotheses:

H 1: In the normative sample, scores on the WMS-R variables will improve with increasing age.

H 2: There will be a significant difference between genders in the normative sample on the WMS-R variables.

Ho 3: There will be a significant correlation between CCAT verbal scores and Logical Memory variables and CCAT nonverbal scores and Visual Reproduction variables.

H 4: There will be a significant correlation between WISC-III Vocabulary scores and Logical Memory variable scores.

Ho 5: A group of children with traumatic brain injuries aged 9 through 15 will score significantly lower on WMS-R variables than (a) a control group matched on age and gender, or (b) a control group matched on age and WISC vocabulary score.

Data Analysis

The statistical analysis of data was divided into two parts. The analysis for part 1 involved the normative sample and for part 2, comparing clinical and control samples. In part 1, means and standard deviations were calculated by age group of the WMS-R variables, WISC-III Vocabulary scores, and CCAT scores. Following this, correlations between the WMS-R variables and WISC-III Vocabulary raw scores and between CCAT scores and WMS-R variables were calculated.

A MANOVA by age, sex, and CCAT scores was then conducted on the Logical Memory variables. A second MANOVA was conducted on the Visual Reproduction variables. Divisions of age were done by year. In a study on the development of norms for the Wisconsin Card Sorting Test, Paniak, Patterson, Miller, Murphy, and Keizer contended that "age and years of education are confounded in school-age children. However, the CCAT could possibly be used in place of years of education to stratify normative data for Canadian children" (p. 5). The CCAT scores were divided into two levels: 112 and above, which corresponds to the CCAT classification of above average or higher; and 111 and below, which corresponds to a classification of average or lower. This division of the sample based on CCAT scores also divides the number of students in the normative sample roughly in half. CCAT verbal scores were used in the analysis of Logical Memory test scores, because Logical Memory I and II are tests of verbal recall. CCAT nonverbal scores were used in the analysis of Visual Reproduction test scores. Visual Reproduction I and II are tests of visual recall. The use of the CCAT, a test of cognitive abilities, allows the analysis of the relationship between verbal ability and verbal recall, and nonverbal ability and figural memory. The multivariate analyses of variance determined if there were any main effects for age, sex, and CCAT scores on the WMS-R. An analysis of variance was then conducted for those independent variables (age, sex, or CCAT scores) which were shown to have a main effect on the MANOVA.

The statistical analysis for part 2 involved the comparison of clinical and control groups. Two MANOVAs were conducted to determine whether the clinical and control groups differed significantly on the dependent variables (WMS-R variables). A MANOVA was conducted on the three Logical Memory variables of immediate recall, delayed recall, and percentage recalled (savings score). A MANOVA was also conducted on the three Visual Reproduction variables of immediate recall, delayed recall, and percentage recalled (savings score). An analysis of variance was then conducted for those independent variables (age, sex, or CCAT scores) which were shown to have a main effect on the MANOVA.

Mann-Whitney U Tests were utilized in the analyses for Logical Memory recognition data and the Visual Reproduction recognition data. This was done to compare the performance of clinical and control group 1 and clinical and control group 2 on the recognition measures. There were 10 subjects in the clinical group and 10 subjects in each of the control groups.

CHAPTER 4

RESULTS

The findings of the data analyses are presented in this chapter. The purpose of the analyses was to introduce normative data for children on the Wechsler Memory Scale-Revised (WMS-R) and to compare clinical and control groups of children on selected subtests of this instrument.

Hypothesis 1

H 1: In the normative sample, scores on the WMS-R variables will improve with increasing age.

In order to test this hypothesis, two three-way MANOVAs were performed. One three-way MANOVA (age x sex x CCAT verbal score) was conducted for the composite of the Logical Memory I, II, savings, and recognition scores of the WMS-R. Using Wilks' criterion, there were significant main effects for age $F(24, 2062)=6.18$ $p<.01$, and CCAT verbal score $F(4, 591)=20.5$, $p<.01$, but not for sex $F(4, 591)=.25$, $p>.05$. The significant ($p<.01$) positive effect for age indicates that age has an effect on Logical Memory test scores for children aged 9 through 15.

Another three-way MANOVA (age x sex x CCAT nonverbal score) was conducted for the composite Visual Reproduction I, II, savings, and recognition scores of the WMS-R. Using Wilks' criterion, there were significant effects for age $F(24, 2052)=13.18$, $p<.01$, and CCAT nonverbal score $F(4, 588)=15.05$, $p<.01$, but not for sex $F(4, 588)=1.07$, $p>.05$. The significant ($p<.01$) positive effect for age indicates that age has an effect on Visual Reproduction scores for children aged 9 through 15.

Table 7 illustrates univariate F-tests which were conducted on individual WMS-R variables.

Table 7

Univariate F-Test Results for WMS-R Variables

Indep. Variable	Dep. Variable	df	F	p
Age	LMI	6,594	21.61429	.000*
	LMII	6,594	18.63554	.000*
	LMSAV	6,594	.89612	.497
	LMREC	6,594	10.79345	.000*
	VMI	6,591	38.04359	.000*
	VMII	6,591	44.78811	.000*
	VMSAV	6,591	9.16410	.000*
	VMREC	6,591	5.95333	.000*
CCATVS	LMI	1,594	74.10235	.000*
	LMII	1,594	70.11424	.000*
	LMSAV	1,594	1.86315	.173
	LMREC	1,594	22.45873	.000*
CCATNVS	VMI	1,591	53.49780	.000*
	VMII	1,591	36.50784	.000*
	VMSAV	1,591	1.51500	.219
	VMREC	1,591	4.70420	.030*

Note. CCATVS = Canadian Cognitive Abilities Test verbal score
CCATNVS = Canadian Cognitive Abilities Test nonverbal score
LMI = Logical Memory I
LMII = Logical Memory II
LMSAV = Logical Memory Savings Score
LMREC = Logical Memory Recognition
VMI = Visual Memory I
VMII = Visual Memory II
VMSAV = Visual Memory Savings Score
VMREC = Visual Memory Recognition

The results indicate a significant effect ($p < .05$) for age on the WMS-R variables of Logical Memory I, II, and recognition scores, and on Visual Reproduction I, II, savings, and recognition scores. This positive significant ($p < .05$) effect for age indicates that age has an effect on the variables of Logical Memory I, II, and recognition scores and on Visual Reproduction I, II, savings, and recognition scores. The results also indicate a significant effect ($p < .05$) for CCAT verbal scores on WMS-R variables of Logical Memory I, II, and recognition. A significant effect

($p < .05$) for CCAT nonverbal scores was shown for Visual Reproduction I, II, and recognition.

Table 8 presents the means and standard deviations by age for the WMS-R variables. The results indicate that scores on Logical Memory I and II and Visual Reproduction I and II tend to improve with age. The results on Logical Memory and Visual Reproduction savings scores did not show a consistent pattern. Recognition trial means tended to improve with age, the exceptions being at ages 10 and 15.

Table 8

Means and Standard Deviations of the Wechsler Memory Scale-Revised

		Age							
Variable		9	10	11	12	13	14	15	Overall sample
Subjects	*N*	81	140	132	123	96	116	28	716
Males	*n*	36	64	76	50	40	45	15	326
Females	*n*	45	76	56	73	56	71	13	390
LMI	Mean	19.74	21.24	23.23	24.90	25.35	27.78	28.82	24.01
	SD	7.67	7.33	7.39	6.81	6.86	6.44	6.90	7.54
LMII	Mean	17.31	18.65	20.17	22.31	22.15	24.67	25.57	21.15
	SD	7.61	7.53	6.94	6.81	6.94	6.77	7.46	7.49
LMSAV	Mean	88.05	86.61	86.39	89.47	86.68	88.33	87.68	87.55
	SD	21.19	14.50	13.29	11.64	12.54	11.32	12.90	13.98
LMREC	Mean	7.20	7.14	7.42	7.75	8.12	8.46	8.57	7.70
	SD	1.76	1.78	1.54	1.59	1.51	1.35	1.03	1.65
VRI	Mean	29.25	29.78	31.20	33.32	34.42	35.50	35.43	32.37
	SD	4.33	4.28	4.73	3.65	3.29	2.64	2.43	4.46
VRII	Mean	23.85	26.32	27.08	30.69	31.42	33.66	33.43	29.09
	SD	6.06	5.47	5.75	4.47	5.13	3.76	4.01	6.04
VRSAV	Mean	81.61	88.77	86.97	92.36	91.07	94.77	94.11	89.73
	SD	18.02	16.78	14.96	11.06	11.88	9.07	8.94	14.26
VRREC	Mean	3.72	3.61	3.77	3.87	3.90	3.91	3.93	3.79
	SD	.53	.56	.52	.36	.34	.28	.26	.46

In summary, these findings generally support the hypothesis that WMS-R variables would increase with increasing age. Logical Memory I, II, and recognition trial scores, along with Visual Reproduction I, II, savings, and recognition scores increase with increasing age for children aged 9 through 15. Age did not have a significant effect on the Logical Memory savings score, indicating that the percentage of retention of verbal material does not change significantly with age.

Hypothesis 2

H 2: There will be significant differences between genders in the normative sample on WMS-R variables.

A three-way MANOVA (age x sex x CCAT verbal score) was conducted for the composite of the Logical Memory I, II, savings, and recognition scores and another (age x sex x CCAT nonverbal score) on the composite Visual Reproduction I, II, savings, and recognition scores. There was no significant main effect for sex in either MANOVA analysis.

Gender is not significant ($p < .05$) for the following WMS-R variables: Logical Memory I, II, savings, or recognition scores and Visual Reproduction I, II, savings or recognition scores. These results did not support the hypothesis that genders would differ on WMS-R variables.

Hypothesis 3

Ho 3: There will be a significant correlation between Canadian Cognitive Abilities Test (CCAT) verbal scores and Logical Memory variables, and CCAT nonverbal scores and Visual Reproduction variables.

The correlations between CCAT scores and WMS-R scores for the entire normative group for which CCAT scores were available is presented in Table 9.

Table 9

Correlation of CCAT and WMS-R Scores (n=617)

	LMI	LMII	LMSAV	LMREC
CCATVS	.3978**	.3793**	.0645	.2903**
	VMI	VMII	VMSAV	VMREC
CCATNVS	.3788*	.3078**	.0791	.1749**

1-tailed significance: * -.01; ** -.001

For the normative group, there were significant ($p < .001$)correlations between CCAT verbal scores and Logical Memory I, II, and recognition trial scores ($r = .3978$, $r = .3793$, $r = .2903$, respectively). For the normative group as a whole, there were significant ($p < .001$) correlations between CCAT nonverbal scores and Visual Reproduction I, II, and recognition trial scores ($r = .3788$, $r = .3078$, $r = .1749$, respectively).

Tables 10 and 11 illustrate statistically significant correlations by age between CCAT verbal scores and the WMS-R variables.

Table 10

Correlations Between CCAT Verbal Scores and Logical Memory Variables by Age

	Age						
	9	10	11	12	13	14	15
	N						
	77	127	114	96	80	99	25
LMI	.5512**	.4913**	.3939**	.4229**	.3205*	.5112**	.3566
LMII	.4987**	.5252**	.3810**	.3595**	.3778**	.3817**	.3911
LMSAV	-.1012	.2832**	.0696	-.0379	.2231	-.0933	.2738
LMREC	.3210*	.3194**	.2976**	.4176**	.2885*	.2531*	.0858

1-tailed significance: * -.01; ** -.001

Table 11

Correlations Between CCAT Nonverbal Scores and Visual Reproduction Variables by Age

	Age						
	9	10	11	12	13	14	15
	N						
	77	127	114	96	80	99	25
VMI	.4190**	.2418*	.5143**	.4236**	.5212**	.3233**	.5863*
VMII	.2753*	.2281*	.4095**	.1890	.4776**	.2993*	.5979**
VMSAV	.0366	.0609	.0475	-.1884	.2470	.1176	.3565
VMREC	.0057	.1766	.2434*	.2015	.1785	.1022	.2117

1-tailed significance: * -.01; ** -.001

There were significant (p<.001) correlations between CCAT verbal scores and Logical Memory I at ages 9, 10, 11, 12, 14 (r=.5512, r=.4913, 4=.3939, r=.4229, r=.5112, respectively). At age 13 the CCAT verbal score was significantly (p<.01) correlated with Logical Memory I (r=.3205). CCAT verbal scores were significantly (p<.001) correlated with Logical Memory II at ages 9, 10, 11, 12, 13, 14 (r=.4987, r=.5252, r=.3810, r=.3595, r=.3778, r=.3817, respectively). There were significant (p<.001) correlations between CCAT verbal scores and Logical Memory recognition trial scores at ages 10, 11, 12 (r=.3194, r=.2976, r=.4176, respectively); and significant (p<.01) correlations were found at ages 9, 13, 14 (r=.3201, r=.2885, r=.2531, respectively). A Logical Memory savings score was significantly (p<.001) correlated with CCAT verbal score at age 10 (r=.2832).

There were significant (p<.001) correlations between Visual Reproduction I and CCAT nonverbal scores at ages 9, 11, 12, 13, 14 (r=.4190, r=.5143, r=.4236, r=.5212, r=.3233, respectively) and significant (p<.01) correlations at ages 10 and

15 (r=.2418, r=.5863, respectively). CCAT nonverbal scores were significantly (p<.001) correlated with Visual Reproduction II at ages 11, 13, 15 (r=.4095, r=.4776, r=.5979, respectively) and with ages 9, 10, 14 (r=.2753, r=.2281, r=.2993, respectively) at the .01 level. Visual Reproduction recognition trial scores were statistically (p<.01) correlated with CCAT nonverbal scores at age 11 (r=.2434). See Appendix C for correlations of CCAT verbal, quantitative, and nonverbal scores with WMS-R variables.

The results obtained support the hypothesis that CCAT verbal scores would correlate significantly with Logical Memory variables and that CCAT nonverbal scores would correlate significantly with Visual Reproduction test variables. Although statistical significance was found, the correlations tended to be low.

Hypothesis 4

H 4: There will be a significant correlation between Wechsler Intelligence Scale for Children-III (WISC-III) Vocabulary scores and Logical Memory variable scores.

Table 12 shows the correlation between the WISC-III Vocabulary raw scores and the Logical Memory test variables. For the normative sample as a whole, there were significant (p<.001) correlations between WISC-III Vocabulary scores and Logical Memory I, II, and recognition trial scores (r=.5610, r=.5291, r=.4113, respectively).

WISC-III Vocabulary scores were significantly (p<.001) correlated with Logical Memory I at ages 9, 10, 11, 12, 13, 14 (r=.5979, r=.5486, r=.3374, r=.4944, r=.4601, r=.4933, respectively). WISC-III Vocabulary scores were significantly (p<.001 correlated with Logical Memory II at ages 9, 10, 11, 12, 13, 14 (r=.4997, r=.5555, r=.3228, r=.4607, r=.4997, r=.4006, respectively). There was a significant (p<.01) correlation at age 10 between WISC-III Vocabulary and Logical Memory savings scores (r=.2291). WISC-III Vocabulary scores and Logical

Table 12

Correlations Between WISC-III Vocabulary Raw Scores and WMS-R Scores

WMS-R variables	Age 9	10	11	12	13	14	15	Total
N	81	140	131	122	96	116	20	712
LMI	.5979**	.5486**	.3374**	.4944**	.4601**	.4933**	.3816	.5610**
LMII	.4997**	.5555**	.3228**	.4607**	.4997**	.4006**	.3502	.5291**
LMSAV	-.0818	.2291*	.0381	.0079	.2274	-.0409	.1888	.0682
LMREC	.3635**	.3763**	.2011	.3640**	.2909*	.2302*	.0115	.4113**

1-tailed significance: * -.01; ** -.001

Memory recognition trial scores were significantly ($p < .001$) correlated at ages 9, 10, 12 ($r = .3635$, $r = .3763$, $r = .3640$, respectively) and at ages 13 and 14 ($r = .2909$, $r = .2302$, respectively) at the .01 level.

The results generally support the hypothesis that there will be a significant correlation between WISC-III Vocabulary scores and Logical Memory variable scores. Whereas Logical Memory I, II, and recognition scores were correlated with WISC-III Vocabulary scores, Logical Memory savings scores were correlated with WISC-III Vocabulary scores at age 10 only.

Hypothesis 5

Ho 5: A group of children with traumatic brain injuries aged 9 through 15 will score significantly lower on WMS-R variables than (a) a control group matched on age and gender, or (b) a control group matched on age and WISC vocabulary score.

Table 13 illustrates the results of two MANOVAs (by clinical/control group 1, matched on age and gender; and clinical/control group 2, matched on age and WISC Vocabulary score) which were conducted for Logical Memory I, II, and savings

Table 13

Multivariate Analysis of Variance for Composite Logical Memory Variables

Source of variance	Wilks' lambda	Hypoth. DF	Error DF	Approx. F	p
Clin. & co. #1	.85623	3.00	48.00	2.68649	.057
Clin. & co. #2	.86378	3.00	48.00	2.52330	.069

Note: Clin. & Co. #1 = Clinical and Control Group #1 (matched on age and gender)
Clin. & Co. #2 = Clinical and Control Group #2 (matched on age and WISC Vocabulary score)

scores of the WMS-R. The results of clinical/control group 1 and clinical/control group 2 approach statistical significance ($p=.057$ and $p=.069$, respectively).

Table 14 shows the results of two MANOVAs (by clinical/control group 1 and clinical/control group 2) which were conducted for Visual Reproduction I, II, and savings scores of the WMS-R. The MANOVAs for the composite Visual Reproduction scores revealed significant differences between clinical and control group 1, $F(3, 48)=5.53$ $p<.01$, and also between clinical and control group 2, $F(3, 48)=5.31$ $p<.01$.

Table 14

Multivariate Analysis of Variance for Composite Visual Reproduction Variables

Source of variance	Wilks' lambda	Hypoth. DF	Error DF	Approx. F	p
Clin. & co. #1	.74313	3.00	48.00	5.53050	.002
Clin. & co. #2	.75073	3.00	48.00	5.31255	.003

Note: Clin. & Co. #1 = Clinical and Control Group #1 (matched on age and gender)
Clin. & Co. #2 = Clinical and Control Group #2 (matched on age and WISC Vocabulary score)

Univariate F-tests were then conducted on each of the three Logical Memory variables and on the three Visual Reproduction variables to determine which of these variables contributed to the effects shown on the MANOVAs. Table 15 illustrates that clinical and control groups, matched on age and gender, show statistically significant differences ($p < .05$) for the following variables: Logical Memory I, II, savings and Visual Reproduction II and savings. A comparison of mean scores for these variables shows consistently lower means for the clinical group (LMI, 18.23; LMII, 13.85; LMSAV, 71.37; VMII, 20.04; VMSAV, 64.44) than for the control group (LMI, 22.96; LMII, 20.27; LMSAV, 86.43; VMII, 28.85; VMSAV, 89.07).

Table 15

Univariate F-Tests of Clinical and Control Group 1 for WMS-R Variables

Variable	df	F	p
LMI	1,50	4.09365	.048*
LMII	1,50	6.88923	.011*
LMSAV	1,50	6.16735	.016*
VRI	1,50	1.55290	.219
VRII	1,50	15.25068	.000*
VRSAV	1,50	13.10825	.001*

Table 16 shows that clinical and control groups matched on WISC-R/WISC-III Vocabulary scores and age are significantly different ($p < 0.05$) for the following variables: Logical Memory savings score (LMSAV), Visual Reproduction II (VMII), and Visual Reproduction savings score (VMSAV). A comparison of mean scores for these variables shows consistently lower means for the clinical group (LMSAV, 71.37; VMII, 20.04; VMSAV, 64.44) than for the control group (LMSAV, 87.23; VMII, 28.96; VMSAV, 89.64).

Table 16

Univariate F-Tests of Clinical and Control Group 2 for WMS-R Variables

Variable	df	F	p
LMI Total	1,50	.35076	.556
LMII Total	1,50	1.97359	.166
LMSAV	1,50	7.33815	.009*
VRI Total	1,50	1.35591	.250
VRII Total	1,50	14.86358	.000*
VRSAV	1,50	13.75422	.001*

Table 17 presents the means and standard deviations by group for the WMS-R variables.

Table 17

Means and Standard Deviations of Clinical and Control Groups

WMS-R variables	Clinical group		Control group 1		Control group 2	
LMI	18.23	(9.22)	22.96	(7.56)	19.62	(7.55)
LMII	13.85	(9.39)	20.27	(8.22)	17.12	(7.26)
LMSAV	71.37	(27.27)	86.43	(14.59)	87.23	(12.14)
LMREC	7.20	(1.75)	7.54	(2.04)	7.19	(1.55)
VRI	30.62	(6.39)	32.46	(4.02)	32.42	(4.67)
VRII	20.04	(10.34)	28.85	(5.03)	28.96	(5.69)
VRSAV	64.44	(32.07)	89.07	(13.25)	89.64	(13.12)
VRREC	3.30	(.82)	3.77	(.43)	3.85	(.46)

The results shown in Table 17 indicate that mean scores are lower for the clinical group than for either of the control groups on the WMS-R variables.

A Mann-Whitney U test was conducted on Logical Memory and Visual Reproduction Recognition data. The results indicate that there was no statistical difference ($p < .05$) between clinical and control group 1 or clinical and control group 2 on Logical Memory or Visual Reproduction Recognition scores. The means (with standard deviations in parentheses) for clinical and control group 1 on Logical Memory Recognition data were 7.20 (1.75) and 7.30 (2.41), respectively. Control group 2 had a mean of 7.00 (SD=3.80) on Logical Memory Recognition data. The means (with standard deviations in parentheses) for clinical and control group 1 on Visual Reproduction Recognition data were 3.30 (.82) and 3.70 (.48), respectively. Control group 2 had a mean of 3.80 (SD=.63) on Visual Reproduction Recognition data.

In summary, this hypothesis was partially supported. The clinical group scored significantly lower than a control group matched on age and gender on the variables of Logical Memory I, II, and savings score and Visual Reproduction II and Visual Reproduction savings score. Significant differences between these groups were not found for Visual Reproduction I. The clinical group scored significantly lower than a control group matched on age and WISC-R/WISC-III vocabulary on the Logical Memory savings score and Visual Reproduction II and Visual Reproduction savings score. Significant differences between these groups were not found for Logical Memory I, II or Visual Reproduction I. The clinical group did not score significantly lower than either control group on the Logical Memory or Visual Reproduction Recognition trial scores.

CHAPTER 5

DISCUSSION

This study provides information for individuals working with the Wechsler Memory Scale-Revised (WMS-R) in a pediatric population. This chapter includes a discussion of each hypothesis's findings in relation to the investigations of previous studies, a discussion of the implications of the study, and suggestions for further research.

Hypothesis 1

Hypothesis 1 states that scores on the WMS-R variables will improve with increasing age for children aged 9 through 15. The results of the statistical analyses generally support this hypothesis.

The results of two three-way MANOVAs indicate that there was a significant effect for age on both Logical Memory and Visual Reproduction variables of the WMS-R. The univariate F-test results show a significant effect for age on Logical Memory I, II, and recognition scores and Visual Reproduction I, II, savings, and recognition scores. A significant effect for age was not found for Logical Memory savings, indicating that whereas children's immediate verbal recall improves, the percentage of verbal recall does not change. This indicates that although their ability initially to encode information gets better with age, the percentage of retention of verbal material does not change significantly with increasing age. The levels-of-processing view of memory suggests that the retention of information is a function of the depth to which it was processed. In this view of memory, cognitive processes or strategies are emphasized. Effective strategy use tends to improve with age to maturity (Berk, 1991). Because both immediate verbal and delayed verbal recall improved with increasing age, children may have been utilizing both superficial or

Type I processing and Type II or deeper levels of processing. According to the levels-of-processing view of memory, the improved immediate verbal recall may be a result of increasing efficiency of Type I processing, whereas the improved delayed recall may indicate the utilization of more elaborate processing skills. Verbal retention (savings) scores were not statistically significant. This may indicate that the development of Type I and Type II processing is proceeding at a similar rate.

A normative database for people under 16 years of age has not previously been established for the WMS-R. This study has gone beyond previous studies in introducing normative data for children aged 9 through 15. The finding that age (in a child population) has a significant effect on WMS-R variables is consistent with studies by Ivinskis et al. (1971) on the Wechsler Memory Scale (WMS) and Curry et al. (1986) on Russell's Revision of the Wechsler Memory Scale (RWMS). Ivinskis et al. found that 10- to 14-year-olds scored lower on most WMS subtests than did 16- to 18- or 20- to 29-year-olds. In a study utilizing the RWMS, Curry et al. found main effects for age in a child population for Logical Memory I, II, and Visual Reproduction I and II. This is consistent with the findings in this study which utilized the WMS-R. Curry et al. did not find main effects for age on the derivative (savings) scores. This study found an effect for age on the Visual Reproduction savings score but not on the Logical Memory savings score. According to the levels-of-processing view of memory, children may have processed visual material at a deeper level than verbal material.

This study goes beyond previous research by introducing recognition trial information to the WMS-R. The WMS-R has been criticized by Butters et al. (1988), Haut et al. (1992), and Reid and Kelly (1993) as lacking recognition tests for verbal and nonverbal tests. The introduction of recognition trials by Miller et al. (1993) and the analysis of recognition data for 9- through 15-year-olds in this study has contributed to the efficacy of the WMS-R.

In summary, scores on WMS-R variables increase with increasing age for children aged 9 through 15. The lack of a significant effect for age on one variable, Logical Memory savings, indicates that the retention of verbal material does not change significantly with increasing age.

Hypothesis 2

Hypothesis 2 states that there will be significant differences between genders on the WMS-R for children aged 9 through 15. The results do not support this hypothesis. Significant differences between genders in the normative sample on Logical Memory and Visual Reproduction variables of the WMS-R were not found.

Because normative data for people aged 9 through 15 have not yet been established for the WMS-R, direct comparisons of gender differences with other sources is not possible. This finding is consistent, however, with Wechsler (1987), who stated that males and females (16 years of age and older) did not differ significantly on the set of WMS-R indexes; and, therefore, he did not feel that adjustment of scores for the gender of the examinee was required. This finding differs from that of Curry et al. (1986) in their introduction of normative data on the RWMS for children aged 9 through 15. They contended that it is important to analyze memory development separately by sex due to relationships that they found in their study between memory scores, age, verbal intelligence, and sex of the subject.

Hypothesis 3

Hypothesis 3 states that a significant correlation will exist between CCAT verbal scores and Logical Memory variables and between CCAT nonverbal scores and Visual Reproduction variables. The results generally support this hypothesis. However, correlations between CCAT verbal scores and Logical Memory I, II, and recognition trial scores and between CCAT nonverbal and Visual Reproduction I, II, and recognition were not strong. This indicates that although there is a relationship between CCAT verbal scores and Logical Memory variables and CCAT nonverbal and Visual Reproduction subtests, the relationship is not strong enough to imply that the tests supply the same information and could be interchangeable. The Logical Memory and Visual Reproduction subtests supply different information from CCAT verbal and nonverbal tests.

Hypothesis 4

Hypothesis 4 states that there will be significant correlations between Wechsler Intelligence Scale for Children-III (WISC-III) Vocabulary raw scores and Logical Memory variable scores. The results generally support this hypothesis.

The significant ($p < .001$) correlation between WISC-III Vocabulary scores and Logical Memory I, II, and recognition scores indicates that there is an overlap in cognitive assessment between the WISC-III Vocabulary test and Logical Memory I, II, and recognition subtests. A study of the WMS by Ivinskis et al. (1971) found significant correlations between the WMS total score and the WISC and Wechsler Adult Intelligence Scale (WAIS) Verbal IQ for 10- to 19-year-olds. Ivinskis said that this would be expected because, other than on the Visual Reproduction subtests, there is a similarity of tasks on these tests. The other subtests are of a verbal nature.

Although significant correlations were found between WISC-III Vocabulary subtests and Logical Memory subtests, the strength of the relationship is such that a WISC-III Vocabulary score will not provide the same information as Logical Memory I, II, and recognition subtests will. A thorough cognitive assessment would not be complete with the WISC-III Vocabulary score or even an entire IQ test; a complete cognitive assessment, including that of memory, would require an instrument such as the Logical Memory I, II, and recognition tests.

Hypothesis 5

Hypothesis 5 states that a clinical group will score significantly lower than either of two control groups on WMS-R variables. The results partially support this hypothesis.

A MANOVA on the combined Logical Memory I, II, and savings score variables between the clinical and control group matched on age and gender approached statistical significance (p=.057). A second MANOVA on the combined Visual Reproduction I, II, and savings score variables was statistically significant (p=.002). An inspection of univariate comparisons revealed significant differences for these groups on Logical Memory I, II, and Logical Memory savings score, as well as Visual Reproduction II and Visual Reproduction savings score. Mean scores indicated that the clinical group scored lower than this control group on these WMS-R variables.

A MANOVA on the combined Logical Memory I, II, and savings score variables between the clinical and control group matched on age and WISC-R/ WISC-III Vocabulary score approached statistical significance (p=.069). Another MANOVA on the combined Visual Reproduction I, II, and savings score variables was statistically significant (p=.003). The univariate results showed that these two groups differed on Logical Memory savings score and Visual Reproduction II and Visual Reproduction savings score. Mean scores indicated that the clinical group scored lower than this control group did on these WMS-R variables.

Because the overall MANOVA main effect on Logical Memory variables for the clinical and both control groups' scores approached, but yet were not significant (p=.057 and p=.069), caution is advised in interpreting differences between scores. The present findings indicate that Logical Memory I and II cannot discriminate the clinical group from the control groups independently of a verbal intellectual level because significant differences were eliminated on these measures when a clinical and a control group were matched on verbal intelligence. This is consistent with the findings of Prigatano (1977) and Sherer, Nixon, Anderson, and Adams (1992). Prigatano, when comparing adult subjects with brain dysfunctions to a group of control subjects, found that brain-dysfunction patients generally performed poorly on most subtests of the WMS, but differences decreased when IQ levels were matched. Sherer et al. studied the sensitivity of RWMS to the effects of IQ and brain damage in groups of brain-damaged and non-brain-damaged adult subjects. They found significant IQ effects on Logical Memory I and II and Visual Reproduction I and II.

The lack of significant differences between the clinical group and either control group on Visual Reproduction I, a measure of immediate visual recall, indicates that these groups do not differ to a significant degree in their ability on the immediate recall of simple visual material.

The clinical group performed more poorly than either control group on Visual Reproduction II, a measure of delayed visual recall. This finding is consistent with that of Reid and Kelly (1993), who found a clinical group of closed-head-injured adult subjects exhibited greater deficits in remembering previously recalled information after a delayed period of time. Reid and Kelly found that the clinical group performed more poorly on the delayed performance of both Logical Memory and Visual Reproduction. The levels-of-processing view of memory would suggest that because the clinical and control groups differed on delayed recall but not on immediate recall, the clinical group of children did not process the visual material as deeply as the control groups did.

The clinical group performed more poorly than either control group on Logical Memory and Visual Reproduction savings scores. This is consistent with studies done with subjects aged 16 and older by Sherer et al. (1992) and Reid and Kelly (1993). Sherer et al., in their study of the RWMS, found Logical Memory and Visual Reproduction savings scores to be affected by brain damage, but not IQ level. Reid and Kelly found that adult individuals who sustained head injuries performed more poorly than did the controls on savings scores. According to the levels-of-processing view of memory, the significantly poorer performance of the clinical group compared to either control group on Logical Memory and Visual Reproduction savings scores would be indicative of a lack of deeper processing by the clinical group of subjects.

Mann-Whitney U tests conducted on Logical Memory and Visual Reproduction recognition data revealed no significant differences between the clinical group and either control group. This indicates that head-injured and normal subjects do not differ significantly in their recognition memory, as measured by the current tests. It is possible that the small sample size of subjects may have contributed to the failure to find a significant relationship.

In summary, this hypothesis stating that a clinical group of head-injured children will perform significantly poorer than either of two control groups on WMS-R variables was partially supported. Whereas head-injured subjects did not differ significantly from normal subjects on their ability to recall visual material immediately, this was not true for the ability on the delayed recall of visual material. The clinical group performed significantly poorer on this measure. Measures of immediate and delayed recall of verbal material appeared to be affected by verbal intelligence. The clinical group performed significantly poorer than a control group matched on age and gender on immediate and delayed recall of verbal material; however, these differences were not found between the clinical and the control group matched on age and WISC Vocabulary score. Logical Memory and Visual Reproduction savings scores effectively discriminated between mean clinical and control groups' performance, whereas recognition trials could not discriminate between them.

Implications of the Research

The primary contribution of this study is the introduction of normative data on the WMS-R for children aged 9 through 15. Normative data for this age group were not previously available for the WMS-R. This study introduced normative data on the Logical Memory and Visual Reproduction subtests of the WMS-R for children aged 9 through 15. The introduction of normative data for children will enhance the ability of clinicians to assess children on this instrument. The results may be used to develop intervention programs for children with brain-related disorders.

The second part of this study focussed on comparing a clinical group of children with traumatic brain injuries to two groups of control subjects. Once again, such information on children aged 9 through 15 was lacking. This study introduced information on how clinical and control groups of children perform, relative to each other, on Logical Memory and Visual Reproduction subtests of the WMS-R. Savings scores were the most useful in discriminating between the groups.

In the past the WMS-R has been criticized for the lack of tests of verbal and nonverbal recognition memory. The lack of recognition tasks prevents comparisons between recall and recognition memory on the WMS-R (Butters et al., 1988; Haut et al., 1992; Reid & Kelly, 1993). This study's analysis of recognition trial data introduced by Miller et al. (1993) sought to address this concern.

Recommendations for Future Research

The present study has implications for future research on the WMS-R in a pediatric population. This study introduced normative data for children aged 9 through 15 on the Logical Memory and Visual Reproduction subtests of the WMS-R. Future research of normative data on the WMS-R could utilize a sample of children representative of the geographic and cultural composition of the Alberta population.

Further research on the comparison of clinical and control groups on the WMS-R could be undertaken. Similar studies to this one, utilizing larger sample sizes, could be undertaken to further our understanding of the WMS-R as it relates to children.

The lack of recognition tasks on the WMS-R has been an area of criticism. Further research in the area of recognition memory on the WMS-R could be undertaken. Larger sample sizes of clinical and control subjects could be utilized to investigate the comparative performance of children with and without head injuries.

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Appendix A

Matched Samples

Table A1

Matched Samples

Clinical group			Control group 1		Control group 2	
Age (mos.)	Gender	Vocab. SS	Age (mos.)	Gender	Age (mos.)	Vocab. SS
109	f	8	109	f	109	8
111	m	6	111	m	112	8
111	m	7	111	m	112	8
116	m	4	116	m	120	5
123	m	8	123	m	124	8
128	f	1	128	f	127	4
128	m	9	128	m	129	8
131	f	8	131	f	131	8
134	f	10	134	f	134	10
134	m	9	134	m	135	9
138	f	5	138	f	139	5
143	f	6	143	f	143	7
149	m	8	149	m	148	8
151	m	10	151	m	150	10
152	f	10	152	f	153	10
164	m	4	164	m	163	7
170	m	9	170	m	170	9
171	m	4	171	m	170	4
172	f	9	172	f	172	9
174	f	8	174	f	174	7
175	f	9	175	f	175	9
178	m	11	178	m	178	10
178	m	7	178	m	181	7
180	f	1	180	f	182	3
187	m	10	188	m	186	10
190	f	9	188	f	196	9

Appendix B

Logical Memory and Visual Reproduction

Recognition Items

The first story was about a woman named Anna Thompson.

1. Where did she live?

    A. North Boston
    B. Los Angeles
    C. South Boston

2. What did she do for a living?

    A. She was a waitress.
    B. She was a cook.
    C. She was a teacher.

3. How many children did she have?

    A. Four
    B. Five
    C. One

4. When was she held up?

    A. During the day
    B. That night
    C. The night before

5. What did the police do?

    A. Took up a collection
    B. Chased the robber
    C. Found her purse

The second story was about a man named Robert Miller.

1. What was he driving?

   A. A pick-up truck
   B. A 10-ton truck
   C. A car

2. What was the truck carrying?

   A. Chickens
   B. Eggs
   C. Furniture

3. What happened to his truck?

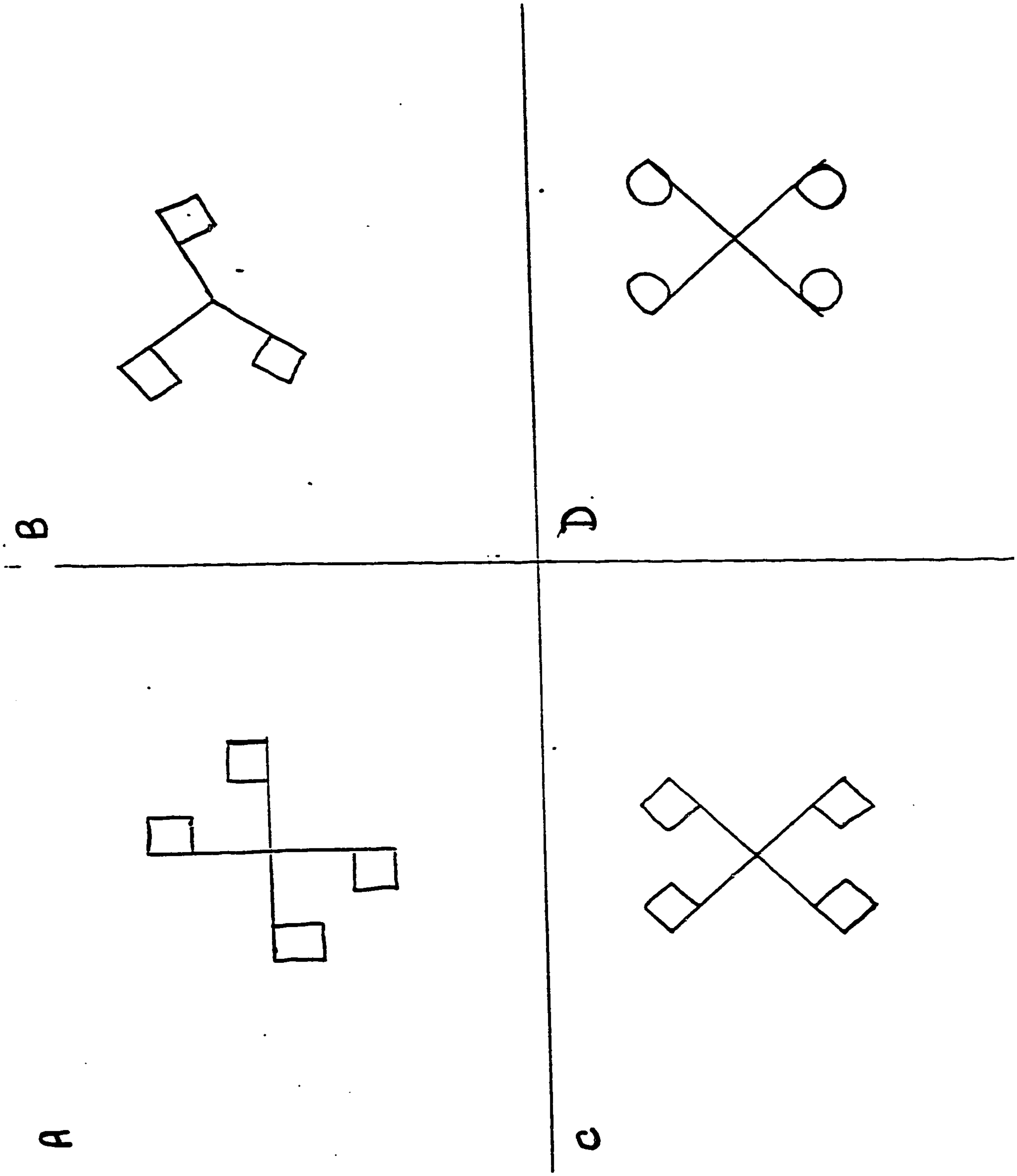
   A. It skidded off the road.
   B. It was stolen.
   C. It rolled over.

4. What did his two-way radio do?

   A. It buzzed.
   B. It beeped.
   C. It went dead.

5. What did he say into his radio?

   A. "This is Cricket."
   B. "This is Puppet."
   C. "This is Grasshopper."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A
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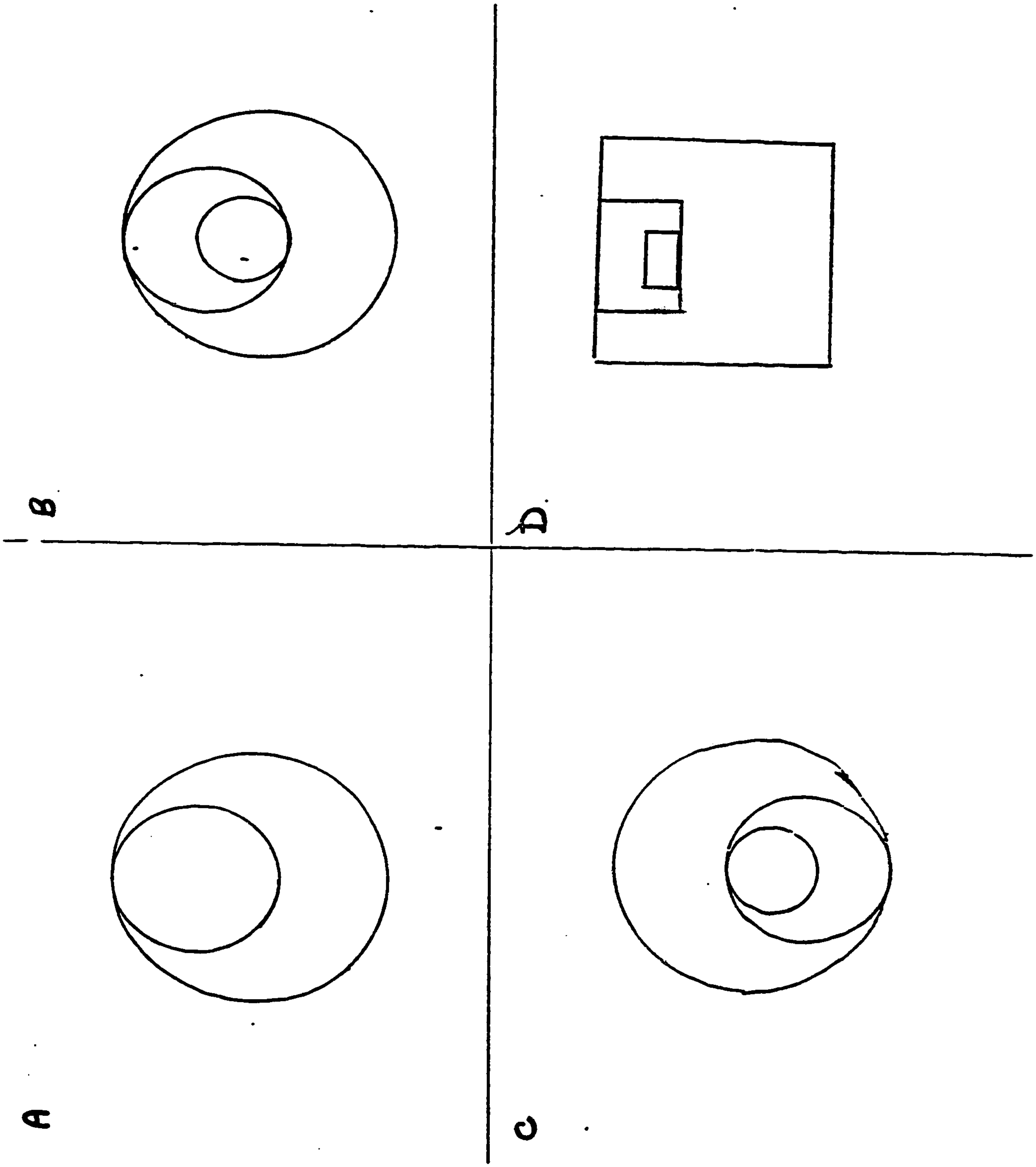
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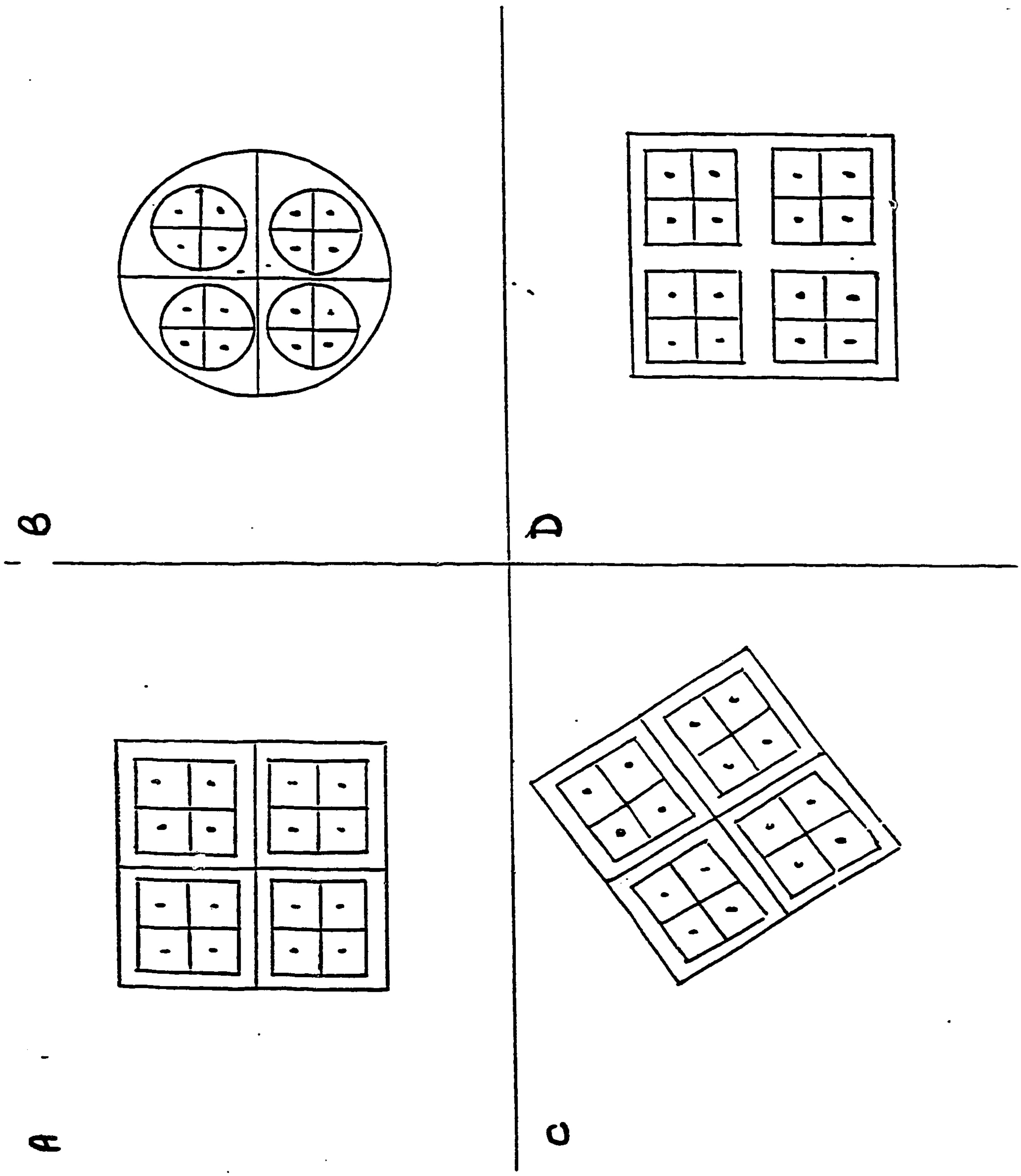
A
C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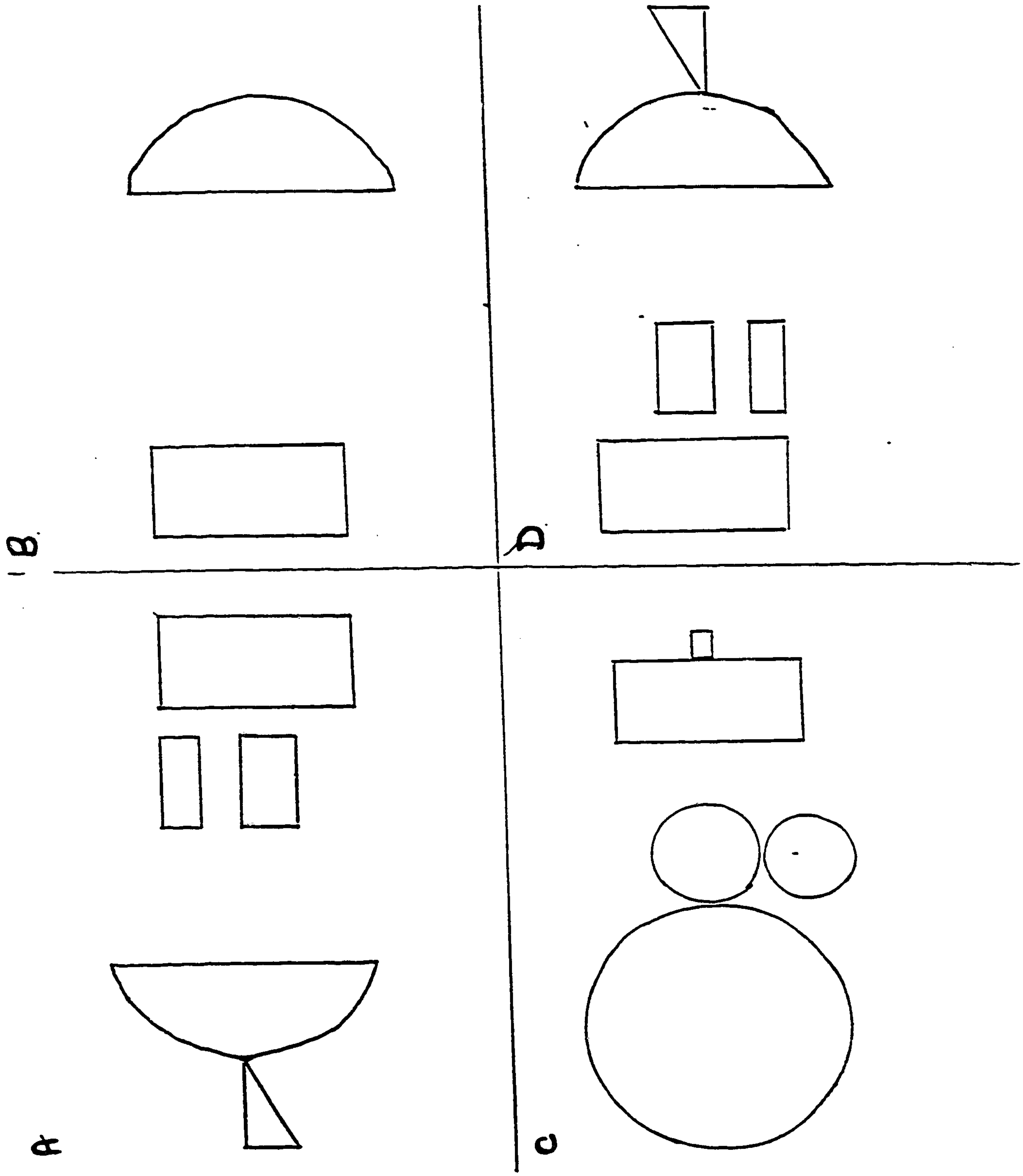
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Appendix C

CCAT and WMS-R Correlations

Table C1

Correlation of CCAT and WMS-R Scores (Age 9 n=77)

	LMI	LMII	LMSAV	LMREC	VMI	VMII	VMSAV	VMREC
CCATVS	.5512**	.4987**	-.1012	.3201*	.2765*	.2668*	.1633	-.0334
CCATQS	.3184*	.3217*	.0742	.2182	.2819*	.2124	.0524	-.0683
CCATNVS	.1829	.2396	.0614	.1655	.4190**	.2753*	.0366	.0057

1-tailed significance: * -.01 ** -.001

Table C2

Correlation of CCAT and WMS-R Scores (Age 10 n=127)

	LMI	LMII	LMSAV	LMREC	VMI	VMII	VMSAV	VMREC
CCATVS	.4913**	.5252**	.2832**	.3194**	.1877	.3211**	.2166*	.1018
CCATQS	.3616**	.3763**	.1827	.2479*	.1963	.3107**	.1994	.0848
CCATNVS	.2340*	.2282*	.1005	.2073*	.2418*	.2281*	.0609	.1766

1-tailed significance: * -.01 ** -.001

Table C3

Correlation of CCAT and WMS-R Scores (Age 11 n=114)

	LMI	LMII	LMSAV	LMREC	VMI	VMII	VMSAV	VMREC
CCATVS	.3939**	.3810**	.0696	.2976**	.2968**	.3054**	.1220	.2364*
CCATQS	.3350**	.3298**	.0956	.2464*	.2625*	.1520	-.0354	.2160
CCATNVS	.3493**	.3340**	.0875	.1870	.5143**	.4095**	.0475	.2434*

1-tailed significance: * -.01 ** -.001

Table C4

Correlation of CCAT and WMS-R Scores (Age 12 n=96)

	LMI	LMII	LMSAV	LMREC	VMI	VMII	VMSAV	VMREC
CCATVS	.4229**	.3595**	-.3079	.4176**	.2255	.0972	-.1034	-.0042
CCATQS	.3075*	.2832*	.0406	.2482*	.3847**	.1209	-.2420*	.1535
CCATNVS	.1196	.0800	-.0606	.1042	.4236**	.1870	-.1884	.2015

1-tailed significance: * -.01 ** -.001

Table C5

Correlation of CCAT and WMS-R Scores (Age 13 n=80)

	LMI	LMII	LMSAV	LMREC	VMI	VMII	VMSAV	VMREC
CCATVS	.3205*	.3778**	.2231	.2885*	.1603	.2472	.2304	.2107
CCATQS	.1840	.2035	.0317	.1906	.3255*	.4413**	.3388*	.0905
CCATNVS	.2320	.2[illegible]2	.0512	.1346	.5212**	.4776**	.2470	.1785

1-tailed significance: * -.01 ** -.001

Table C6

Correlation of CCAT and WMS-R Scores (Age 14 n=99)

	LMI	LMII	LMSAV	LMREC	VMI	VMII	VMSAV	VMREC
CCATVS	.5112**	.3817**	-.0933	.2531*	.0486	.0758	.0260	-.1572
CCATQS	.2350*	.2130	-.0107	.14[illegible]7	.3002*	.1412	-.0519	-.0341
CCATNVS	.1704	.1202	-.0479	.1591	.3233**	.2993*	.1176	.1022

1-tailed significance: * -.01 ** -.001

Table C7

Correlation of CCAT and WMS-R Scores (Age 15 n=25)

	LMI	LMII	LMSAV	LMREC	VMI	VMII	VMSAV	VMREC
CCATVS	.3566	.3911	.2738	.0858	.1354	.1897	.2124	.0603
CCATQS	.3348	.2462	-.1562	.1981	.4752*	.6285**	.4698*	.1827
CCATNVS	.3063	.1962	-.2367	.2181	-.5863*	.5979**	.3565	.2117

1-tailed significance: * -.01 ** -.001

Table C8

Correlation of CCAT and WMS-R Scores (n=617)

	LMI	LMII	LMSAV	LMREC	VMI	VMII	VMSAV	VMREC
CCATVS	.3978**	.3793**	.0645	.2903**	.1697**	.1806**	.1093*	.0914
CCATQS	.2129**	.2118**	.0597	.1614**	.1622**	.1195*	.0243	.0739
CCATNVS	.2349**	.2212**	.0337	.1823**	.3788**	.3078**	.0791	.1749**

1-tailed significance: * -.01 ** -.001