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The WISC III Processing Speed Index: Differences
Among Clinical Populations

by

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Abstract

The diagnostic value of the WISC-III Processing Speed (PS) factor was examined. First, it was hypothesized that subjects with a single diagnosis would have reduced processing speed. Second, it was hypothesized that a diagnosis in two areas would result in lower processing speed. Male and female subjects (n = 171), aged 6 to 16 years, were assessed at the Education Clinic at the University of Alberta. Assessment tools included: the WISC-III, as well as achievement, visual motor integration (VMI) and/or emotional or behavioral (B/E) measures. Results indicated that: 1. subjects diagnosed with VMI, B/E or Attention Deficit Hyperactivity Disorder achieved significantly lower mean scores on PS factor, Coding (CD) and Symbol Search (SS) subtests; and 2: dual diagnosis subjects achieved significantly lower mean scores on all three measures. Results suggest reduced diagnostic specificity and that more severe cognitive difficulties result in reduced speed of processing.

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CHAPTER ONE

Introduction

The contention that an individual's speed of cognitive processing is related to intelligence dates back to psychology's earliest explorations into the nature of cognition (Marr & Sternberg, 1987). Marr & Sternberg (1987) suggest that mental speed is important in Western notions of intelligence. For example, we often believe that 'quick' people are more intelligent than 'slow' people. This is exemplified by our belief that a student who arrives at an answer first is more intelligent than a student taking more time. Research examining implicit theories of intelligence has also demonstrated that widely diverse groups of people in this society (e.g., varying socioeconomic groups), consider behaviors that explicitly reference mental speed to be somewhat characteristic of intelligence (Sternberg, Conway, Ketron, & Bernstein, 1981). This supports the argument that mental speed may be somewhat indicative of intelligence.

The new and revised Wechsler Intelligence Scale for Children-Third Edition (WISC-III) is one of the most important tools for assessing children's cognitive abilities. This tool appears to support the notion that an individual's speed of cognitive processing should be included in our conceptualization of intelligence. Due to the inclusion of the new Symbol Search (SS) subtest in the WISC-III, as well as a revision of the test items, a new four factor model is reported (Wechsler, 1991). The new factor solution now consists of the following four factor indexes: Verbal

Comprehension, Perceptual Organization, Freedom from Distractibility and Processing Speed. The new PS factor, comprised of the SS and Coding (CD) subtests, now encompasses the fourth factor of the WISC-III. The new PS factor has resulted in the development of the WISC-III to include the assumption that an individual's speed of cognitive processing is an important component of intelligence.

Purpose of the Study

The purpose of the present study was to examine whether the WISC-III PS factor score (comprised of the SS and CD subtests), distinguishes between groups of children with different identified problems interfering with school performance and their general level of functioning. The present research is a largely a replication and extension of Tiholov's (1995) study. Consequently, one of the goals of the study is to attempt to clarify some of Tiholov's (1995) results.

Statement of the Research Problem

The purpose of this research is to examine the utility of the PS Factor in distinguishing between groups of children with different identified problems interfering with their academic and general level of functioning. Some of these problem areas included: visual-motor integration problems (VMI), behavioral or emotional difficulties (B/E), attention-deficit hyperactivity disorder or attention deficit disorder (AD/HD), learning disabilities (LD), physical health problems and prenatal/first year of life health problems. It is hoped that this replication study will be instrumental in improving the diagnostic process and will provide more information as to the utility of the PS factor in differentiating between groups of children with various problems interfering with school performance. One of the goals of this study is to help diagnosticians when interpreting WISC-III results. Overall, the goal of this research is help clinicians make more reliable and valid diagnostic conclusions, and ultimately to help children who are experiencing different problems interfering with their school performance and home life.

By replicating and extending the results of Tiholov's (1995) study, an attempt is made to explore the diagnostic value of the PS factor of the WISC III. The broad question to be answered is: Can we reliably distinguish between different population groups based on their WISC-III PS index scores (Tiholov, 1995). Specifically, the question to be answered in this study is: Do children with various identified problems (e.g., AD/HD, B/E, physical health conditions, learning disabilities and visual-motor integration difficulties, as well as combinations of the above problems), show significantly different mean scores on the WISC-III PS index when compared to children without difficulties in these domains?

CHAPTER TWO

Literature Review

Importance of Speed in Early Infancy

From infancy to adulthood, research suggests that individual differences in the speed of some cognitive processes may be related to individual differences in intelligence. In the literature on cognitive development in infancy, it is assumed that infants who habituate more quickly are more intelligent than those who take more time to habituate. (Habituation is the process of showing less interest in a stimulus as a result of exposure and can be measured through looking time.) To illustrate, in a habituation study, infants are exposed to one stimulus until it becomes familiar. Once the infant becomes bored with this stimulus (measured by when the baby stops looking at the stimulus), a new stimulus is introduced. The degree to which the infant looks at the new stimulus, as opposed to the old one, is taken as a dishabituation measure. In one important study, researchers found significant correlations between the speed of infant habituation to visual stimuli at 5 to 7 months of age and their vocabulary scores when seven years old (McCall & Kagan, 1970). As well, Lewis & Brooks-Gunn (1981) examined 79 infants at three months of age. These researchers used a habituation procedure and a test of infant intelligence, the Bayley test of infant development, at three months and at twenty-four months. The correlations between the measure of dishabituation to the new stimulus at three months, and Bayley scores at three and twenty-four months were 0.52 and .40, respectively. This suggests that the habituation paradigm could predict verbal infant intelligence test scores at two years of age.

Fagan & McGrath (1981) used a visual novelty preference paradigm with infants in order to assess the effects of a time delay on immediate visual recognition memory. In this paradigm, infants were shown a stimulus until they habituated (about one-half to two minutes). Infants were then shown the familiar object together with a novel object during the testing phase. Researchers recorded the amount of time the infant spent looking at the new stimulus and the old. 'Visual novelty preference' scores were determined by the amount the infant looked at the new stimulus in comparison to the old one. Fagan and McGrath (1981) found that visual novelty preference scores at about 4 to 7 months of age correlated significantly with IQ scores at 4 years of age and at seven years in another group. Thus, babies demonstrating greater preference for the new item had higher IQ scores several years later. As well, visual novelty preference scores were significantly lower in babies with a high risk of retardation (Miranda & Fantz, 1974). As much as the habituation paradigm relies upon cognitive operations necessary to change the new stimulus into a recognizable one, the rate of habituation may be viewed as a reflection of processing speed. However, it must be stressed that the infant's rate of habituation is likely to depend upon additional factors such as concept acquisition and visual and auditory perception. However, it is beyond the scope of the present paper to fully address these issues.

History of speed of cognitive processing

The concept that mental speed is an important part of cognition and is correlated with intelligence dates back to the beginnings of experimental research on intelligence (Eysenck, 1987). More than one hundred years ago, Sir Francis Galton attempted to approach the study of intelligence in an experimental manner. He studied reaction time, or people's speed of reaction to sounds and lights in order to examine individual differences in academic performance (Galton, 1883). At that time, findings suggested that there was a positive relationship between rate and ability in mental tests. McFarland (1928) concluded that:

> In the six more recent studies of the past four years where investigations have been conducted under carefully controlled conditions, the evidence, although contradictory, decidedly tends to favor the existence of a positive relationship between rate and ability in mental tests (p. 610). It is evident . . . that further research confined to laboratory techniques is necessary in order to clear the issue and to establish negative or positive significance of this important psychological problem.

Although the reaction time task is now one of the most studied tasks in field of psychology, McFarland's recommendation was not immediately followed as interest in the experimental study of intelligence decreased during the middle of the 1900s. During the early 1920's, however, some researchers showed interest in cognitive speed in mental tests. May (1921) and Ruch & Koerth (1923) compared subjects' scores on IQ tests when time limits were imposed to scores obtained when unlimited time was allowed. The results of these and similar experiments showed high correlations between the timed and untimed test scores, suggesting that speed was important in the measurement of cognitive abilities (McFarland, 1928).

High Level versus Low Level Conceptualizations of Intelligence

There are two major points of view concerning the conceptualization of intelligence: a social or culturally determined view and a biologically or genetically based view of intelligence. Galton and Binet, respectively, may be viewed as theorists of the social and biological camps. Eysenck (1987) summarizes the differences between these two psychologists' different viewpoints towards intelligence. First, Galton believed there is a 'general factor' of intelligence which is fundamental to all cognitive processes. This 'general factor' is believed to mediate individual differences in intelligence. Binet, on the other hand, contended that intelligence was a statistical creation or an 'average' of many semi-independent abilities such as verbalization and memory, and even factors such as suggestibility and emotion. Second, Galton believed that differences in intelligence were determined by genetic, biologically based factors, and that differences in synaptic efficiency or speed, for example, determine individual differences in intelligence (e.g., Eysenck, 1986b; Jenson, 1982). However, Binet was more interested in the environmental or cultural influences on intelligence. Third, Galton believed that intelligence could be measured by physiological indices such as reaction time. Binet, on the other hand, believed that intelligence could be measured by tasks such as problem solving, following directions and memorization.

Jenson Model of Intelligence

During the 1960s reaction time again entered the field of intelligence measurement. A great deal of important theoretical and empirical work was done by the Jenson school (Jenson, 1982). This model is based on the importance of a time element in intelligence and on a few concepts of cognitive psychology. The first concept is that the brain acts as a limited capacity information processing system. Thereby, it can deal only with limited amounts of information. This limited capacity restricts the number of operations that can be performed on arriving information. Consequently, the model hypothesizes that it is advantageous for the brain to process information quickly, as more operations can be performed per unit of time without overloading the information processing system.

A second principle of this theory is that traces of information from stimuli quickly decrease. Thus, speed is likely to be beneficial as operations need to be performed on the information while it is still available. Third, the individual must rehearse and store the information in long-term memory (LTM) (which has a nearly unlimited size). However, storing information in LTM is a time consuming process, thereby using up limited resources in short-term memory (STM). Consequently, there is likely to be a compromise between the storage and processing of incoming information. Jenson postulates that the more complex the information and the operations required on it, the more time will be required to process the information. Consequently, quickness is advantageous. Speed of information processing should be increasingly related to success in processing cognitive information as that information overload strains the limited resources in STM.

Resurgence of the Reaction Time Measure

The resurgence of interest in measuring reaction time as an indicator of cognitive processing speed was created by an interest in the theoretical explanations of intelligence. Proponents of 'G' as a general factor of intelligence attempted to find a measure of a basic process which would correlate with intelligence (Jenson, 1987). Spearman (1927) noted that :

> For the purpose of indicating the amount of 'G' possessed by a person, any test will do just as well as any other, provided only that its correlation with 'G' is equally high. With this proviso, the most ridiculous 'stunts' will measure the self-same 'G' as will the highest exploits of logic or flights of imagination.

Potential measures were those seeming to be related to mental speed. The reaction time measure (RT), appeared to be a natural candidate as it seemed to be a simple task (i.e., most people can easily understand and perform task requirements (Jenson, 1987)), and could be argued to be a measure of mental speed.

Description of the Reaction Time Task

The measurement of reaction time has not always been constant. However, it recently has become quite standardized around the procedure used by Jensen (Jenson, 1982 a, b). Choice reaction time tasks discussed are the same as the tasks described by Jensen (1979, 1982a). Subjects make their responses by touching a computer screen. At the beginning of each trial a display of 1, 2, 4, 6 or 8 empty windows appears on the screen and a small bar is at the bottom of the screen. The subject presses and continues to press the bar in order to begin, watching the screen until a window lights up. The subject moves his or her finger from the bar and touches the lit window as quickly as possible. Upon making the response, the screen goes blank and subsequently a new trial begins.

Choice reaction time measures: decision time and movement time.

There are a number of measures which may be obtained during each trial. Carroll (1980) recommended that reaction time be divided into decision time and movement time. Decision time is the amount of time from the onset of the stimulus to initiating the response. It is measured as the duration of time the subject keeps his or her finger on the bar at the bottom of the screen after one of the windows has lit up. Movement time is the amount of time required to respond and is measured as the time from when the subject lifts his or finger from the bar until the window is touched.

Other measures of interest include: number of errors and the total amount of time for each trial. One measure which has received a great deal of attention is the slope of decision time over set size. As the number of alternatives to be scanned becomes larger, an increase in reaction time is expected.

Hick's law.

Although Jenson (1987) noted that it was a German psychologist, Blank (1934), who first noted that RT increases as a linear function of the logarithm of n, Hick was ultimately given credit for this discovery (Hick, 1952). Hick (1952) proposed that reaction time is a linear function of the log (base 2) of the number of choices, since the log of number of choices is the amount of windows (e.g., 1,2,4,6 or 8). Researchers questioned whether differences in slope for individuals are related to differences in intelligence. It is expected that less intelligent persons have more difficulty as the amount of information (i.e., the number of windows) increases. Consequently, steeper slopes should indicate lower IQs.

Roth (1964) found that more intelligent subjects show a lower rate of increase in reaction time (RT) as information increases than less intelligent subjects. Conversely, less intelligent subjects show a greater increase in reaction time in comparison to the more intelligent subjects. Lehrl (1983) illustrates Roth's findings demonstrating that reaction time increases as the number of choices (e.g., windows) increases according to the subject's IQ. The correlation of the angle of the regression line for Roth's fifty-eight subjects is approximately -.39 with the Amthauer (1955) intelligence test. Thus, less intelligent subjects demonstrate longer reaction times in comparison to more intelligent subjects.

Reaction Time in Various Populations

Overall, strong, negative correlations have been reported between reaction time measures and intelligence (Rattan, 1992). This relationship has been found among various groups including those with varying degrees of mental retardation (e.g. Lally & Nettelbeck, 1977; Vernon, 1981), gifted people, normals (e.g. Carlson & Jenson, 1982), and even with different cultural groups outside North America.

Mental retardation research.

During the early 1960's researchers explored the role of mental speed when attempting to discover processes explaining intellectual differences among individuals, particularly in the mentally retarded population. Major findings in this line of research support the contention that there is a relationship between speed of information processing and intelligence (Lally & Nettelbeck 1977; Nettelbeck, 1980; Nettelbeck & Kirby, 1983).

Baumeister and Kellas (1968) have summarized the major results of this line of research. First, mentally retarded subjects, on the average, tend to be slower than their peers of average intelligence. In their study, two groups of subjects (20 mentally retarded young adults enrolled in special education classes and 20 college students), were given the choice reaction time task and a test of cognitive abilities--the WAIS-R. Results indicated that decision time--the amount of time required for the subject to remove his finger from the bar--significantly correlated with IQ ($r = -.29$). This finding concurs with the results of other investigators. Baumeister and Kellas (1968) concluded mentally retarded person's responses are more variable than intellectually average persons. In fact, mentally retarded subjects' fastest responses are no different from intellectually average subjects' fastest responses. However, the number of longer responses they make outweigh those of intellectually average individuals.

Gifted individuals.

Not only is there a relationship between speed of information processing and intelligence in mentally retarded and normal populations, but gifted and normal children tend to differ in speed of information processing on extremely simple cognitive tasks. Cohn, Carlson, & Jensen (1985) examined the relationship between intelligence and choice reaction time in normal and gifted subjects. Seventy subjects (mean age 13.9) with scores one standard deviation above statewide norms on a test of basic abilities were compared to 60 students (mean age 13.6) with average scores. The results were as follows: 1) the various RT measures discriminate between gifted and intellectually average subjects as much as studies have found the measures to distinguish between average and mentally retarded groups; and 2) the gifted subjects differ from their average peers in more than just scholastic knowledge and advanced problem-solving skills. They differed fundamentally in speed of information processing on extremely simple cognitive tasks.

Reh, Roberts & Prichard-Levy (1994) examined the relationship between intelligence and choice reaction time in normal and gifted children. In this study, 41 intellectually gifted children aged 9 to 12 years and 39 university students, aged 18 to 48 years, completed a test of non-verbal abstract reasoning ability, the Standard Ravens Progressive Matrices Test (RPM), as well as a Choice Reaction Time task (CRT). Correlations between RPM scores and CRT measures were significant at all levels, suggesting that CRT measures and intelligence are related. For all conditions, speed of response was significantly correlated with intelligence as measured by the RPM test.

Normal individuals.

In a series of studies, Jensen and colleagues (Carlson & Jenson, 1982; Cohn, Carlson, & Jenson 1985; Jenson, 1979, 1980a, 1982a, 1982b, 1984; Jenson & Munro, 1979; Vernon, 1981, 1983; Vernon & Jenson, 1984) have made a case for the relationship between speed of information processing and intelligence among 'normal' subjects. Jenson's main choice reaction time results have been supported by other investigators, supporting the assertion that choice reaction time varies systematically across groups differing in IQ (e.g., Barrett, Eysenck, & Lucking, 1986; Hemmelgarn & Kehle, 1984). While there has been some criticism of this research (i.e., Longstreth, 1984), the major findings are consistent with the research done with mentally retarded and gifted samples.

One of the most thorough studies on the relationship between IQ and RT was completed by Vernon (1983). One-hundred university students were given five measures of efficiency of cognitive processing and the Wechsler and Raven scales as measures of IQ. The measures of speed included: inspection time; the Sternberg STM scanning task; the Posner LTM information retrieval task; an efficiency of STM storing and processing task, which is essentially a combination of the Sternberg and Posner tasks; and, reaction time. The matrix of correlations between these speed of processing tests was factor analyzed and results demonstrated a strong first main factor: results showed that the only variable that correlated significantly with IQ was speed of processing.

Jensen (1982 a, b), gives a thorough discussion of the literature to-date and formulates a number of conclusions. The most important of these are as follows: 1) simple reaction time shows a negative correlation with intelligence (around -0.2 to -0.3) (whether this is a small or large relationship is fairly subjective (Detterman, 1987)); 2) choice reaction time shows more substantial correlations with IQ than simple reaction time; 3.) choice movement time shows significant correlations with IQ; 4) as the number of choices (windows) increases, the correlation of RT with IQ increases; 5) the angle of the Hick Slope (b) is negatively correlated with IQ; and, 6) inspection time is significantly and negatively correlated with IQ.

Individuals from different cultures.

The relationship between reaction time and intelligence has also been supported in different cultural groups. Shigehisa & Lynn (1991) examined the relation between reaction time and intelligence among children in Japan in order to determine whether the associations between reaction times and intelligence would be found cross-culturally. Results confirm the positive association between fast reaction times and intelligence. However, similar to other research the size of the correlation is moderate (e.g., about .30).

To summarize, speed of cognitive response appears to be related to performance on several psychometric measures of intelligence (e.g., WAIS-R). This effect is found among certain populations in western society including the mentally challenged, gifted and normal populations, as well as in other cultures, such as Japan.

Neurophysiological Correlates and Intelligence

The theoretical interest of these results (i.e., the correlation between RT and IQ), is that they suggest that speed of information processing at the neurological level, operationalized in terms of reaction time, is a component of intelligence. Jensen (1982) proposed that the crucial neurological factor is speed of neural transmission. This factor would be common to performance on both reaction time tasks and intelligence. The relationship between response time and intelligence is argued to reflect the subject's neurological cohesiveness; that is, reaction time may directly reflect characteristics of the subject's central nervous system. It is hypothesized that reaction time may be a behavioral measure of the biological basis of intelligence. Longer response times are likely to be demonstrated by lower scores on measures of intelligence. For example, Eysenck (1982b, 1986b), has suggested that individual differences in reaction time may reflect individual differences in synaptic conductivity. Such differences may be more directly observed as individual differences in cortical response patterns (Hendrickson, D., 1982).

The case supporting the relationship between intelligence and neural speed has been supported by some research examining neurophysiological data in mentally retarded and normal subjects. Cortical Average Evoked Potentials (AEPs), have been shown (when appropriately measured), to be related to intelligence (Haier, Robinson, Braden, & Williams, 1983; Hendrickson, A. 1982 ; Hendrickson, D. 1982). One investigation using an auditory stimulus (a click), correlated reaction time and other Hick parameters with cortical average evoked potentials (AEP) in a group of severely retarded subjects. The AEP amplitude (found to correlate with IQ in previous studies using subjects of average and superior intelligence) correlated both with psychometric 'g' and with Hick parameters in a group of 54 severely retarded adults (Jenson, Schafer, & Crinella, 1981).

Schafer, Amochaev, and Russell (1982) also examined the relationship between the Average Evoked Potential (AEP) and reaction time. In this study, eight normal adults were given the Hick task with three different set sizes (1, 4 and 8). Subjects' cortical average evoked potentials were recorded. Results showed that the set size affected the latency of the AEP. The cortical evoked potential latencies also demonstrated Hick's Law: latencies increased linearly in relation to the amount of visual information (set size). This suggests that both latency and amplitude of cortical AEPs appear to manifest Hick's Law to the same degree as reaction time. Overall, further investigations of the relationship between RT variables, evoked cortical potentials and intelligence is required (Jenson, 1987).

Although there is some support for the relationship between neural speed and intelligence, there are problems, both of a biological and psychological nature, with this research as outlined by Tiholov (1995). For example, it is possible that the electrical potentials or AEPs may be distorted for the following biological reasons: cerebral spinal fluid conductivity, skin properties and skull peculiarities. Cortical AEPs may also vary due to psychological factors, such as variations in processing strategies as well as the attentional state of the subject.

In conclusion, the literature in this area is inconclusive and more research must be done in order to form any valid and reliable conclusions. Simply because reaction time can be shown to be related to intelligence does not mean that intelligence can be equated with neural speed or efficiency as some have suggested (e.g. Eysenck, 1982). The relationship between the above variables found in AEP research is not unambiguous, and other interpretations or a possible third factor such as motivation may be responsible for the results.

Moderator Variables between the RT and Intelligence Relationship

A recent review by Frearson, Barrett, & Eysenck (1988), seemed to suggest that task variables may moderate the RT-intelligence relationship. Agrawal & Kumar (1993) examined whether task variables (i.e., the nature of the task) moderate the RT-intelligence relationship. The results showed that for two sensory modalities (auditory and visual), and three task complexity levels, the relationship between intelligence and RT indices is negative and generally significant. Thus, higher intelligence is associated with faster speed of information processing and does not appear to be modality specific. Results are somewhat surprising, considering that there are basic differences between auditory and visual processing.

Relationship Between Speed and Intelligence in Complex Tasks

For the most part, researchers have examined speed of processing with tasks requiring minimal information processing such as the reaction time task (e.g.. Eysenck, 1967), rather than with tasks involving more complex cognitive processing. Rattan, Dean, & Fischer (1986) investigated the role of response time with a more complex measure, the Halsteid-Reitan Neuropsychological Test Battery (HRNB). They collected response time measures on the Category test, an index of neuropsychological integrity. Response time measures were factor analyzed, and findings demonstrated that in a sample of normal adult subjects, response time loaded heavily on the first factor and accounted for greater variability (21.2%) than the other neuropsychological variables. The fact that no other variables significantly loaded on the first factor suggested to the authors that speed of information processing is an important component in cognition.

Further attempting to assess the efficacy of the speed of information processing variable, response time measures on the Category Test (HRNB) were examined in relation to academic achievement. Results showed that average correct response items from the Category test were the only significant predictor of reading ($r = .34$) and spelling ($r = .32$) on the Wide Range Achievement Test -Revised (WRAT-R) for a group of 42 normal children (Sujansky, Griffith, & Rattan, 1990). This suggests that response time may be an important component in the measurement of academic achievement.

Research has also suggested that a meaningful association exists between speed of performance and cognitive ability as measured by selected components of the WISC-R (Kaufman, 1979). In this experiment, the WISC-R standardization sample was used to examine the relationship between speed of performance and problem solving ability on WISC-R performance scale tasks including: Block Design, Picture Arrangement and Object Assembly. The results showed that children who solved items more quickly were more efficient 'problem solvers' than those who solved them slowly. For example, children solving a problem in 1-5 seconds were better problem solvers than children (within the same age group) solving the problem in 6-10 seconds, who in turn were better than those solving the problem in 11 to 15 seconds. This suggests that speed of response may be a potentially important aspect of intelligence. However, Kaufman cited caution in interpreting the results, as other nonintellectual factors, such as anxiety, motor difficulties, reduced motivation or a reflective cognitive style, could possibly decelerate an individual's performance.

Rattan (1992) also investigated the relationship between response time and intelligence on more complex measures, such as the WISC-R. Rattan (1992) attempted to determine whether response time measures contribute unique explanatory information to WISC-R scores. Response times in this study, when contrasted to reaction time research, included both initiation and movement time as a part of the latency measure. Specifically, response times from the Picture Arrangement, Block Design and Object Assembly subtests were used as dependent variables in a factor analytic study. Rattan found that response time scores contributed unique variance to WISC-R scores and concluded that speed of information processing should be given greater consideration in the assessment of cognitive functioning. This finding is consistent with studies reporting that response time is a significant factor in the measurement of general neuropsychological functioning (e.g., Rattan et al., 1986) and academic achievement (e.g., Sujansky et al, 1990).

Anderson's Theory of Cognitive Development

Researchers such as Eysenck (1988) argue that a theory is required in order to account for the possible relationship between perceptual-motor processes (e.g., reaction time) and physiological processes (e.g., evoked cortical potentials) on the one side, and measures of intelligence or IQ on the other (Tiholov, 1995). Anderson's cognitive theory suggests that processing speed is the basis of individual differences in intelligence. However, he concedes that other factors may play a role in intelligence (e.g., modules). Anderson's theory of cognitive development attempts to synthesize two camps of psychology: biological and genetically based determinants of intelligence with cultural and social determinants.

Anderson's theory proposes that there are two routes to knowledge acquisition: Route 1 and Route 2. Route 1 knowledge acquisition is defined as "knowledge that is acquired by the implementation of an algorithm generated by a specific processor" (Anderson, 1992, p. 206). He hypothesizes that input goes through a specific processor, verbal or nonverbal, also known as SP 1 and SP 2 respectively. This information then moves to the Basic Processing Mechanism (BPM). The BPM speed restricts not only how much information can go through, but also the elaboration of knowledge, thereby resulting in individual differences in intelligence. It is this mechanism that represents the foundation of the mind, and is believed to be the biological constraint on thought. The BPM is considered to be responsible for 'general intelligence' and is not considered to change with an individual's development. It is when knowledge is acquired through this route "that we are said to be *thinking*" (Anderson, 1992, p. 206).

The model suggests that individuals with a slow BPM are likely to have a low level of intelligence. It is hypothesized that individuals with slow BPMs have less information transferred to LTM and lose more sensory input (see Eyseneck (1987) and Jenson (1987) for details on this process).

Second, it is also possible that individual differences in intelligence may be related to Route 2 knowledge acquisition, rather than to speed of information processing. Route 2 knowledge acquisition is described as "Knowledge that is directly given by dedicated modules" (Anderson, 1992, p. 206). Anderson posits that modules are the second type of processing mechanism, and they are not constrained by the speed of the basic processing mechanism. These modules are believed to be shaped by the process of evolution, and give the individual necessary information required for coping with the environment; this information cannot be provided by thought. Anderson contends that it is the maturation of the modules which is responsible for developmentally changing cognitive abilities.

According to Anderson's model, there is a secondary developmental process which may influence individual differences in intelligence: knowledge elaboration. He maintains that there are three influences on knowledge elaboration. First, he states that "knowledge is elaborated using Route 1 knowledge acquisition mechanisms" (Anderson, 1992, p. 207). More *powerful* Route 1 mechanisms will result in more elaborate knowledge structures. Second, "knowledge elaboration will also depend on the representational systems available to thought; such systems may be considered to be a *language of thought*" (Anderson, 1992, p. 207). Anderson suggests that module maturation provides alternative representational formats, thereby improving the 'language of thought'. Third, knowledge elaboration is believed to be influenced by a range of factors, such as age and an individual's experiences.

To summarize, Anderson has attempted to provide a comprehensive theory to synthesize the data from a wide range of psychological literature including reaction time literature, infant development, mental retardation, neuropsychology and evoked potentials. As well, the theory attempts to combine biological (e.g., modules, BPM) and social (e.g., the effect of experience on knowledge elaboration) determinants of intelligence. The theory suggests that intelligence is related to biological variables, as well as social variables such as an cultural upbringing and the types of information he or she is exposed to.

Wechsler Scales of Intelligence

The Wechsler Scales were first developed in 1939, when Wechsler combined a number of tests of intelligence previously developed by others (e.g., Army Alpha and Army Beta, Kohs Block Design Test, and the Healy Picture Completion Tests), into a single battery. Wechsler's goal was to create a more comprehensive measure of intelligence and thereby increase our understanding of intelligence.

Wechsler's first scale, the Wechsler-Bellevue Intelligence Scale Form 1, was a point scale (i.e., points are assigned on the basis of correctness and quality of response, and in certain cases the speed of response) and consisted of 11 different subtests. To standardize the test, he obtained representative samples of individuals at every age, examined their performance, and assigned an IQ of 100 as the 'average' performance of persons at each age. Next, IQs of all other similarly aged persons (scoring above and below 100), were computed as deviations from the average score of 100. In 1955, this scale was revised into the Wechsler Adult Intelligence Scale.

Wechsler's definition of intelligence.

Wechlser had a global view of intelligence, believing that intelligence is part of the larger whole of the personality. For him, intelligence was composed of qualitatively different abilities (Wechsler, 1958). Intelligence was not only the sum of certain abilities (such as memory, social comprehension, etc.), but it was defined by the way in which these abilities were combined. As well, factors such as motivation and incentive were believed to play a role in the conceptualization of intelligence. Consequently, his test was designed to take into consideration factors contributing to the total effective intelligence of the individual. He took a practical view of intelligence as he believed that intelligence is known by what it enables us to do. Wechsler maintained that although various aspects of intelligence can be measured, intelligence test scores are not equivalent to or synonymous with intelligence.

The WISC and WISC-R.

The WISC, published in 1949, was an extension of the adult intelligence test, the Wechsler-Bellevue Intelligence Scale. This scale was designed to measure the intelligence of children between the ages of 5 and 15. To make the adult scale more appropriate for children, simpler items were added to the beginning of each subtest.

In the early 1970's the WISC became the WISC-R and was revised to assess children between the ages of 6 and 16. The WISC-R was standardized on a sample of 2200 American children, 6 to 16-11 years of age; the children were representative of the 1970 United States Census. As with the previous scales (e.g., WISC), there were three separate IQ's (verbal, performance and full scale) each with a mean of 100 and a standard deviation of 15.

A factor analysis of the standardization group suggested that three factors characterized the WISC-R: Verbal Comprehension, Perceptual Organization and Freedom from Distractibility. The Verbal Comprehension factor was believed to measure verbal knowledge and understanding obtained through both informal and formal education, and reflected the application of verbal skills to new situations. Vocabulary, Information, Comprehension and Similarities subtests had the highest loadings on this factor, followed by Arithmetic. The Perceptual Organization factor, a non-verbal score, reflected the ability to interpret and organize visual information within a limited period of time. It appeared to measure a variable common to the Performance Scale subtests. Block Design, Object Assembly and Picture Completion subtests had the highest loadings on this factor; Mazes and Picture Arrangement had moderate loadings. The Freedom from Distractibility factor appeared to measure the ability to attend, focus and concentrate. The Arithmetic and Digit Span subtests had high loadings on this factor; Information and Coding B subtests had moderate loadings (Coding A had only minimal loading). The factor structure of the WISC-R is considered to closely agree with the actual organization of the subtests.

WISC III.

The WISC III, the latest version of the Wechsler scales for children, was published in 1991. Similar to the other tests, it was designed for children ages 6 through 16 years. The main reason for revision was to update the norms. The standardization sample of 2200 children (200 in each of 11 age groups) is considered excellent and is stratified on the characteristics of age, race, geographic region and parental education (used as a measure of socioeconomic status). The new WISC-III contains 13 subtests, with six subtests in the Verbal scale and seven in the Performance scale. The Verbal scale consists of the following subtests: Information, Similarities, Arithmetic, Vocabulary and Comprehension. The Performance Scale consists of the following subtests: Picture Completion, Picture Arrangement, Coding, Block Design and Object Assembly. There are three remaining supplementary subtests: Digit Span in the Verbal scale, and Symbol Search and Mazes in the Performance scale. Symbol Search is the new supplementary WISC-III subtest.

WISC-III subtests as measures of 'G'.

The WISC-III is a fair measure of 'G' as 43% of its variance attributed to 'G'. Sattler (1992) posits that the Full Scale IQ is generally considered to be the best measure of cognitive ability or 'G'. It may be affected by factors including: motivation, interests, cultural opportunity, natural endowment, neurological integrity, attention span, and the ability to process verbal and visual information. The Full Scale IQ score is made up of the Verbal and Performance Scale IQ. The Verbal Scale is a measure of verbal comprehension, providing information about language processing, reasoning, attention, verbal learning and memory. The Performance Scale IQ is a measure of perceptual organization. This scale provides information about visual processing, planning and organizational ability, attention, nonverbal learning and memory.

Revision of the WISC-III factor structure.

The WISC-III is a substantial revision of the WISC-R. A new supplementary measure of Processing Speed (PS), was added to the WISC-III, partially due to addition of the new SS subtest. A four factor structure has been introduced and has replaced the three factor structure of the WISC-R. According to Wechsler (1991), the new PS factor accounts for 4-5% of the variance. At present, there is little research on this factor, and there is some controversy surrounding the proposed WISC-III factor structure.

The CD and SS subtests have high loadings on the PS factor, ranging from a high of .98 for the CD subtest in the 6 to 7 year age group, to a low of .52 for the SS subtest in the 11-13 year age group (Wechsler, 1991, p. 191-193). The only pattern interruption is the loading of .30 of SS for age group 6-6 years, which is at the limits of non-significance (Wechsler, 1991, p. 191-193). Wechsler (1991) contends that the four factor model is stable across samples and age groups. Based on research demonstrating the stability of the third and fourth factors, Freedom from

Distractibility and Processing Speed respectively, Wechsler (1991) recommends WISC-III diagnosticians to report the four factor index scores (e.g., Verbal comprehension, Perceptual organization, Freedom from Distractibility and Processing Speed).

Overall, there generally appears to be support for the inclusion of the WISC-III PS factor. Prewett & Matavich (1994) tried to determine whether the PS factor is related to another measure of cognitive abilities, the Stanford Binet Intelligence Scale--Fourth Edition (SBIV). Prewett & Matavich (1994) administered the WISC-III and the SBIV to 73 low and low-middle socioeconomic status high school students. The PS factor score was correlated with the SBIV. Results showed that the PS factor significantly correlated ($p < .01$) with the SBIV abstract/visual reasoning scale (.41), quantitative reasoning scale (.44), as well as with the test composite score (.41). Thus, results lend some support to the importance of the PS factor.

Kamphaus, Benson, Hutchinson, & Platt (1994) also found support for the four factor model. These researchers used confirmatory factor analysis to test three models of the WISC-III including: Wechsler's original two factor conceptualization, Kaufman's (1979) three factor model and the four factor model proposed in the WISC-III manual. The sample consisted of the standardization group of students described in the WISC-III manual. The results of this factor analysis showed that incremental fit and cross validation indices showed that the four factor model fit the data better than the other two models for all age groups. Although presently there is no psychological theory to support the four factor conceptualization of the new WISC-III, the researchers recommend additional research to clarify the third and fourth factors (e.g., Freedom from Distractibility and Processing Speed).

Hishinuma & Yamakawa (1993) also examined the validity of four factor model of the WISC-III with an 'at risk' and special education sample and found support for the four factor model. Results showed that the SS subtest loaded highest on the PS factor. However, contrary to expectations, Picture Arrangement loaded almost exclusively on the PS factor. Consequently, Hishinuma & Yamakawa (1993) suggest that the PS factor appears to be associated with timed visual motor/sequential processing.

However, there is controversy regarding the proposed four factor solution (Sattler, 1992). Although still including the PS factor, Sattler found evidence for a three factor solution composed of Verbal comprehension, Perceptual Organization and Processing Speed. Each of these factor scores accounted for 25, 16, and 10 percent of the variance, respectively; for the complete sample, both the CD and SS subtests loaded highly on the PS factor (Sattler, 1992). Sattler (1992) defines the PS factor as requiring eye-hand coordination, attention and concentration when processing visual information quickly. Sattler (1992) suggests that the PS factor score "measures the ability to process visually perceived nonverbal information quickly" (Sattler, 1992, p. 1049).

Sattler (1992) argues that a three factor model best fits the WISC-III data; however, he mentions that it is weak at ages 6 and 15 years, where only two factors emerged from the data. Moreover, PS is usually represented by CD and SS but not at all ages. For example, Arithmetic and Digit Span represent the third factor at 11 years, whereas Symbol Search, Arithmetic, Picture Arrangement, and Coding represent the third factor at 7 years. For the overall age group, however, Sattler notes that both the CD and SS subtests have substantial loadings on the PS factor.

However, other researchers have found support for a three factor not including the PS factor. For example, Allen & Thorndike (1995) examined the stability of the WISC-III factor structure using cross validation of covariance structure models. Their results showed that a three factor solution was stable across age groups consisting of Verbal Comprehension, Perceptual Organization and Freedom from Distractibility.

Overall, the literature in this area is fairly scarce as little research has been done on the new PS factor. Although there is some controversy regarding this new factor, overall the literature appears to support the inclusion of the PS factor. At present there is no specific psychological theory to support the four factor conceptualization of the new WISC-III, and it appears that additional research is required in order to clarify the factor structure of the WISC-III.

Processing Speed in Children with Difficulties Interfering with School Performance

Some evidence suggests that the PS factor score may be lower than normal in children with difficulties interfering with their school performance. Wechsler discovered that children with unspecified learning disabilities (n = 65), reading disorder (n = 34), as well as children with AD/HD (n = 68), exhibit lower than normal PS index scores (Wechsler, 1991). Ackerman, Weir, Holloway, & Dykman (1995) confirmed these findings in their research and found that processing speed is a core weakness in children with reading and arithmetic learning disabilities; in particular, such children tend to have a particularly a low score on the SS subtest.

Saklofske, Schwean, Yackulic, & Quinn (1994) administered the WISC-III to 45 children with AD/HD in order to reassess them after treating them with methlyphenidate. Results showed that the WISC-III PS index score correlated significantly with the Freedom from Distractibility (.46) and Perceptual Organization (.51) factors. Two of the childrens' five lowest subtest scores on the WISC-III were the SS and CD subtests, which make up the PS factor.

Tiholov (1995) found that subjects experiencing various physical health problems have the lowest mean score on the PS index in comparison to all the other groups with a diagnosis (i.e., AD/HD, Learning Disabilities). Tiholov's (1995) most important finding was that visual motor integration (VMI) deficiencies are associated with lower speed of information processing: children diagnosed with VMI difficulties achieved significantly lower mean scores than the rest of the sample on the WISC-III PS index score, as well as on both the CD and SS subtests. In addition, Tiholov (1995) found that the PS index was the lowest of all factor scores in his clinical sample.

Tiholov (1995) also found that children diagnosed with problems in two areas, especially where VMI deficiencies are involved, achieved significantly lower mean scores on information processing speed (PS, CD, and SS) variables, when compared to the rest of the sample not diagnosed with any problems in the two areas. This suggests that more severe overall intellectual impairment results in a general decrease of speed of information processing. Tiholov (1995) cautions that his results are to be interpreted with caution as research on the PS is in its early stages and more data must be collected. Until then, he recommends caution when using the PS factor and subtest scores (e.g., CD and SS) as a basis for a diagnostic hypothesis.

Research Questions

The purpose of the present study was to replicate and extend Tiholov's (1995) results. The goal was to investigate the diagnostic usefulness of the PS factor score on the WISC-III in discriminating between groups of students with a range of difficulties affecting in a direct or indirect way their academic performance and overall level of functioning. Specifically, the research questions were as follows:

1. Do the mean scores on the PS index, as well as the CD and SS subtests constituting the WISC-III PS factor score, obtained by the groups of students diagnosed with a single problem, differ significantly from the mean scores obtained by the rest of the sample, consisting of subjects not experiencing the respective problem (Tiholov, 1995)?

2. Do the mean scores on the PS index, as well as the CD and SS variables, obtained by the groups of subjects diagnosed simultaneously with problems in two areas, differ significantly from the scores on the above measures obtained by groups of subjects who: a. do not experience problems in any of the two respective areas studied in each comparison; and b. are diagnosed with problems in only one of the two respective areas (Tiholov, 1995)?

These questions are based on the following two research hypotheses. First, it is expected that the group of students diagnosed with VMI difficulties will achieve significantly lower mean scores on the PS index, CD and SS subtests, in comparison to the rest of the sample. This hypothesis is based on the expectation that problems with perceptual input and visual-motor output may reduce the child's overall performance (Tiholov, 1995). Second, the groups of students diagnosed with problems in two areas, particularly where VMI deficiencies are involved, are expected to achieve significantly lower mean scores on the information processing speed measures (i.e., PS, CD and SS variables), when compared to the rest of the sample not diagnosed with any problems in the two respective areas (Tiholov, 1995). This hypothesis is grounded on the view that more severe overall cognitive difficulties (e.g., two or more diagnoses), will result in reduced speed of information processing, which is believed to affect all parts of cognitive functioning.

CHAPTER THREE

Research Design and Methodology

Participants

The subjects were a clinical, non-random sample of 171 children referred to the University of Alberta in Edmonton, Alberta, for psycho-educational evaluation during the years 1995-1997. The subjects ranged in age from 6 to 16 years and consisted of 106 males and 65 females; the mean age was 10.58 years (SD = 2.62) (see Tables 1 and 2, Appendix A). The greatest number of children were enrolled in grade 3 (19.3 %), and the lowest was grade 12 (0.6%) and grade 4 (0.6%). Table 3 in Appendix A shows the distribution of the total sample by school grade and Table 4 shows the distribution of subjects by year of test administration. The children were referred for problems related to learning, behavior/emotional problems (B/E), Attention-Deficit/Hyperactivity Disorder (AD/HD) and giftedness. The WISC-III was administered according to standardized procedures (Wechsler, 1991), by clinical students enrolled in 500 and 600 level assessment courses. These student clinicians were supervised by academic supervisors appointed by the University of Alberta, Department of Educational Psychology.

Materials

Each child was administered the WISC-III, an achievement test and a test of visual-motor integration. Depending on the referral question, some clients were also administered a behavioral or personality test (e.g., Child Behavior Checklist).

WISC-III.

The WISC-III is a tool aimed at assessing the intellectual abilities of children and youth between the ages of 6 to 16 years. There are three scales: Verbal, Performance and Full Scale. The following subtests are in the Verbal scale: Information, Similarities, Arithmetic, Vocabulary, Comprehension and Digit Span. The Performance scale consists of the following subtests: Picture Completion, Coding, Picture Arrangement, Block Design, Object Assembly, Symbol Search and Mazes. It should be noted that Digit Span, Symbol Search and Mazes are supplementary subtests.

WISC-III: reliability.

The WISC-III's reliability is outstanding. Over the entire age range, the three scales (Verbal, Performance and Full Scale) have internal consistency reliability coefficients greater than .89. Based on the eleven age groups, the average internal consistency reliability coefficients are .96 for the Full Scale, .95 for the Verbal scale and .91 for the Performance Scale.

The subtest reliability correlation coefficients are lower than those for the three scales. Within the Verbal scale, the lowest average reliability coefficient based on the eleven age groups is .77 for Comprehension and .87 for Vocabulary; within the Performance scale, the lowest reliability coefficient is .69 for Object Assembly to a high of .79 for CD.

The test-retest reliability after a twelve to sixty-three day period (median = 23 days) with 353 children from six age groups (6,7, 10,11, 14, 15) showed that Performance IQ scores are somewhat less stable than Full Scale and Verbal IQ scores (Wechsler, 1991). For purposes of statistical analysis, these age groups were combined to form 3 groups, and the stability coefficients were .92, .95 and .94 for the Full Scale IQ, .90, .94 and .94 for the Verbal IQ, and .86, .88 and .87 for the Performance IQ.

WISC-III: validity.

As the WISC-III is a fairly newly published test there are few experimental studies examining the validity of the test; however, since many of the test items have not changed (73%), much of the research on the validity of the WISC-R is applicable to the WISC-III (Sattler, 1992; Wechsler, 1991). Overall, the WISC-III appears to show adequate concurrent, criterion and construct validity (Wechsler, 1991).

Concurrent validity.

Studies support the contention that the WISC-III shows adequate concurrent validity with the WISC-R (e.g., Doll & Boren, 1993; Gunter, Sapp & Green, 1995; Sabatino, Spangler, & Vance, 1995; Slate & Saarnio 1995). Sabatino et al. (1995) examined the relationship between the WISC-III and the WISC-R with 51 gifted children. The results indicate that the two tests show similar scale and subtest scores. Verbal and Performance scale IQ scores were within two points of one another across the two test administrations, while only a one-point difference existed between the Full Scale IQ scores.

Studies have shown that WISC-III full scale IQ scores are approximately five to nine points lower than scores obtained with the WISC-R (Ackerman, Weir, Holloway & Dykman, 1995; Bolen, Aichinger, Hall, & Webster, 1995; Lyon, 1995; Post & Mitchell, 1993; Sabatino et al. 1995; Slate, 1995; Slate & Jones, 1995; Wechsler, 1991). However, Sattler (1992) believes that this result concurs with studies demonstrating that people usually score lower on newer tests in comparison to older ones.

The WISC-III manual refers to two studies examining the concurrent validity between the WISC-III and the WISC-R. In the first study, experimenters administered the WISC-III and the WISC-R to 206 children between the ages of 6 and 16 years in a counterbalanced order, after a period of 12 to 70 days. The correlations between the two tests were .90 for the Verbal scale, .81 for the Performance scale, and .89 for the Full Scale IQ scores. The Full Scale IQ scores were 5.3 points lower on average for the WISC-III than the WISC-R. The other study examined 104 children with learning difficulties, reading difficulties or attention deficit hyperactivity disorder. These children were administered the WISC-III and the WISC-R in counterbalanced order. The results showed that the correlations were .86 for the Verbal scale, .73 for the Performance scale, and .86 for the Full Scale. Once again, Full Scale IQ points were 5.9 points lower on the WISC-III than on the WISC-R.

Criterion validity.

Wechsler (1991) reports that correlations between WISC-III Full Scale IQ and achievement tests administered in group settings are in the high .50's and .60's. Overall, WISC-III Full Scale IQ and the WRAT-R subtest score correlations range from a low of .28 for Spelling and .53 for Reading, to a high of .58 for the Arithmetic subtest (Wechsler, 1991). Smith, Smith, & Smithson (1995) examined the relationship between the WISC-III and the WRAT-3 and found that the correlations between the two tests ranged from .42 to .66. This is consistent with other research examining general correlations between IQ and achievement test scores (e.g., Vance & Fuller, 1995).

Construct validity.

Construct validity is established by relating a presumed measure of a construct or hypothetical quality with some behavior or manifestation that is supposed to underlie it. Overall, there is support for the construct validity of the WISC-III. The factor analyses cited in the WISC-III manual (Wechsler, 1991), indicate that the test adequately measures the two factors fit to the Verbal and Performance Scales. The WISC-III appears to provide a reasonable measure of general intelligence.

Achievement Tests.

Achievement tests measure an individual's current level of academic achievement in various school subjects. In this study, clinicians chose from an assortment of tests according to the subjects' needs. The following tests were used for assessing the achievement level of the subject or to assess a possible learning disability: Wechsler Individual Achievement Test (WIAT); Canadian Quick Individual Educational Test (Canada Quiet); Wide Range Achievement Test - 3 (WRAT-3); Woodcock-Johnson Psycho-Educational Battery (W-J PEB); Woodcock Reading Mastery Tests - Revised (WRMT-R); Wide Range Achievement Test - 3 (WRAT-3); and Keymath Diagnostic Arithmetic Test. Overall, these tests tend to demonstrate adequate reliability and validity.

Visual motor integration tests.

The two tests used for assessing the subject's visual-motor integration ability were the Bender Visual Motor Gestalt test (Bender) and the Development Test of Visual - Motor Integration (Beery). These two tests are widely used and have adequate reliability. Although different scoring systems are available for the Bender, the Kaufman scoring system was used in this study.

Behavior/personality tests.

A wide range of tests were given to the subjects in this study. Overall, however, the psychometric properties and the reliability of these tests tend not to be very high. However, the Behavior Assessment System for Children (BASC, 1992), appears to have better psychometric properties than other older behavior or personality tests. In general, however, in order to attain higher reliability, a diagnosis of behavioral/emotional problems is generally based on clinical observations as well as additional sources of information, such as parental and teacher reports.

Procedure

The children were administered psycho-educational assessments during the 1995 to 1997 years by graduate students enrolled in 500 and 600 level assessment courses at the University of Alberta. Prior to the testing session, the guardians or parents of the child signed a permission form to allow the data from their files to be used for experimental purposes. Each child was given the following battery of instruments: the WISC-III, an achievement test and a visual motor integration test. However, depending on the child's referral question, in some cases the client was administered additional instruments, such as behavioral or personality tests. After the graduate student completed the assessment, the protocols and reports were examined by qualified supervisors.

The results of the psycho-educational assessments were collected from the client's files with the permission of the clinic authorities. Next, the researcher examined and collected the data from the clients' files. To maintain confidentiality and to protect the anonymity of the files and test results, the subjects' names were replaced with codes and were not included in the statistical analysis. The statistical analysis for this study was divided into two parts: part A and part B.

Step A: Group Division

In order to compare the WISC-III group mean scores, the researcher divided the sample into different groups consisting of VMI difficulties, behavioral/emotional problems (B/E), Attention-Deficit Hyperactivity Disorder (ADHD) or Attention Deficit Disorder (ADD), learning disabilities (LD), physical health problems, prenatal/first year of life health difficulties, bilingualism and no diagnosis (none) in any of the above mentioned areas. Each time, the group mean of subjects diagnosed with a certain disorder or problem in one of the aforementioned areas was compared to the other group of subjects not diagnosed with this particular problem. Consequently, there was not one constant control group consisting of the same subjects. This approach was taken as most subjects were diagnosed with at least one problem interfering with academic or social/emotional functioning. Moreover, this type of classification also provided a broader basis of comparison.

Visual-motor integration (VMI) problems group. The criteria for this diagnosis was based on the subject's performance on either the Bender Visual Motor Gestalt Test (Bender) or the Developmental Test of Visual Motor Integration (Beery). Subjects included in this group were to have scored significantly below their age level, at least one year developmental delay. Table 5 in Appendix B represents the distribution of the VMI subjects.

Behavioral/emotional problems group. Due to similarity between these two types of problems, subjects with these difficulties were combined into one category. On the basis of behavior and/or personality tests, as well as history and clinical observations, subjects were diagnosed with behavioral or emotional problems (B/E). However, the composition of this group is less reliable than the other groups. Consequently, we must interpret findings related to this group with caution. Table 6, Appendix B, demonstrates the distribution of subjects with behavioral or emotional problems.

AD/HD group. The basis for classifying a subject in the AD/HD group was based on the history of the subject, as well as clinical observations. This history was provided by the student's teacher, parent and/or physician. The sample was divided twice on the basis of the AD/HD criterion: first, a division was based on presence or absence of

AD/HD without hyperactivity; and second, a division was based on the presence or absence of AD/HD with hyperactivity. Membership in these groups is included in Table 7, Appendix B.

Learning disability group. The diagnosis of Learning Disability (LD) required fulfillment of the following criteria: average or higher than average intellectual capabilities as measured by the WISC-III Full Scale IQ score and an achievement test score at least one standard deviation lower (15 points) than the WISC-III full scale IQ score. Importantly, there must be no motor or perceptual (auditory or visual) problems or any other conditions which may impair cognitive functioning (e.g. mental retardation, lack of educational opportunities or behavioral/emotional problems).

The basis for classifying subjects as LD relied upon research by Kolligan and Sternberg (1987), and today many researchers support the definition of LD as an IQ/achievement discrepancy requiring average or above average intelligence and a score at least one standard deviation below the measure of intellectual ability in an achievement related area such as reading or mathematics (Juliano, Haddad, & Carroll, 1988; Waldron & Saphire, 1990). Subjects were classified as arithmetically disabled if their score on a test of academic achievement in this subject (i.e. Arithmetic subtest on the WRAT-3) was at least one standard deviation lower than their Full Scale IQ score on the WISC-III. Similarly, if there was a discrepancy between reading achievement and FSIQ on the

WISC-III, they were placed in the Reading LD group. However, in this study, a group consisting of spelling disability was not formed as not all subjects in this sample were administered such a test.

Although there are arguments concerning this particular definition of learning disability (e.g. Siegel, 1990), it is beyond the scope of this present study to fully examine them. Briefly, however, Siegel (1990) suggests that the IQ-achievement discrepancy may be inappropriate as there are children with low IQ scores who can read at an age appropriate level. She suggests that a cut-off IQ score of 80 be used in the diagnosis of LD. Overall, however, many researchers appear to support the definition of LD given by Kolligan and Sternberg (1987). The numbers and categories of the Learning Disabled group is presented in Table 8, Appendix B.

Physical health problems. In this study, a diagnosis of physical health problems was based on the diagnosis by a physician. This information was typically reported in the subject's history. The phrase 'physical health problems' is equivalent to the term 'Generai Medical Condition' in the DSM-IV (1994). Although this specific and definitive criteria suggests that there should be high reliability within this group, it is also likely that subjects did not mention health problems to the diagnostician or that this information was not included in the report. Consequently, the reliability within this group is presently unclear. Table

9, Appendix B, shows the distribution of subjects with a physical health diagnosis.

Prenatal/first year of life health problems. Subjects were classified as having health problems prenatally or in the first year of life if stated in the background information section of the report. Health problems related to the prenatal period and first year of life included: premature birth, anoxia at birth or other health problems diagnosed by a physician during the first twelve months. Similar to the physical health problems group, the reliability of this group may be somewhat reduced, given that a diagnosis in this area required self-report or parental report. The number of subjects with this diagnosis is presented in Table 10, Appendix B.

Bilingual. Subjects were given bilingual status if their first language was a language other than English or if they were enrolled in French Immersion classes for at least one year at the time of testing. This category was included in order to determine whether bilingualism would influence speed of information processing. However, it should be noted that this category is not as 'typical' a diagnosis as the aforementioned groups. Group membership distribution is presented in Table 11, Appendix B.

No diagnosis. This group consisted of subjects who were not diagnosed in any of the previously mentioned areas. Subjects in this group (none) were often referred in order to ascertain giftedness status. The purpose for including this group was to determine whether not having any diagnosis in the previous categories would influence speed of information processing on the WISC-III. Table 1, Appendix B, demonstrates the distribution of this category.

The statistical package used to analyze the data was SPSS (Statistical Package for Social Sciences). The statistical technique used to test for mean differences between two or more populations was the One-Way Analysis of Variance (ANOVA). The ANOVA was used to compare within and between group means. An ANOVA is statistically comparable to a T-test, and it is the most suitable method for testing hypotheses to determine if mean differences exist for two or more populations.

Step B Group Division

After the first statistical analysis, the sample was divided into groups with combined problems. These groups included subjects concurrently diagnosed with problems in two of the earlier mentioned areas. As this second process resulted in reduced group size, several groups were eliminated. For similar reasons, the different LD groups were combined into a group consisting of 'unspecified LD', which is included in the analysis below. In order to retain generalizability of the results from the comparison between group means, five combined problem groups were included in the data analysis:

- B/E and VMI
- LD and VMI
- AD/HD and VMI

- AD/HD and LD
- B/E and LD

Tables 13 to 17 show the distribution of the subjects with the combined problems.

A One-Way ANOVA and multiple comparisons using the Newman-Keuls (NK) post hoc comparisons were performed. The purpose for using the NK post-hoc comparisons was that it tends to produce robust results with differing group sizes. When analyzing the post hoc comparisons, the critical value used to decide the significance of the difference between group means changes depending on the number of means in the comparison. Consequently, the NK method has a smaller critical method which will show a higher likelihood of showing significance. It has been argued that the Tukey analysis is much more likely to be overly conservative (Glass & Hopkins, 1984).

In each comparison, the whole sample was divided into three groups: Group A consisted of subjects diagnosed with problems in two of the illustrated areas; group B consisted of subjects not experiencing any of the problems in group A; and, group C consisting of subjects diagnosed only with the first problem. This last group was included in the analysis to account for and attempt to remove the influence of the first variable (i.e., the first problem diagnosed). The aim was to have a better comparison between the first and second group (e.g., A and B).

CHAPTER FOUR

Results

General Sample Characteristics

Overall findings suggest that the present sample is similar to the WISC-III standardization sample (Wechsler, 1991). Table 18 in Appendix D, illustrates the mean Full Scale Intelligence Quotient (FSIQ), Verbal IQ (VIQ), and Performance IQ (PIQ) of this sample. In addition, this table shows the means of each of the four factor index scores and subtest means for the sample (n = 171). The mean FSIQ score for the sample is 97.45, the mean VIQ is 96.73, and the mean PIQ is 98.76. These differences are not significantly different from the standardization sample average of 100. The FSIQ, VIQ and PIQ standard deviations are 16.97, 15.97, and 15.72, respectively. Although these standard deviations are slightly greater than the standardization group's standard deviation, this difference is non-significant.

The four factor index scores--Processing Speed, Perceptual Organization, Verbal Comprehension and Freedom from Distractibility--are all slightly (non-significantly) lower than the standardization sample. The largest mean score is the PS factor score (Mean = 98.98, SD = 16.42). The other three factor scores are: Perceptual Organization (Mean = 98.65, SD = 15.62), Verbal Comprehension (Mean = 96.63, SD = 16.41), and Freedom from Distractibility (Mean = 95.96, SD = 16.54). The Perceptual Organization score demonstrates the largest variance, while the Verbal

Comprehension index score the smallest. Each factor score is within the standard deviation of 15 from the standardization sample.

The mean scores for each of the thirteen subtests range from a high of 10.25 for Mazes to a low of 8.92 for the Picture Completion subtest. They are all within a standard deviation of three and do not significantly differ from the mean of 10 for the standardization sample (Wechsler, 1991). The subtest standard deviations range from a high of 3.84 for Picture Arrangement to a low of 3.00 for Digit Span.

The two subtests, CD and SS, which make up the PS factor, are within the average scores of the standardization sample. Subtest means for the CD and SS subtests are 9.05 and 10.08, respectively; standard deviations are 3.56 and 3.54, respectively.

To summarize, results suggest that the sample is largely similar to the WISC-III standardization sample (Wechsler, 1991). This indicates that results may possibly generalize to a wider population. However, it should be noted that the present sample is drawn from a clinical population, thereby limiting the generalizability of results to a clinical population.

Statistical Analysis

Since group sizes differed, it was necessary to determine whether or not a One-Way ANOVA was appropriate for statistical analysis. Consequently, the Levene Test for Homogeneity of Variance was used. Overall, results showed no significant differences in variance on the PS index, or on the CD and SS subtest variables.

A One-Way ANOVA was therefore used to determine whether or not there were significant differences between the PS index group mean scores. This statistical method was also used to determine whether or not there were significant differences between the CD and SS subtests. This was done in order to determine each subtest's relative contribution to any significant differences found on the PS index score. The NK post hoc test of multiple comparisons was used to compare group means. In Appendix D, Tables 19 - 34 and in Appendix E, Tables 35 to 84, the results from the ANOVA and NK tests are shown.

The analysis also included the variables sex, bilingual status and present grade in school. Significant differences between male and female subjects were found on the PS index, as well as the SS and CD subtests. Male subjects obtained significantly lower scores on the PS index (Males: Mean = 93.39 versus Females: Mean 103.33; p =.0000), the CD subtest (Males: Mean = 8.41 versus Females: Mean = 10.04; p. = .0043), and the SS subtest (Males: Mean = 9.52 versus Females: 10.98; p = .0032). See Tables 19 - 21 in Appendix D.

Research Question Number 1:

The first research question asked whether "the mean scores obtained by the groups of students diagnosed with *a single problem* on the PS index, as well on the CD and SS subtests, differ significantly from mean scores obtained by the rest of the sample consisting of subjects *not experiencing this problem*?

To answer this question, a series of comparisons between group means on the PS index, CD and SS subtests, were done using a One-Way Analysis of Variance (ANOVA). In each comparison, the first group was made up of subjects diagnosed with one problem (e.g., behavior/emotional problems (B/E), visual motor integration problems (VMI), Attention Deficit Hyperactivity Disorder or Attention Deficit Disorder (AD/HD), physical health difficulties, learning disabilities (LD), prenatal/first year of life problems and no problems at all (none)). The second group was made up of subjects from the rest of the sample not experiencing the respective diagnosis. In four cases, there were significant differences between group means; in one case, results approached significance.

The first significant difference was found in the group of subjects diagnosed with VMI problems. Subjects achieved significantly lower scores on all three variables in comparison to the rest of the sample not experiencing visual motor integration difficulties. VMI subjects obtained mean scores of 89.82 on the PS index versus 102.63 for the rest of the sample ($p = .000$). On the CD and SS subtests, the VMI group obtained respective means of 7.43 ($p = .000$) and 8.64 ($p = .000$), in comparison to the rest of the sample obtaining scores of 10.08 and 11.04. See Tables 22 to 24 in Appendix D.

Second, subjects experiencing B/E problems achieved significantly lower mean scores on the three variables in comparison to the rest of the sample. This group obtained a mean score of 89.50 on the PS index in comparison with 100.75 for the rest of the sample (p = .000). On the CD and SS subtests, the B/E group obtained respective means of 7.43 (p = .0001) and 8.64 (p = .0002) in comparison with the rest of the sample obtaining scores of 9.67 and 10.66 respectively. See tables 25 to 27 in Appendix D.

Third, the group diagnosed with AD/HD achieved significantly lower mean scores on the PS, CD and SS factors in comparison with the rest of the sample. This group obtained a mean of 89.62 on the PS index, in comparison with 99.31 for the rest of the sample (p = .0017). On the CD and SS subtests, the AD/HD group obtained means of 7.86 and 8.52 in comparison to 9.24 (p = .0282) and 10.44 (p = .0015), respectively, for the rest of the sample. Results presented in Tables 25 to 27 in Appendix D.

Fourth, the group diagnosed without problems (none) scored significantly higher than the rest of the sample (i.e., those subjects with one or more diagnoses) on the PS factor, CD and SS subtests. This group obtained a mean score of 111.41 on the PS factor index versus 94.68 for the rest of the sample (p = .000). On the CD and SS subtests, this group obtained scores of 11.13 and 13.04 in comparison to the rest of the sample's scores of 8.56 (p = .0012) and 9.5 (p = .000), respectively. The ANOVA results are shown in Tables 31 to 33, Appendix D.

Finally, the prenatal/first year health problems group approached significance on the SS subtest, with mean scores of 9.07 in comparison to 10.26 for the rest of the sample (p = .0548) (Table 34, Appendix D).

In summary, results supported the first hypothesis: the mean scores obtained by subjects diagnosed VMI deficiencies were significantly lower than the mean scores obtained by the rest of the sample. The One-Way ANOVAs showed that the comparisons between group means produced significant differences on variables measuring speed of information processing (e.g., PS, CD and SS variables). The following significant differences were found:

1. Subjects diagnosed with VMI problems scored significantly lower than subjects without such deficiencies on the PS index factor, CD and SS subtests;
2. Subjects with B/E problems scored significantly lower than subjects without this diagnosis on the PS index factor, CD and SS subtests;
3. Subjects with AD/HD scored significantly lower than subjects without this diagnosis on the PS index, CD and SS subtests;
4. The group with no problems (none) scored significantly higher than the rest of the sample (i.e., those subjects with one or more diagnoses) on the PS factor, CD and SS subtests;
5. The prenatal/first year health problems group approached significance on the SS subtest, with a mean score of 9.10 in comparison to 10.26 for the rest of the sample ($p = .0548$);
6. Males scored significantly lower than females on the PS factor index, CD and SS subtests.

Overall, results suggest that subjects diagnosed with a single problem of VMI difficulties, B/E problems or AD/HD achieved significantly lower mean scores on the PS index, CD and SS subtests in comparison to the rest of the sample not experiencing the respective problem. The group without a diagnosis (none) scored significantly higher on all three variables than the rest of the sample.

Research Question 2:

The second research question asked whether "the mean scores on PS, CD and SS, obtained by groups of subjects diagnosed simultaneously with *problems in two areas* differ significantly from the scores on the above measures obtained by the groups of subjects, who: A) *do not experience problems in the two respective areas* in each comparison; and B) are diagnosed with a problem in *only one of the two respective areas.*

A One-Way ANOVA and the NK post hoc test of multiple comparisons was utilized to answer this second research question. These methods were chosen for the reasons previously discussed. Each of the three variables (PS index, CD and SS) were compared in the following groups:

A) subjects diagnosed with problems in two areas;

B) subjects not diagnosed with a problem in either of the two respective areas (neither);

C) subjects diagnosed only with a problem in the first of the two respective areas.

Results showed that significant differences were discovered in seven cases involving a dual diagnosis. Three double-diagnosis groups appear twice in the analysis: 1. B/E and VMI difficulties (B/E + VMI or VMI + B/E); 2. LD and VMI (LD + VMI or VMI + LD); and 3. AD/HD and VMI difficulties (AD/HD + VMI or VMI + AD/HD). This was done in order to account for the residual influence of the first problem area. For example, when the B/E and VMI group is compared to: 1. the group without a diagnosis in either area; and 2. to the group with a diagnosis only in the first area, the influence of B/E problems but not VMI difficulties is accounted for. Conversely, within the VMI and B/E analysis, the influence of the group diagnosed with VMI difficulties, but not B/E problems is accounted for.

<u>B/E and VMI problems.</u>

The first comparison producing significant results was made between the mean scores of the following groups:

1) subjects with B/E and VMI problems;

2) subjects with neither B/E or VMI problems (neither);

3) subjects with B/E problems but not VMI deficiencies.

Results from the One Way ANOVA yielded significant overall differences between the group means on the PS, CD and SS variables. The NK comparisons showed that the dual diagnosis group (B/E and VMI) scored significantly lower than the group without a diagnosis in either area on the PS ($p = .000$), CD ($p = .0002$) and SS ($p = .0001$) variables. As well, the group with a diagnosis of only B/E problems scored significantly lower than the group with neither diagnosis on all three variables. The mean scores for the three groups are as follows:

B/E + VMI: PS Mean = 86.03, CD mean = 7.03, SS mean = 8.00;

Neither: PS Mean = 105.67, CD mean =10.82, SS mean = 11.59;

B/E no VMI: PS Mean = 94.11, CD mean = 8.04, SS mean = 9.5.

ANOVA and NK results are presented in Tables 35 to 40 in Appendix E.

LD and VMI.

Next, the mean scores of the following groups were compared:

1) subjects with LD and VMI problems;

2) subjects with neither LD or VMI problems (neither);

3) subjects with an LD but not VMI deficiencies.

Results from the One-Way ANOVA yielded significant differences between the group means on the PS (p = .000) and CD (p = .000) variables. The pairwise NK comparisons indicated that the dual diagnosis group (LD and VMI) scored significantly lower on the PS variable than the group with no diagnosis in either area (neither) as well as the group with LD but not VMI (LD no VMI). On the CD subtest, the dual diagnosis group (LD and VMI) scored significantly lower than the other two groups (e.g., the group without a diagnosis in these two areas, and the group with only a diagnosis of LD but not VMI problems).

LD + VMI: PS Mean = 82.75 and CD mean = 6.67;

Neither: PS Mean =103.26 and CD mean = 10.05;

LD no VMI: PS mean = 98.76 and CD mean = 10.06.

Results of this comparison are presented in detail in Appendix E, Tables 41 to 44.

AD/HD and VMI.

The third comparison producing significant results was between the following groups:

1) subjects with AD/HD and VMI deficiencies;

2) subjects with neither AD/HD or VMI deficiencies (neither);

3) subjects with AD/HD but not VMI deficiencies.

Results from the One-Way ANOVA yielded significant differences between the group means on the PS (p = .000), CD (p = 00023) and SS (p = .0001) variables. The pairwise NK comparisons indicated that the dual diagnosis group (AD/HD and VMI) scored significantly lower than the group without a diagnosis and the group with a single diagnosis of AD/HD on the PS, CD and SS variables.

Results showed highly significantly differences on all three variables (i.e., PS, CD and SS) and mean scores for the three groups are as follows:

AD/HD + VMI: PS Mean = 81.36, CD mean = 6.45, SS mean = 7.09;

Neither: PS Mean = 103.67, CD mean = 10.27, SS mean = 10.45;

AD/HD no VMI: PS Mean = 98.70, CD mean = 9.40, SS mean = 10.10.

Refer to tables 45 to 50 for more detail, Appendix E.

AD/HD and LD.

The fourth comparison producing significant differences was made between the mean scores on the following groups:

1) subjects diagnosed with AD/HD and LD problems;

2) subjects with neither AD/HD or LD (neither);

3) subjects with AD/HD but not LD problems.

Results yielded significant overall differences between the group means on the variables PS ($p = .0047$) and SS ($p = .0023$). NK comparisons indicated that the single diagnosis group (AD/HD no LD) and the dual diagnosis group scored significantly lower than group without a diagnosis in either area on the PS index. On the SS variable, the group with a single diagnosis of AD/HD (AD/HD no LD) scored significantly lower than the group without a diagnosis in either area.

AD/HD + LD:	PS Mean = 85.20 and SS mean = 9.9;
Neither:	PS Mean = 99.31 and SS mean = 10.45;
AD/HD and no LD:	PS Mean = 91.00 and SS mean = 8.09.

See Tables 51 to 55 in Appendix E for more detailed results.

VMI and B/E problems.

The fifth comparison producing significant results was made between the following groups:

1) subjects with VMI and B/E problems;

2) subjects with neither VMI or B/E problems (neither);

3) subjects with VMI but not B/E.

Results yielded significant overall differences between the group means on the variables PS (p = .000) , CD (p = .000) and SS (p = .000). NK comparisons indicated that the dual diagnosis group scored significantly lower than the group without a diagnosis (neither) on the PS index, CD and SS variables. As well, the group with a single diagnosis (VMI) scored significantly lower than the group without a diagnosis (neither) on the PS, CD and SS variables.

The mean scores for the three groups are as follows:

VMI + B/E: PS Mean = 86.03, CD mean = 7.03, SS mean =8.00;

Neither: PS Mean = 105.67, CD mean =10.82, SS mean = 11.59;

VMI no B/E: PS mean = 93.27, CD mean = 7.86, SS mean = 9.25.

Refer to tables 55 to 60 in Appendix E for ANOVA and NK results.

<u>VMI and LD.</u>

Next, the mean scores of the following groups were compared:

1) subjects with VMI and LD problems;

2) subjects with neither VMI or LD (neither);

3) subjects with VMI but not LD.

Results from the One-Way ANOVA yielded significant differences between the group means on the PS (p = .000) and CD (p = .000) variables. The pairwise NK comparisons indicated that the dual diagnosis group (VMI and LD) scored significantly lower than the group without a diagnosis on the PS and CD variables. The group with a single diagnosis (VMI) scored significantly lower than the group without a diagnosis on the PS and CD variables. On the SS variable, the single diagnosis group (VMI) scored significantly lower than the group without a diagnosis in either area.

VMI + LD: PS Mean = 82.75, CD mean 6.67 and SS = 9.08;

Neither: PS Mean =103.26, CD mean = 10.05 and SS = 10.35;

VMI no LD: PS Mean = 91.20, CD mean - 7.59 and SS = 8.57.

Please see Appendix E, Tables 61 to 66.

VMI and AD/HD.

The next comparison producing significant differences was made between the mean scores on the following groups: VMI and AD/HD;

1) subjects diagnosed with VMI and AD/HD;

2) subjects with neither VMI or AD/HD (neither);

3) subjects diagnosed with VMI but not AD/HD.

Results yielded significant overall differences between the group means on the PS (p = .000), SS (p = .000) and CD (p = .000) variables. NK comparisons indicated that dual diagnosis group (VMI and AD/HD) scored significantly lower than the group without a diagnosis in either area, and the single diagnosis group (VMI no AD/HD) on the PS, CD and SS variables. As well, the group with a single diagnosis of VMI problems scored significantly lower than the group without a diagnosis in either area on the PS and SS variables.

Results showed highly significantly differences on all three variables and mean scores for the three groups are as follows:

VMI and AD/HD: PS Mean = 81.36, CD mean = 6.45, SS mean = 7.09;

Neither: PS Mean = 99.31, CD mean = 10.27, SS mean = 10.45;

VMI no AD/HD: PS mean = 95.26, CD mean = 7.8, SS mean = 9.28.

The ANOVA and Newman-Keuls multiple range tests are presented in Tables 67 to 72, Appendix E.

B/E and LD.

Next, the mean scores of the following groups were compared:

1) subjects with B/E and LD;

2) subjects with neither B/E problems or LD (neither);

3) subjects with B/E but not LD.

Results from the One-Way ANOVA yielded significant differences between the group means on the PS ($p = .0003$), CD ($p = .0022$) and SS ($p = .0002$) variables. The pairwise NK comparisons indicated that the dual diagnosis group (B/E and LD) and the single diagnosis group (B/E), scored significantly lower than the group without a diagnosis in either area on the PS and SS variables. On the CD variable the group with a single diagnosis of B/E scored significantly lower than the group without a diagnosis in either area.

B/E + LD: PS Mean = 87.36, CD mean 7.55 and SS = 7.46;

Neither: PS Mean =102.02, CD mean = 9.79 and SS = 10.89;

B/E no LD: PS Mean = 91.72, CD mean = 7.67 and SS = 8.74.

See tables 73 to 78 for more details.

LD and B/E

Next, the mean scores of the following groups were compared:

1) subjects with LD and B/E problems;

2) subjects with neither LD or B/E problems (neither);

3) subjects with LD but not B/E problems.

Results from the One-Way NOVA yielded significant differences between the group means on the PS (p = .0003), CD (p = .0022) and SS (p = .0002) variables. The pairwise NK comparisons indicated that on all three variables, the dual diagnosis group scored significantly lower than the group without a diagnosis in either area. On the CD variable, the dual diagnosis group scored significantly lower than the group with a diagnosis in one area (LD).

LD + B/E: PS Mean = 87.36, CD mean 7.54 and SS 7.45;

Neither: PS Mean =102.01, CD mean = 9.79 and SS 10.86;

LD no B/E: PS Mean = 98.38, CD mean - 9.47 and SS 10.67.

Refer to Tables 79 to 84 for more details on ANOVA and NK tests.

In summary, results supported the second hypothesis: the groups of subjects diagnosed with problems in two areas, particularly those diagnosed with VMI deficiences, achieved significantly lower mean scores on the measures of speed of information processing. Nine cases of comparison between mean scores on the PS, SS and CD variables demonstrated significant differences between groups:

1) The dual diagnosis group (B/E and VMI) scored significantly lower than subjects not diagnosed with problems in either area (neither) on the PS, CD and SS variables; as well, the group with one diagnosis (B/E) scored significantly lower than the group with no diagnoses in either area (neither) on all three variables;

2) the dual diagnosis group (LD and VMI) scored significantly lower on the PS variable than the group with no diagnosis in either area (neither) and the group with LD (LD no VMI); on the CD subtest, the dual diagnosis group scored significantly lower than the other two groups;

3) the dual diagnosis (AD/HD and VMI) group scored significantly lower than the group without a diagnosis (neither) and the group with a single diagnosis (AD/HD no VMI) on all three variables;

4) the single diagnosis group (AD/HD no LD) and the dual diagnosis group (AD/HD and LD) scored significantly lower than group without a diagnosis in either area (neither) on the PS variable; on the SS variable, the group with a single diagnosis of AD/HD (AD/HD no LD) scored significantly lower than the group without a diagnosis in either area;

5) the dual diagnosis group (VMI and B/E) scored significantly lower than the group without a diagnosis in either area on the PS, SS and CD variables; as well, the group with a single diagnosis (VMI no B/E) scored significantly lower than the group without a diagnosis on the PS, CD and SS variables;

6) the dual diagnosis group (VMI and LD) scored significantly lower than the group without a diagnosis on the PS and CD variables; as well, the group with a single diagnosis (VMI no LD) scored significantly lower than the group without a diagnosis on the PS and CD variables; on the SS variable, the single diagnosis group (VMI no LD) scored significantly lower than the group without a diagnosis in either area (neither);

7) the dual diagnosis group (VMI and AD/HD) scored significantly lower than the single diagnosis ggroup (VMI no AD/HD) and the group without a diagnosis on the PS, CD and SS variables; in addition, the group with a single diagnosis of VMI problems scored significantly lower than the group without a diagnosis in either area (neither) on the PS and SS variables;

8) the dual diagnosis group (B/E and LD) and the single diagnosis group (B/E no LD), scored significantly lower than the group without a diagnosis in either area on the PS and SS variables; on the CD variable, the group with a single diagnosis (B/E no LD) scored significantly lower than the group without a diagnosis in either area;

9) on all three variables, the dual diagnosis group (LD and B/E) scored significantly lower than the group without a diagnosis in either area; on the CD variable, the dual diagnosis group scored significantly lower than the group with a diagnosis in one area (LD).

Hypothesis 1:

The group of subjects diagnosed with VMI problems was expected to achieve significantly lower mean scores than the rest of the sample on the WISC-III PS index, as well as on the CD and SS subtests.

This hypothesis was supported by statistical analysis for the first question. Subjects with VMI difficulties scored significantly lower than the group without VMI difficulties on the three measures of information processing (PS, SS and CD). Subjects diagnosed with VMI problems achieved significantly lower scores on all three variables than the rest of the sample not experiencing any such difficulties. This group obtained a mean score of 89.81 on the PS index versus 102.62 for the rest of the sample ($p = .000$). On the CD and SS subtests, the VMI group obtained respective means of 7.43 and 8.64, in comparison to the rest of the sample which obtained scores of 10.08 and 11.00 respectively.

These results support the contention that VMI deficiencies may result in slower information processing speed, as measured by the WISC-III PS factor, made up of the CD and SS subtests. As well, a diagnosis of B/E difficulties or AD/HD may also result in slower speed of information processing. In the present study, subjects without a diagnosis (none) in any area scored significantly higher than subjects with single or multiple diagnoses.

Hypothesis 2:

The groups of subjects diagnosed with problems in two areas, especially those diagnosed with VMI difficulties, were expected to achieve significantly lower mean scores on measures of speed of information processing (i.e., PS index, CD and SS subtests), when compared to the rest of the sample not diagnosed with any problems in the two respective areas.

This hypothesis was supported by the results from comparisons between group means described under Research Question 2. The groups of subjects diagnosed with problems in two of the following areas: B/E, LD, AD/HD and VMI produced significant differences on the PS, CD and SS variables.

In three cases, subjects whose first diagnosis was VMI problems and whose second diagnosis involved either B/E, LD or AD/HD showed significantly lower mean scores than subjects without a diagnosis in either of the two variables (neither), when the influence of a single diagnosis with VMI problems was accounted for. First, the dual diagnosis group (VMI and B/E) and the single diagnosis group (B/E) scored significantly lower than the without a diagnosis in either area (neither) on the PS index, SS and CD variables; second, the dual diagnosis group (VMI and LD) and the single diagnosis group (VMI) scored significantly lower than the group without a diagnosis in either area (neither) and the group with a single diagnosis (VMI) on the PS and CD variables; and finally, the dual diagnosis group (VMI and AD/HD) scored significantly lower than the single diagnosis group (VMI) and the group without a diagnosis on the PS, CD and SS variables. As well, subjects with a diagnosis of VMI scored significantly lower than the group without a diagnosis on the PS and SS variables.

Thus, there is support for the contention that multiple diagnoses results in reduced speed of information processing as there were overall significantly lower mean scores were found on the PS, CD and SS variables for the dual diagnoses group (e.g., B/E and VMI; AD/HD and LD, etc.).

In summary, findings suggest that cases involving a diagnosis of VMI deficiencies support the second hypothesis with respect to the PS variable, and to a certain extent, the SS and CD variables. They also support the first hypothesis: VMI deficiencies may result in reduced speed of information processing. As well, the second hypothesis was also supported: multiple diagnoses may also be related to reduced speed of information processing. To a certain extent, results support Anderson's (1992) argument that speed of information processing plays an important part in the overall cognitive functioning of the mind.

Summary

Overall findings suggest that the present sample is similar to the WISC-III standardization sample (Wechsler, 1991). Results showed that male subjects demonstrated significantly lower scores than female subjects on the PS, SS and CD variables. Subjects diagnosed with VMI deficiencies showed significantly lower group mean scores on the PS, SS and CD variables. As well, groups diagnosed with B/E or AD/HD also demonstrated lower group mean scores on all three measures of speed of information processing. Subjects not diagnosed without any problems (none) scored significantly higher than the rest of the sample on all three variables. As well, subjects diagnosed with health problems during the prenatal period or first year of life, approached significance on the SS subtest.

These results support the first hypothesis: the group of subjects diagnosed with VMI difficulties achieved significantly lower mean scores than the rest of the sample on measures of speed of information processing. It also suggests that subjects with B/E problems or AD/HD are likely to score lower on the speed of information processing variables. As well, subjects with "no problems" (or no diagnosis) are likely to score higher on measures of speed of information processing than subjects with a diagnosis in one of the aforementioned areas.

The second hypothesis suggested that groups of subjects diagnosed with problems in two areas, especially if they are diagnosed with VMI difficulties, are expected to achieve significantly lower mean scores on measures of speed of information processing (i.e., PS index, CD and SS subtests), when compared to the rest of the sample not diagnosed with any problems in the respective two areas. Findings from comparisons between dual diagnosis group means described under the second research question supported this hypothesis.

CHAPTER FIVE

Discussion

The purpose of this research was to determine whether the WISC-III PS Index, which is comprised of the CD and SS subtests, could distinguish between groups of subjects diagnosed with various problems including: VMI difficulties, B/E problems, attention deficit/hyperactivity disorder (ADD or ADHD), LD, physical health problems and prenatal/first year of life health difficulties. Additional groups included: bilingual subjects and subjects not diagnosed with any problems (none). This research replicated and extended Tiholov's (1995) work. The purpose of this research was to explore the diagnostic value of the PS factor of the WISC III. The broad question that was attempted to be answered was: Can we reliably distinguish between different population groups based on their WISC-III PS index scores? Present findings suggest that VMI deficiencies result in lower speed of information processing. As well, a diagnosis of B/E or AD/HD is related to reduced speed of processing. Findings indicate that subjects with a dual diagnosis, particularly if they are diagnosed with VMI problems, are likely to obtain lower scores on measures of speed of information processing when compared to subjects not diagnosed with any problems in the two respective areas. Present findings tend to support Anderson's (1992) theory that speed of information processing plays an important role in cognitive functioning. However, results also suggest that the answer to the aforementioned question is not simple and certainly far more research is required before this question may be comprehensively answered.

The purpose of this chapter is to: a) compare current results to past research related to the WISC-III PS factor: b) discuss possible reasons for present results; c) discuss remediation and practical implications for psycho-educational assessment; and d) discuss recommendations for future research.

Comparison to Past Research

Presently, the PS factor has not been the subject of much research in the psychological or educational literature. As a result, it will be necessary to refer to studies examining the past edition of the WISC-III, the WISC-R, as well as to current WISC-III research. This study was based on Tiholov's (1995) work, which aimed to explore the diagnostic power of the WISC-III PS index. Similar to Tiholov's (1995) findings, the present study found that the mean scores on the three measures of speed of information processing obtained by children diagnosed with VMI difficulties were significantly lower than the rest of the sample. This finding suggests that VMI deficiencies may result in reduced speed of information processing.

As well, similar to Tiholov's (1995) results, the present study found that male subjects scored significantly lower than female subjects on the PS index, as well as SS and CD subtests. This may suggest that male children have greater difficulties with measures of speed of information processing speed than female children. However, it is also possible that this result may be related to the greater number of male subjects in the study (e.g., more statistical power) or a developmental phenomenon. Subjects without any problems (none), scored significantly higher than the rest of the sample on all three variables. It should be noted that these subjects were typically being evaluated for 'gifted' status. However, this finding may be viewed as lending support to the relationship between speed of cognitive processing and intelligence.

VMI problems.

The most important finding in this study concurs with Tiholov's main result: subjects diagnosed with VMI problems demonstrate lower speed of information processing (as measured by the PS index) than subjects not diagnosed with such difficulties. This result was significant and was found several times in the present study: first, when comparing the mean PS scores of subjects diagnosed with VMI problems to the rest of the sample, and later in similar comparisons between groups representing different dual diagnosis involving VMI problems. VMI groups with dual diagnoses scored significantly lower on the PS index than groups without any diagnosis in the two areas. These cases included subjects diagnosed with visual motor integration problems and: 1) behavioral or emotional problems; 2) AD/HD; and 3) an unspecified LD (e.g., reading and/or mathematics).

It is conceivable that the present results are associated with possible deficiencies experienced by subjects in these groups. Sattler (1992) suggests that VMI tests measure at least three areas: fine motor development, perceptual discrimination and the ability to integrate perceptual and motor processes (p. 361). He also suggests that reduced performance on tests of visual motor integration may be related to difficulties with input (i.e., inaccurate perception or design interpretation), output (i.e., fine motor response problems) and/or integration or central processing (i.e., poor short-term memory storage or retrieval). The Bender and the Beery, both tests of visual motor integration used by clinicians in this study, also require that attention be shifted between the original design and copy of the original. Not only are such abilities required for Beery and Bender performance, but they are also needed for good performance on the WISC-III CD and SS subtests. This may suggest that any difficulties in one of these areas (e.g., fine motor development, perceptual discrimination, ability to integrate perceptual and motor processes, and attention) may result in reduced visual motor integration performance (e.g., on the Beery or Bender), as well as diminished CD and SS test performance.

VMI difficulties and Anderson's model

Anderson's model of minimal architecture of mind allows for the hypothesis that subjects with VMI deficiencies may experience difficulties with Routes 1 and/or 2 in knowledge acquisition. To remind the reader, Anderson suggests that here are two routes to knowledge acquisition: Route 1 and Route 2. Route 1 knowledge acquisition is defined as "knowledge that is acquired by the implementation of an algorithm generated by a specific processor" (Anderson, 1992, p. 207). With respect to our findings, it is possible that input may be impaired through Route 1 when the visual input (i.e., the figure to be copied) goes through a nonverbal specific processor (SP 2), and is procured by applying an algorithm produced by a processor. The visual input would then move to the Basic Processing Mechanism (BPM). The speed of the BPM restricts not only the amount of information going through, but the elaboration of knowledge, thereby resulting in individual differences in intelligence.

Since subjects with VMI deficiencies have been shown in this study to have significantly lower speed of information processing than non-VMI diagnosed subjects, the model suggests that this may be caused by lower BPM speed. Lower BPM speed may result in less visual information being transferred to the knowledge store (memory) and more sensory input being lost (see Eyseneck, 1987 and Jenson, 1987 for details on this process). Consequently, this may result in reduced performance on tests of visual motor integration at the onset of the perceptual process. It may perhaps explain the nature of perceptual problems, as well as the integrative and central processing difficulties as suggested by Sattler (1992).

Alternatively, according to Anderson's model, it may be not only the speed of the BPM which reduces knowledge acquisition, but knowledge elaboration may also result in individual differences in intelligence. Knowledge elaboration is contingent upon the mechanisms that are bound by the basic processing mechanism (route one), and consequently this elaboration is intimately related to individual differences in intelligence. More powerful Route 1 mechanisms result in more elaborate knowledge structures. According to this model, it may be hypothesized that not establishing elaborate knowledge structures, in conjunction with lower speed of information processing, may also be related to the central processing difficulties leading to poor performance on tests of visual motor integration.

Second, it is also possible that VMI difficulties may related to the Route 2 of knowledge acquisition, rather than to speed of information processing. Anderson suggests that there is a second type of processing mechanism in the minimal cognitive architecture -- modules. The computations of the modules are not constrained by the speed of the basic processing mechanism. It is possible, for example, that a module such as "Perception of 3 Dimensional space" is related to performance on VMI tasks. That is, maturational delay may be referred to as developmental delay, which may result in poor VMI test performance. However, as there is very little detail regarding the operation of this module, "perception of 3 dimensional space", and given that the list of modules is incomplete, this course of argument is difficult to pursue.

To summarize, Anderson's (1992) theory of minimal cognitive architecture of mind appears to provide some explanation for present results with respect to lower speed of information processing for subjects with visual motor integration problems. If this is applied to the information processing model, is possible that slow information processing speed limits the amount of information arriving by way of sensory input (Sattler, 1992). As well, slower speed would tend to limit the amount of information available for sensory storage and perceptual encoding (Sattler, 1992). Alternatively, it is possible that less elaborate knowledge structures limit central processing functions and response selection mechanisms. However, deficiencies may also be related to Route 2 mechanisms (e.g., modules). The relationship between speed and motor output on VMI tests appears to be remote, and no clear hypothesis can presently be formulated in this respect.

Other Findings

Behavior/emotional problems (B/E). In the present study, the single diagnosis group with B/E difficulties scored significantly lower than subjects without such a diagnosis on all three variables (PS factor, as well as CD and SS subtests).

Overall, results indicate that the dual diagnosis groups including behavioral or emotional problems with a diagnosis of LD or VMI scored lower on measures of speed of information processing. First, the dual diagnosis group (B/E and LD) and the group diagnosed only with B/E problems (not LD) scored significantly lower than the group without a diagnosis in either area (neither) on the PS and SS variables. On the CD variable, the group with a single diagnosis of B/E difficulties scored significantly lower than the group without a diagnosis in either area. Second, the dual diagnosis group (LD and B/E) scored significantly lower than the group without a diagnosis on all three variables. Present findings suggest that B/E problems may result in lower speed of information processing. It should be noted that results differed from Tiholov's (1995) research as he did not find this effect. However, it may be also hypothesized that there may be higher incidences of depression in the present study, thereby resulting in reduced psychomotor speed (Sattler, 1992). Reduced scores may also reflect multiple diagnoses, given the fact that this group often experienced multiple problems. As well, given that the categories and numbers of emotional difficulties (e.g., anxiety, depression) and behavioral problems were not presented in Tiholov (1995), it is difficult to determine the reason for the discrepancy between results.

The present study found that the dual diagnosis groups (B/E and VMI; VMI and B/E), scored significantly lower than the group without a diagnosis on all three variables. As well, Tiholov (1995) found that the dual diagnosis group (B/E and VMI; VMI and B/E), scored significantly lower on the PS and CD variables (but not on the SS subtest), than subjects without a diagnosis (neither problem), as well as subjects experiencing B/E but not VMI problems. Overall, results may suggest that dual diagnosis of B/E and VMI problems is related to reduced speed of information processing.

Learning disabilities. The present study found that the dual diagnosis group (VMI and LD) and the single diagnosis group (VMI) scored significantly lower on the PS and CD variables than the group without a diagnosis in either area. The dual diagnosis group (LD and VMI) scored significantly lower on the PS variable than the single diagnosis group (LD) group. Again, results support the assertion that a dual diagnosis, particularly involving VMI problems, reduced speed of information processing. This is based on the anticipation that greater overall cognitive impairment will result in a decrease of speed of information processing, which is believed to affect all aspects of intellectual functioning.

Although Tiholov's (1995) found that the unspecified LD group (no VMI difficulties), scored significantly *higher* than subjects not having either a diagnosis of LD or VMI problems, suggesting that a diagnosis of learning disability may result in higher CD scores, other research has suggested that children with learning disabilities show lower than average processing speed scores (Wechsler, 1991). Ackerman, Weir, Holloway & Dykman (1995) report that processing speed is a core weakness in children with learning disabilities in reading and math. Schoepp (1994) reports that a suppressed PS index mean score is characteristic of learning disabled groups. As well, he found that the spelling disabilities group achieved their lowest mean subtest scores on the CD subtest, and the math disabilities group achieved their lowest means score on the SS subtest. Everall (1994) demonstrated that the math disabilities group achieved their lowest factor score on the PS index and lowest subtest score on the CD subtest. In a WISC-R study examining learning disabled subjects, Kavale and Nye (1985 to 1996) found that children diagnosed with a learning disability showed slower psychomotor speed than subjects without such a diagnosis. However, given the differences between the WISC-R and WISC-III, results should be interpreted with some caution, as the PS factor is not in the WISC-R edition. At present, the discrepancy between the present research and Tiholov's findings is unclear. However, it may possibly be attributed to different ratios of subjects experiencing visual-spatial deficits as opposed to auditory linguistic problems (e.g., visual-spatial deficits may result in lower PS scores).

AD/HD.

The present study found that the group diagnosed with AD/HD achieved lower mean scores on the PS index, CD and SS subtests in comparison with the rest of the sample. The dual diagnosis group (AD/HD and VMI) scored significantly lower than the group without a diagnosis in either area, and the group with a single diagnosis of AD/HD on all three variables. The dual diagnosis group (VMI and AD/HD) scored significantly lower than the group without a diagnosis and the single diagnosis group (VMI) on all three variables. Overall, Tiholov's (1995) findings are largely similar to these results: the dual diagnosis group (AD/HD and VMI) scored significantly lower on the PS and SS variables than subjects diagnosed only with AD/HD or no diagnosis in either of area. As well, he found that the dual diagnosis group (VMI and AD/HD) and subjects diagnosed with VMI scored significantly lower than subjects without either of the two diagnoses on all three variables.

Current results are somewhat supported by Saklofske's (1994) finding that two of the five lowest subtest scores in 45 children diagnosed with AD/HD were the CD and SS subtests. As well, Wechsler (1991), found that children with AD/HD exhibit a lower than normal processing speed score. Sattler (1992) observed that hyperactive children may make serious errors on tests of visual-motor integration, perceptual-motor functioning and measures of sustained attention. The major difficulties of hyperactive children lie "in their inability to focus, sustain, and organize attention" (Sattler, 1992). Due to the overlap between features measured by the tests of visual motor integration (e.g., Bender and Beery), and the WISC-III SS and CD subtests, this may suggest that children with AD/HD may score lower on the WISC-III PS factor. As well, given that the present study contained larger numbers of children with Attention Deficit Hyperactivity Disorder (ADHD) than Attention Deficit Disorder, it may be more likely that this group will tend to have difficulties in the outlined areas.

Physical Health Problems.

Tiholov (1995) found that subjects diagnosed with physical health difficulties obtained significantly lower mean scores on the three measures of speed of information processing in comparison to the rest of the sample. Although the present study did not replicate this finding, the group diagnosed with prenatal or first year physical health problems approached significance on the SS subtest, with a mean score of 9.07 in comparison to 10.26 for the rest of the sample ($p = .0548$). This provides some support for the contention that early developmental difficulties may result in lower speed of information processing. Differing results between these two studies may possibly be attributed to the range of differing health problems in the two studies (e.g., chronic versus acute health problems). Moreover, in both studies information about whether the subject was experiencing an active stage in their physical disorder or presently in remission was not available. Thus, in order to determine the relationship between physical health and speed of information processing, it may be appropriate to more fully examine speed of information processing speed scores between differing types of health conditions (e.g., chronic versus acute; active stage or in remission).

Coding and Symbol Search Results

AD/HD and LD.

The dual diagnosis (AD/HD and LD) group and the single diagnosis group (AD/HD) scored significantly lower than the group without a diagnosis in either area on the PS index and SS subtest, but not the CD subtest. Although performance on the CD and SS subtests is believed to require similar abilities (e.g., speed, accuracy, attention, concentration and short-term memory (Sattler, 1992)), it may also be influenced by motor activity (e.g., handwriting speed) and visual motor coordination (albeit to a minor role in the SS subtest, as the only motor role is drawing a slash). The key difference between the two subtests appears to be a greater requirement for visuo-perceptual discrimination on the SS subtest (Sattler, 1992). Consequently, it is possible that the AD/HD subjects in the present study may experience problems with visuo-perceptual discrimination.

LD and VMI

The dual diagnosis (LD and VMI) group scored significantly lower than the group without a diagnosis in either area annd the group with a single diagnosis of LD on the PS variable. On the CD subtest, the dual diagnosis group scored significantly lower than the single diagnosis (LD) group and the group without a diagnosis in either area. The dual diagnosis group (VMI and LD) scored significantly lower than the group without a diagnosis on the PS and CD variables. The group with a single diagnosis of VMI (no LD) scored significantly lower than the group without a diagnosis in either area on the PS and CD variables. This suggests that the differing factor between the group means on the PS index is due to CD subtest performance. It is possible that subjects diagnosed with both LD and VMI difficulties may have slower motor output or difficulty memorizing the key with the symbols which usually leads to higher CD subtests scores. Although the approach of memorization is not expressly stated during testing, subjects may choose to do this naturally. Since the CD test is believed to measure the ability to learn a new code, similar to learning to read, it may be hypothesized that children with learning disabilities, particularly in the area of reading, are likely to perform less well on such a task. In an inspection of thirty studies, Sattler (1982) found that the Arithmetic, Coding, Information and Digit Span subtests were the most difficult for reading disabled children (forming the acronym ACID). He suggests that low scores on the CD subtest may reflect that failure to "use an effective labeling strategy as a memory aid, which increases the time needed to complete the task" (Sattler, 1992). Subjects with learning disabilities are hypothesized to have problems with tasks requiring active information processing, difficulty focusing attention, possible inadequate executive control functions (e.g., strategies used to problems solve), and difficulty analyzing tasks in ways that will result in best performance strategy (Sattler, 1992). Given that performance on the CD task requires speed, accuracy, attention, concentration and short-term memory, it may be hypothesized that learning disabled students are likely to have difficulty with this task.

Practical Implications

It is important to note that results must be interpreted with care and caution, as this research is in its initial stages. Presently, little research has presently been done on the WISC-III, particularly with respect to the new PS factor. Until this new fourth factor is researched more carefully and thoroughly (e.g., CD and SS subtests), using factor and subtest scores and the relationship to speed of information processing as a basis for diagnostic hypotheses should be made in a very cautious manner.

Considering that subjects with behavioral/emotional problems, AD/HD, and VMI problems scored significantly lower than subjects without each of these diagnoses on all three variables, this suggests that there is reduced diagnostic specificity. Rather than attempting to relate each of these diagnoses to as broad an area as speed of information processing, it may somewhat more helpful to examine specific problems experienced by such individuals in order to contribute to a definitive diagnosis and pertinent remediation planning.

Relevance for Making Diagnoses for Children with VMI Problems

By definition, children with poor visual motor integration tend to have difficulty with tasks requiring fine motor eye-hand coordination. On a functional level, this may affect many areas of a child's daily life -- both in school and at play. For example, in a classroom, visual motor integration deficiencies may result in poor handwriting and drawing skills. Such children may perform slowly in the classroom on written assignments and speeded tasks or tests. This may affect not only how the child sees himself or herself, thereby impacting the child's self-esteem (e.g., the child may become frustrated), but also the manner in which the teacher perceives the child's abilities. Either way, academic performance may be affected. In daily life, children with VMI deficiencies tend to have difficulty with activities requiring fine motor coordination. For example, they may experience difficulty manipulating buttons, fasteners or bottle caps. They may have difficulty getting keys into locks and using small tools such as scissors for cutting shapes.

Diagnosis and VMI deficiencies.

If VMI difficulties are indeed related to the child's speed of information processing, then the WISC-III PS factor may provide confirmatory evidence for difficulties related to visual motor integration. For example, if a student scores poorly on the Bender or Beery, then one should compare results with WISC-III CD and SS subtests. Both tests require some visual motor coordination, although Sattler (1992) states that visual motor coordination plays a minor role in the SS subtest as the only motor movement is that of drawing a slash. The CD subtest involves speed and accuracy of visual-motor coordination and handwriting speed. Again, one may wish to provide confirmatory evidence for visual motor integration difficulties by examining the CD subtest results. The present study suggests that there may be some relation between speed of information processing and visual motor integration.

Coding and Symbol Search diagnostic features.

For diagnostic purposes, present results suggest that if the diagnostician discovers VMI deficiencies (e.g., through the Beery or Bender), this may be compared for additional confirmation with the child's WISC-III PS factor score. In order to determine more precisely the way in which VMI deficiencies affect the child, upon completing regular testing, one may 'test the limits'. Specifically, by changing the 'regular' course of testing, one can inquire as to what approaches the child uses while doing the CD or SS subtest. The two subtests may also provide information about attention. For example, if other tests indicate that the child has adequate response speed and visual acuity, then poor scores on CD may be associated with attentional deficiencies rather than with visuo-perceptual difficulties. For example, does the child try to memorize the items on the CD subtest? Alternatively, the subtest may be administered without time limits, which may yield information as to whether the difficulties are related to processing speed or to difficulties with memorizing the code.

Alternative strategies that may be used to 'test the limits' include telling the child to slow down and check the accuracy of his or her work. Moreover, if the child is rushing through the test, it may be important to determine whether impulsivity or emotional distress, such as anxiety, has affected test scores. Conversely, if a child conveys a slow and deliberate approach while doing the subtest, depressive features or a reflective tendency may be indicated (Sattler, 1992).

If a child makes many mistakes on a subtest, the examiner may wish to go over incorrectly marked items, and question the child's response (e.g., "Tell me about your answer"). One may also compare response style on this test with other tests, to determine if there are any differences. If there are differences, the diagnostician may wish to determine factors that may account for them. For example, one may wish to consider the nature of the tasks (timed or untimed) and when the tasks were administered (e.g., at the end of a long testing day). It is also possible that a bright child may be bored and not challenged with the SS task (Sattler, 1992). Answering such questions may provide data for planning possible remediation strategies for the child.

In terms of neurological difficulties, if the child shows perseveration on the Bender or the Beery, the examiner may wish to reconfirm this with examining WISC-III results. For example, on the CD task does the child draw the same symbol over and over again even though the numbers change? Alternatively, if the child's symbol marks show distortions, do they appear only once, occasionally or each time the child draws the symbol? How many symbols are distorted? In summary, examining the child's responses on the CD and SS subtests is likely to provide the diagnostician with clues as to areas of difficulty for the child.

Remediation Techniques

General methods for remediation include specific analysis of areas of difficulty (e.g., does the child have difficulty shifting attention between the key and answer sheet?). It should be noted that in order to assess teaching or remediation effectiveness, it is generally important to obtain baseline levels of performance before intervention. One may wish to use explicit step-by-step instructions to ensure that the child understands what is expected. Once the examiner has determined more specifically the area of difficulty for the child, it may be relevant to teach him or her how to break large tasks (e.g., how to draw the picture), and demonstrate how to complete the task. For example, one may wish to teach the child how to break down visual information such as a drawing, into smaller chunks or more meaningful chunks of information. As well, it would likely be helpful to provide the child with explicit feedback on performance as how to approach the task.

Methods of improving visual motor integration skills may include having the child work on tasks using these skills. For example, children can play 'connect the dots', be shown how to use scissors, use finger painting and paper-folding activities, and create pegboard designs (Sattler, 1992). As well, using tracing exercises (e.g., with geometric forms and letters), having children copy patterns of forms or pictures and/or drawing from memory, and making large circles and lines on the chalkboard may be useful in promoting eye hand coordination skills (Sattler, 1992).

Recommendations for Future Research

VMI.

Future research may include specifically examining the correlation between VMI deficiencies and speed of information processing. In this study, the cut-off point for determining the presence of VMI problems was an age delay of one year. However, many subjects experienced delays of four or more years. One may wish to determine whether subjects with relatively greater VMI deficiencies (e.g., four year delay) had significantly lower speed of information processing scores than subjects with less severe delays (e.g., one year).

One may also compare results on 'pencil and paper' tasks of motor coordination (e.g., Beery/Bender) with more 'hands-on' tasks of motor coordination. Are present findings concurrent with more active tasks of fine motor coordination (e.g., Purdue Pegboard; Valpar Wiring Test)? Do the paper and pencil tasks of speed of information processing correspond to more 'active' measures of visual motor integration? If so, do they correspond with present findings as with respect to reduced speed of information processing in subjects with VMI problems?

Physical Health.

Although Tiholov (1995) found that that information processing speed appears to be influenced in a negative direction to the greatest extent among subjects with physical health problems in comparison to all other groups, the present study did not support this finding. This may be attributed to the fact that the exact nature of health problems likely differed between the two studies. Given the relatively small numbers in this group, it was not possible to further break down the group into various subcategories. However, in the present study, the prenatal/first year health problems group approached significance on the SS subtest, with a mean score of 9.07 in comparison to 10.26 for the rest of the sample ($p = .0548$). This finding may be interpreted as lending some support to the hypothesis that the information processing speed of subjects experiencing health problems during their early development *may* be somewhat lower than subjects not experiencing such difficulties.

Considering the discrepancy in results between the two studies (e.g., Tiholov, 1995), the need for further study of subjects diagnosed with various physical health problems is warranted. Future research may include breaking up the health problems group into various subgroups of various medical conditions. For example, subjects may be divided into chronic versus acute groups. Alternatively, one may wish to compare groups according to stage of disease (e.g., in remission or active stage).

Behavior/emotional.

In the present study (as well as in Tiholov, 1995), subjects with behavioral and/or emotional problems were incorporated into in one group. Consequently, given the wide range of problems falling into this category, this group is highly diverse. This diversity may account for the discrepant results between Tiholov (1995) and the present study. For example, it is possible that the present study included greater numbers of depressed subjects which may thereby reduce psychomotor speed (Sattler, 1992). This in turn, may reduce scores on measures of information processing. Alternatively, one may wish to specifically examine disorders within the emotional realm (e.g., depression versus anxiety) versus the behavioral realm. Given the rather small number of subjects in this category, breaking down the present sample into various groups based on the type of emotional or behavioral difficulty (e.g., depression, anxiety) was not possible. In the future, it is advised that this group be divided into more restrictive groups (e.g., behavioral disorders or emotional problems). Performing comparisons on the information processing speed variables between scores obtained by groups with more specific diagnoses (or groups of diagnoses) may shed more light on nature of such relationships. However, this strategy would also reduce the generalizability of results.

AD/HD.

The present study found that the group diagnosed with AD/HD obtained lower group mean scores than the rest of the sample on all three speed of information processing variables. Although Tiholov (1995) did not find this effect, results may suggest that a diagnosis of AD/HD is related to lower speed of information processing. Given this discrepancy, it may be useful to further examine this relationship. Results may also be related to multiple diagnosis within the AD/HD group (e.g., VMI problems, B/E difficulties). Sattler (1992) observed that hyperactive children may make serious errors on tests of visual-motor integration, tests of perceptual-motor functioning and measures of sustained attention. However, given the relatively small numbers of subjects diagnosed with either ADD or ADHD, group mean scores between these two subgroups could not be compared in this study. It is also possible that the present study contained more hyperactive children (AD/HD) than those diagnosed with ADD. Future research may wish to flesh out the possible group mean score differences between these two subgroups in order to specifically examine the relationship between speed of information processing and a diagnosis of ADHD or ADD.

Summary

This replication study of Tiholov (1995) attempted to explore the diagnostic value of the PS factor of the WISC III. The broad question attempted to be answered was: Can we reliably distinguish between different population groups based on their WISC-III PS index scores? Specifically, do children with various identified problems show significantly different mean scores on the WISC-III PS index when compared to children without difficulties in these domains?

Research results replicated Tiholov's (1995) findings: 1. subjects diagnosed with VMI problems scored significantly lower than subjects without such deficiencies on the PS index factor, CD and SS subtests; and 2. males scored significantly lower than females on the PS factor index and CD subtest (in the present study males also scored lower than females on the SS subtest). Anderson's (1992) theory of minimal cognitive architecture of mind appears to provide some explanation for present results with respect to lower speed of information processing for subjects with visual motor integration problems. The difference between male and female subjects may be related to the greater number of male subjects in the study (e.g., more statistical power) or a possible developmental phenomenon.

However, in contrast to Tiholov's results, present findings indicate that subjects diagnosed with B/E or AD/HD scored significantly lower than the rest of the sample on all three variables of speed of information processing. This suggests that a diagnosis of B/E problems or AD/HD may result in lower speed of information processing. Given that categories and numbers of emotional difficulties (e.g., anxiety, depression) and/or behavioral problems were not given, it is difficult to determine an exact reason for present findings. With respect to the findings for the AD/HD group, Saklofske (1994) discovered that two of most difficult tests for children diagnosed with AD/HD were the CD and SS subtests. Sattler (1992) observed that hyperactive children may make serious errors on tests of visual-motor integration, perceptual-motor functioning and measures of sustained attention. The major difficulties of hyperactive children lie in their difficulties focusing, sustaining and organizing attention (Sattler, 1992). Due to the overlap between features measured by the tests of visual motor integration and the SS and CD subtests, children with AD/HD may score lower on such tests.

As well, results did not replicate Tiholov's (1995) findings with respect to the physical health problems group achieving significantly lower scores than the rest of the sample on all three variables. However, in this study, the group diagnosed with prenatal or first year physical health problems approached significance on the SS subtest. This finding may be interpreted as lending some support to the hypothesis of information processing speed of subjects experiencing health problems during their early development *may* be somewhat lower than subjects not experiencing such difficulties. However, in order to determine the relationship between physical health and speed of information processing, it may be appropriate to more fully examine speed of information processing speed scores (e.g., PS WISC-III) between differing types of health conditions (e.g., chronic versus acute; active stage or in remission).

As well, in the present study, subjects with no diagnosis (none) scored significantly higher on all three variables than the rest of the sample. It should be noted that these subjects were typically being evaluated for 'gifted' status. This finding may be viewed as lending support to the contention that there may be a relationship between speed of cognitive processing and intelligence.

With respect to the second research question, similar to Tiholov's (1995) findings, present results indicated that subjects with dual diagnoses, particularly when there are VMI deficiencies, are likely to have lower speed of information processing scores. VMI groups with dual diagnoses scored significantly lower on the PS index than groups without any diagnosis in the two areas. These cases included subjects diagnosed with VMI deficiencies and: 1) B/E; 2) AD/HD; and 3) LD. As well, dual diagnosis groups (AD/HD and L/D, B/E and LD) scored significantly lower on the measures of speed of information processing than groups without any diagnoses in the two areas. Thus, support for the contention that multiple diagnoses may result in reduced speed of information processing was found as overall significantly lower mean scores were found on the PS, CD and SS variables for the dual diagnoses groups. To a certain extent, results may support Anderson's (1992) argument that speed of information processing plays an important part in the overall cognitive functioning of the mind.

With respect to specific subtests, the dual diagnosis group (AD/HD and LD) scored significantly lower than the group without a diagnosis on the PS index and SS subtest, but not the CD subtest. This may suggest that subjects diagnosed with AD/HD (and not a diagnosis of LD) may experience problems with visuo-perceptual discrimination or cognitive flexibility when compared to subjects without dual diagnoses.

As well, the dual diagnosis (LD and VMI) group scored significantly lower than the group without a diagnosis in either area, and the group with a single diagnosis (VMI problems) on the PS and CD variables. These findings are contrary to Tiholov's (1994) finding that a diagnosis of learning disability may result in higher CD scores. However, other research supports the contention that a diagnosis of a learning disability results in reduced speed of information processing (e.g., Schoepp, 1994; Everall, 1994; Kavale and Nye (1985 to 1996). It is possible that subjects diagnosed with both learning disabilities and VMI difficulties have slower motor output and have difficulty memorizing the key with the symbols which usually leads to higher CD subtests scores. Since the test is believed to measure the ability to learn a new code, similar to learning to read, it may be hypothesized that children with learning disabilities, particularly in the area of reading, are likely to perform less well on such a task. Given that performance on the CD task requires speed, accuracy, attention, concentration and short-term memory, it may be hypothesized that learning disabled students are likely to have difficulty with this task.

The chapter concluded by discussing remediation techniques and practical implications for psycho-educational assessment, as well as future research. It is important to note that results must be interpreted with care and caution until this factor is researched more carefully and thoroughly (e.g., CD and SS subtests). At present, using factor and subtest scores and the relationship to speed of information processing as a basis for diagnostic hypotheses should be made cautiously. Considering that subjects with B/E, AD/HD, and VMI problems scored significantly lower than subjects without each of these diagnoses on all three variables, there is reduced diagnostic specificity. Rather than attempting to relate each of these diagnoses to a broad an area as speed of information processing, it may somewhat more helpful to examine specific problems experienced by such individuals in order to contribute to a concrete diagnosis and relevant planning of remediation.

Can we reliably distinguish between different population groups based on their WISC-III PS index scores? Given current findings, results suggest that the answer is not simple and more research is required before this question is comprehensively answered.

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Appendix A

Summary statistics (frequencies) for the clinic sample

Table 1

Distribution of the total sample by Sex

Sex	Number of subjects	Percent
Male	106	38
Female	65	62
Total	171	100

Table 2

Distribution of the total sample by Age

Age	Number of subjects	Cumulative Percent
6	4	2.3
7	16	11.7
8	24	25.7
9	23	39.2
10	25	53.8
11	19	64.9
12	17	74.9
13	13	82.5
14	14	90.6
15	10	99.6
16	6	100.0
Total	171	100.0

Note. Age rounded to highest year.

Table 3

Distribution of the total sample by School Grade

Grade	Number of subjects	Cumulative Percent
Kindergarten	1	0.6
1	11	6.4
2	19	11.1
3	33	19.3
4	1	0.6
5	18	10.5
6	13	7.6
7	23	13.5
8	12	7.0
9	14	8.2
10	18	10.5
11	2	1.2
12	1	0.6
SE	5	3.0
Total	171	100.0

Note. SE refers to Special Education.

Table 4

<u>Distribution of the total sample by Year of Administration</u>

Year tested	Number of subjects	Cumulative Percent
1995	13	7.6
1996	152	88.9
1997	6	3.5
Total	171	100.0

Appendix B

Summary statistics (frequencies) of the groups with a single diagnosis

Table 5

Distribution of VMI subjects of total sample

Description	Number of Subjects	Percent
No	95	55.6
Yes	76	44.4
Total	171	100.0

Note. VMI problems refer to at least a one year delay on a test of visual-motor integration (e.g., Bender or Beery).

Table 6

Distribution of the subjects with B/E problems of total sample

Description	Number of Subjects	Percent
No	113	66.1
Yes	58	33.9
Total	171	100.0

Note. B/E refers to a diagnosis made by student clinicians based on results from Behavior Check Lists and Personality Tests, as well as previous history and clinical observations.

Table 7

Distribution of the subjects with AD/HD of total sample

Description	Number of Subjects	Percent
No AD/HD	129	75.4
AD/HD Inattention*	15	8.8
AD/HD Hyperactivity**	27	15.8
Total	171	100.0

Note. AD/HD Hyperactivity refers to predominantly Inattentive Type (DSM-IV, 1994); and, AD/HD Inattention refers to predominantly Hyperactive Type (DSM-IV, 1994).

Table 8

Distribution of the subjects with LD of total sample

Description	Number of Subjects	Percent
No LD	140	81.8
Reading LD	20	11.7
Mathematics LD	10	5.8
Reading + Math	1	0.6
Total	171	100.0

Note. LD as referred to in the DSM-IV (1994).

Table 9

Distribution of the subjects with Physical Health problems of total sample

Description	Number of Subjects	Percent
No	118	69.0
Yes	53	31.0
Total	171	100.0

Note. Physical Health Problems refer to General Medical Condition (DSM-IV, 1994), a diagnosis made by a physician, reported and included in the subject's history.

Table 10

Distribution of the pre-natal/first year of life health difficulties subjects of total sample

Description	Number of Subjects	Percent
No	130	76.0
Yes	41	24.0
Total	171	100.0

Table 11

Distribution of the Bilingual subjects of total sample

Description	Number of Subjects	Percent
No	149	87.1
Yes	22	12.9
Total	171	100.0

Note. Bilingualism refers to two kinds of subjects: a) subjects whose first language is a language other than English; and b) subjects enrolled in French Immersion classes for at least one year.

Table 12

Distribution of subjects of total sample without any diagnosis (none)

Description	Number of Subjects	Percent
No	148	86.5
Yes	23	13.5
Total	171	100.0

Note. 'None' refers to subjects who have not been given any diagnosis (e.g., VMI, LD, Bilingualism, etc.). These subjects were typically assessed for gifted status.

APPENDIX C

Summary statistics (frequencies) of the dual diagnoses groups

Table 13

Distribution of subjects with B/E problems and VMI problems of the total sample

Description	Number of Subjects	Percent
No	138	80.7
Yes	33	19.3
Total	171	100.0

Table 14

Distribution of subjects with AD/HD and VMI problems of the total sample

Description	Number of Subjects	Percent
No	149	87.1
Yes	22	12.9
Total	171	100.0

Table 15

Distribution of subjects with LD and VMI problems of total sample

Description	Number of Subjects	Percent
No	159	93.0
Yes	12	7.0
Total	171	100.0

Table 16

Distribution of subjects with AD/HD and unspecified LD of total sample

Description	Number of Subjects	Percent
No	161	94.2
Yes	10	5.8
Total	171	100.0

Table 17

Distribution of subjects with B/E problems and LD of total sample

Description	Number of Subjects	Percent
No	160	93.6
Yes	11	6.4
Total	171	100.0

Appendix D

Mean WISC-III scores and One-Way Analysis of Variance for the total sample on the variables Processing Speed Index (PS), Coding (CD) and Symbol Search (SS) by the variables Sex, VMI, B/E, AD/HD, NONE and Prenatal/first year.

TABLE 18

WISC-III average scores for the whole sample (N =171)

WISC-III score	Mean	Standard Deviation
Full Scale IQ	97.45	16.47
Verbal IQ	96.73	15.97
Performance IQ	98.76	16.82
VCI	96.63	16.41
POI	98.65	16.62
FDI	95.96	16.54
PSI	98.98	16.42
Verbal Subtests:		
Information	9.25	3.64
Similarities	9.61	3.54
Arithmetic	9.28	3.60
Vocabulary	9.36	3.67
Compreh.	9.51	3.41
Digit Span	8.92	3.00
Performance Subtests:		
Picture Completion	10.25	3.50
Coding	9.05	3.56
Picture Arrangement	9.81	3.84
Block Design	9.87	3.48
Object Assembly	9.72	3.41
Symbol Search	10.08	3.54
Mazes	10.24	3.57

Note. VCI = Verbal Comprehension Index; POI = Perceptual Organization Index; FDI = Freedom from Distractibility Index; and PSI = Processing Speed Index.

TABLES 19 - 21

One-Way Analysis of Variance on the WISC-III variables PS index, CD and SS by the variable SEX

Table 19

One-Way Analysis of Variance - Variables PS by SEX

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	5057.11	5057.11	17.45	.000
Within Groups	169	61729.67	289.91		0
Total	170	66786.78			

Table 20

One-Way Analysis of Variance - Variables CD by SEX

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	134.90	134.90	11.18	.0010
Within Groups	169	2570.63	12.07		
Total	170	2705.53			

Table 21

<u>One-Way Analysis of Variance - Variables SS by SEX</u>

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	107.61	107.61	8.881	.0032
Within Groups	169	2580.88	12.12		
Total	170	2688.49			

TABLES 22 - 24

One-Way Analysis of Variance on the WISC-III Variable PS index, CD, and SS by the Variable VMI (Visual-Motor Integration Deficiencies)

Table 22

One-Way Analysis of Variance - Variables PS by VMI

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	6929.07	6929.07	25.80	.0000
Within Groups	169	45380.40	268.52		
Total	170	52309.48			

Table 23

One-Way Analysis of Variance - Variables CD by VMI

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	296.51	296.51	26.68	.0000
Within Groups	169	1878.00	11.11		
Total	170	2174.50			

Table 24

One-Way Analysis of Variance - Variables SS by VMI

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	242.67	242.67	22.89	.0000
Within Groups	169	1791.24	10.60		
Total	170	2033.91			

TABLES 25 - 27

One-Way Analysis of Variance on the WISC-III Variable PS index, CD, and SS by the Variable B/E

Table 25

One-Way Analysis of Variance - Variables PS by B/E

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	4848.91	4848.91	17.26	.0001
Within Groups	169	47460.56	280.83		
Total	170	52309.48			

Table 26

One-Way Analysis of Variance - Variables CD by B/E

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	191.06	191.06	16.28	.0001
Within Groups	169	1983.44	11.74		
Total	170	2174.50			

Table 27

One-Way Analysis of Variance - Variables SS by B/E

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	157.29	157.29	14.16	.0002
Within Groups	169	1876.62	11.10		
Total	170	2033.91			

TABLES 28 - 30

One-Way Analysis of Variance on the WISC-III Variable PS index, CD and SS by the Variable AD/HD

Table 28

One-Way Analysis of Variance - Variables PS by AD/HD

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	2978.04	2978.04	10.20	.0017
Within Groups	169	49331.44	291.90		
Total	170	52309.48			

Table 29

One-Way Analysis of Variance - Variables CD by AD/HD

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	61.30	61.29	4.9	.0282
Within Groups	169	2113.20	12.50		
Total	170	2174.50			

Table 30

One-Way Analysis of Variance - Variables SS by AD/HD

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	117.51	117.51	10.36	.0015
Within Groups	169	1916.40	11.34		
Total	170	2033.91			

TABLES 31 - 33

One-Way Analysis of Variance on the WISC-III Variable PS index, CD, and SS by the Variable NONE

Table 31

One-Way Analysis of Variance - Variables PS by NONE

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	5572.08	5572.08	20.15	.0000
Within Groups	169	46737.40	276.55		
Total	170	52309.48			

Table 32

One-Way Analysis of Variance - Variables CD by NONE

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	131.44	131.44	10.87	.0012
Within Groups	169	2043.06	12.09		
Total	170	2174.50			

Table 33

One-Way Analysis of Variance - Variables SS by NONE

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	249.95	249.95	23.68	.0000
Within Groups	169	1783.96	10.56		
Total	170	2033.91			

Table 34

One-Way Analysis of Variance on the WISC-III Variable SS by the Variable PRENATAL/FIRST YEAR

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	44.02	44.02	3.74	.0548
Within Groups	169	1989.89	11.77		
Total	170	2033.91			

Appendix E

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the PS, CD and SS variables for the dual diagnosis groups.

TABLES 35 - 40

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS index, CD, and SS by the variable B/E_VMI (Behavioral/emotional and Visual-Motor Integration problems)

Table 35

One-Way Analysis of Variance - Variables PS by B/E_VMI

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	6253.51	3126.76	11.41	.0000
Within Groups	168	46055.97	274.14		
Total	170	52309.48			

Table 36

One-Way Analysis of Variance - Variables CD by B/E_VMI

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	208.88	104.44	8.93	.0002
Within Groups	168	1965.63	11.70		
Total	170	2174.50			

Table 37

One-Way Analysis of Variance - Variables SS by B/E VMI

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	208.69	104.35	9.6	.0001
Within Groups	168	1825.21	10.86		
Total	170	2033.91			

Table 38

Student Newman-Keuls Test of Comparison - Variable PS by Variable B/E_VMI

Mean	Group	B/E + VMI	Neither	B/E No VMI
86.03	B/E + VMI			
105.67	NEITHER	*		*
94.11	B/E no VMI			

Table 39

Student Newman-Keuls Test of Comparison - Variable CD by Variable B/E_VMI

Mean	Group	B/E + VMI	Neither	B/E No VMI
7.03	B/E + VMI			
10.82	NEITHER	*		*
8.04	B/E no VMI			

Table 40

Student Newman-Keuls Test of Comparison - Variable SS by Variable B/E VMI

Mean	Group	B/E + VMI	Neither	B/E No VMI
8.00	B/E + VMI			
11.59	NEITHER	*		*
9.5	B/E no VMI			

TABLES 41- 44

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS index and CD by the variable LD_VMI (LD and Visual-Motor Integration problems)

Table 41

One-Way Analysis of Variance - Variables PS by LD VMI

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	7698.92	2566.31	9.61	.0000
Within Groups	168	44610.56	267.13		
Total	170	52309.48			

Table 42

One-Way Analysis of Variance - Variables CD by LD VMI

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	295.83	98.61	8.71	.0000
Within Groups	168	1878.68	11.25		
Total	170	2174.50			

Table 43

Student Newman-Keuls Test of Comparison - Variable PS by Variable LD_VMI

Mean	Group	LD + VMI	Neither	LD NO VMI
82.75	LD + VMI		*	*
103.26	NEITHER			
98.76	LD no VMI			

Table 44

Student Newman-Keuls Test of Comparison - Variable CD by Variable LD_VMI

Mean	Group	LD + VMI	Neither	LD NO VMI
6.67	LD + VMI		*	*
10.05	NEITHER			
10.06	LD no VMI			

TABLES 45 - 50

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS index, CD, and SS by the variable AD/HD-VMI (AD/HD and visual motor integration problems)

Table 45

One-Way Analysis of Variance - Variables PS by AD/HD VMI

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	6126.65	3063.33	11.14	.0000
Within Groups	168	46182.83	274.90		
Total	170	52309.48			

Table 46

One-Way Analysis of Variance - Variables CD by AD/HD VMI

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	152.19	76.09	6.32	.0023
Within Groups	168	2022.32	12.04		
Total	170	2174.50			

Table 47

One-Way Analysis of Variance - Variables SS by AD/HD VMI

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	212.37	106.18	9.79	.0001
Within Groups	168	1821.54	10.84		
Total	170	2033.91			

Table 48

Student Newman-Keuls Test of Comparison - Variable PS by Variable AD/HD VMI

Mean	Group	AD/HD + VMI	Neither	AD/HD NO VMI
81.36	AD/HD + VMI		*	*
103.67	NEITHER			
98.70	AD/HD no VMI			

Table 49

Student Newman-Keuls Test of Comparison - Variable CD by Variable AD/HD VMI

Mean	Group	AD/HD + VMI	Neither	AD/HD NO VMI
6.45	AD/HD + VMI		*	*
10.27	NEITHER			
9.40	AD/HD no VMI			

Table 50

Student Newman-Keuls Test of Comparison - Variable SS by Variable AD/HD VMI

Mean	Group	AD/HD + VMI	Neither	AD/HD NO VMI
7.09	AD/HD + VMI		*	*
10.45	NEITHER			
10.10	AD/HD no VMI			

TABLES 51 - 54

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS and SS by the variable AD/HD and learning disability (LD)

Table 51

One-Way Analysis of Variance - Variables PS by AD/HD LD

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	3234.34	1617.17	5.54	.0047
Within Groups	168	49075.13	292.11		
Total	170	52309.48			

Table 52

One-Way Analysis of Variance - Variables SS by AD/HD LD

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	142.37	71.18	6.32	.0023
Within Groups	168	1891.54	11.26		
Total	170	2033.91			

Table 53

Student Newman-Keuls Test of Comparison - Variable PS by Variable AD/HD LD

Mean	Group	AD/HD + LD	Neither	AD/HD NO LD
85.20	AD/HD + LD			
99.31	NEITHER	*		
91.00	AD/HD no LD		*	

Table 54

Student Newman-Keuls Test of Comparison - Variable SS by Variable AD/HD LD

Mean	Group	AD/HD + LD	Neither	AD/HD NO LD
9.90	AD/HD + LD			
10.45	NEITHER			
8.09	AD/HD no LD		*	

TABLES 55 - 60

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS index, CD, and SS by the variable VMI_B/E (VMI and Behavioral/emotional problems)

Table 55

One-Way Analysis of Variance - Variables PS by VMI_B/E

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	9908.3206	3302.77	13.00	.0000
Within Groups	168	42401.1600	253.90		
Total	170	52309.4800			

Table 56

One-Way Analysis of Variance - Variables CD by VMI_B/E

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	433.51	144.50	13.86	.0000
Within Groups	168	1741.00	10.43		
Total	170	2174.50			

Table 57

One-Way Analysis of Variance - Variables SS by VMI B/E

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	334.69	111.56	10.96	.0000
Within Groups	168	1699.22	10.18		
Total	170	2033.90			

Table 58

Student Newman-Keuls Test of Comparison - Variable PS by Variable VMI_B/E

Mean	Group	VMI + B/E	Neither	VMI No B/E
86.03	VMI + B/E			
105.67	NEITHER	*		*
93.27	VMI no B/E			

Table 59

Student Newman-Keuls Test of Comparison - Variable CD by Variable VMI_B/E

Mean	Group	VMI + B/E	Neither	VMI No B/E
7.03	VMI + B/E			
10.82	NEITHER	*		*
7.86	VMI no B/E			

Table 60

Student Newman-Keuls Test of Comparison - Variable SS by Variable VMI_B/E

Mean	Group	VMI + B/E	Neither	VMI No B/E
8.00	VMI + B/E			
11.59	NEITHER	*		*
9.25	VMI no B/E			

TABLES 61 - 66

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS index and CD by the variable VMI and LD (VMI and LD)

Table 61

One-Way Analysis of Variance - Variables PS by VMI LD

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	7698.92	2566.31	9.61	.0000
Within Groups	168	44610.50	267.13		
Total	170	52309.48			

Table 62

One-Way Analysis of Variance - Variables CD by VMI LD

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	295.83	98.61	8.77	.0000
Within Groups	168	1878.68	11.25		
Total	170	2174.50			

Table 63

One-Way Analysis of Variance - Variables SS by VMI_LD

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	245.50	81.83	7.64	.0001
Within Groups	168	1788.40	10.71		
Total	170	2033.91			

Table 64

Student Newman-Keuls Test of Comparison - Variable PS by Variable VMI LD

Mean	Group	LD + VMI	Neither	VMI No LD
82.75	VMI + LD			
103.26	NEITHER	*		*
91.20	VMI no LD			

Table 65

Student Newman-Keuls Test of Comparison - Variable CD by Variable LD VMI

Mean	Group	LD + VMI	Neither	VMI No LD
6.67	VMI + LD			
10.05	NEITHER	*		*
7.59	VMI no LD			

Table 66

Student Newman-Keuls Test of Comparison - Variable SS by Variable LD_VMI

Mean	Group	LD + VMI	Neither	VMI No LD
9.08	VMI + LD			
10.35	NEITHER			*
8.57	VMI no LD			

TABLES 67 - 72

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS, CD and SS by the variable VMI and AD/HD

Table 67

One-Way Analysis of Variance - Variables PS by VMI AD/HD

Source	DF	Sum of Squares	Squares	F Ratio	F Prob.
Between Groups	2	9531.57	3177.19	12.40	.0000
Within Groups	168	42777.91	256.15		
Total	170	52309.48			

Table 68

One-Way Analysis of Variance - Variables CD by VMI AD/HD

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	338.08	112.69	10.25	.0000
Within Groups	168	1836.42	10.99		
Total	170	2174.50			

Table 69

One-Way Analysis of Variance - Variables SS by VMI AD/HD

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	339.91	113.30	11.17	.0000
Within Groups	168	1693.99	10.14		
Total	170	2033.91			

Table 70

Student Newman-Keuls Test of Comparison - Variable PS by Variable VMI_AD/HD

Mean	Group	VMI + AD/HD	Neither	VMI No AD/HD
81.36	VMI + AD/HD			
103.70	NEITHER	*		
95.26	VMI no AD/HD	*	*	

Table 71

Student Newman-Keuls Test of Comparison - Variable CD by Variable VMI_AD/HD

Mean	Group	VMI + AD/HD	Neither	VMI No AD/HD
6.45	VMI + AD/HD			
10.27	NEITHER	*	*	
7.80	VMI no AD/HD			

Table 72

Student Newman-Keuls Test of Comparison - Variable SS by Variable VMI_AD/HD

Mean	Group	VMI + AD/HD	Neither	VMI No AD/HD
7.09	VMI + AD/HD			
11.29	NEITHER	*		
9.28	VMI no AD/HD	*	*	

TABLES 73 - 78

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS, SS, and CD by the variable Behavioral/emotional and learning disability

Table 73

One-Way Analysis of Variance - Variables PS by B/E LD

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	4673.31	1557.77	6.15	.0003
Within Groups	168	39946.48	239.20		
Total	170	44619.79			

Table 74

One-Way Analysis of Variance - Variables CD by B/E LD

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	173.88	57.96	5.06	.0022
Within Groups	168	1911.74	11.45		
Total	170	2085.63			

Table 75

One-Way Analysis of Variance - Variables SS by B/E LD

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	228.69	76.23	7.04	.0002
Within Groups	168	1808.02	10.83		
Total	170	2036.71			

Table 76

Student Newman-Keuls Test of Comparison - Variable PS by Variable B/E LD

Mean	Group	B/E + LD	Neither	B/E No LD
87.36	B/E + LD			
102.01	NEITHER	*		*
91.77	B/E no LD			

Table 77

Student Newman-Keuls Test of Comparison - Variable CD by Variable B/E LD

Mean	Group	B/E + LD	Neither	B/E No LD
7.56	B/E + LD			
9.79	NEITHER	*		*
7.68	B/E no LD			

Table 78

Student Newman-Keuls Test of Comparison - Variable SS by variable B/E LD

Mean	Group	B/E + LD	Neither	B/E No LD
7.45	B/E + LD			
10.86	NEITHER	*		*
8.74	B/E no LD			

TABLES 79 - 84

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS, SS, and CD by the variable learning disability and behavioral/emotional

Table 79

One-Way Analysis of Variance - Variables PS by LD B/E

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	4673.31	1557.77	6.51	.0003
Within Groups	168	39946.48	239.20		
Total	170	44619.79			

Table 80

One-Way Analysis of Variance - Variables CD by LD B/E

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	173.88	57.96	5.06	.0022
Within Groups	168	1911.74	11.45		
Total	170	2085.63			

Table 81

One-Way Analysis of Variance - Variables SS by LD B/E

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	228.69	76.23	7.04	.0002
Within Groups	168	1808.02	10.83		
Total	170	2036.71			

Table 82

Student Newman-Keuls Test of Comparison - Variable PS by Variable LD B/E

Mean	Group	LD + B/E	Neither	LD no B/E
87.36	LD + B/E			
102.01	NEITHER	*		*
98.38	LD no B/E			

Table 83

Student Newman-Keuls Test of Comparison - Variable CD by Variable LD B/E

Mean	Group	LD + B/E	Neither	LD no B/E
7.56	LD + B/E			
9.79	NEITHER	*		
9.47	LD no B/E			

Table 84

Student Newman-Keuls Test of Comparison - Variable SS by variable LD_B/E

Mean	Group	LD + B/E	Neither	LD no B/E
7.45	LD + B/E			
10.86	NEITHER	*		
10.67	LD no B/E	*		