University of Alberta

Diagnosis based on the Processing Speed Factor of the WISC-III

by

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To Krista Liebe and Andre Zawallich:

Thank you for your tremendous help and support!

Abstract

Chapter 1 presents a brief introduction concerning the use of the Wechsler Intelligence Scale for Children: Third Edition (WISC-III) in psychoeducational assessment and outlines the purpose of the present study and its limitations. Chapter 2, the literature review, consists of three main parts. First, the major areas of research developed in the field during the last two decades. Second, theories explaining the research findings which emphasize a cognitive theory of intelligence and development. Third, the relationship between the measures of speed of information-processing and the WISC-III as reflected in recent studies. The second chapter concludes with detailed research questions and hypotheses. Chapter 3 describes the participants and the research design, procedures, and instruments. Chapter 4 contains the presentation of the results. Chapter 5 examines the relationship of these results to the research questions and hypotheses and ends with considerations applicable in psychoeducational assessment and implications for future research.

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CHAPTER ONE

INTRODUCTION

The Wechsler Intelligence Scale for Children - Third edition (WISC-III), along with the other Wechsler Scales, is one of the most widely used instruments in psychoeducational assessment today. Representing a third revision of the original Wechsler Intelligence Scale for Children, which was first published in 1949, the WISC-III was introduced to the public in 1991, and since then not much research related to it has been published. In the manual for the test users (Wechsler, 1991) the authors of the WISC-III report a four-factor solution from the factor analysis of the data used to standardize the test, as well as from other confirmatory studies. This solution introduces a new factor labelled Processing Speed. Both, the four-factor solution and the existence of the Processing Speed factor, have been a subject of some controversy and objection based on research done by other authors (Little, 1992; Sattler, 1992).

Purpose of the Study

The present study was in part brought to life by the above mentioned controversy. The primary goal of the study is to answer the question: Can the Processing Speed factor scores be used to distinguish between groups of children with different identified problems interfering with their school performance? These problems include the areas of Attention Deficit/Hyperactivity Disorder (AD/HD, DSM-IV, 1994), behavioral and/or emotional problems, physical health (General medical condition, DSM-IV, 1994), bilingualism, Learning Disorders (DSM-IV, 1994; synonymous with learning disabilities), visual-motor integration (VMI) difficulties, as well as combinations thereof. At the same time, the study aims at providing practising clinicians with diagnostic information, which may possibly contribute to a more thorough interpretation of the results obtained from the WISC-III.

Sample

The present study was conducted using a clinic referral sample - the participants were referred for psychoeducational or personality assessment to the Education Clinic at the University of Alberta, Department of Educational Psychology, by schools, medical settings, family members, as well as by the individuals themselves.

Delimitations

1. There was not a single control group used in this study. In the first part of the study, for every comparison the whole sample was divided into two parts: A) the group of students diagnosed with a certain problem and B) the group of students, who did not experience that particular problem. In the second part of the study the sample was divided into 3

groups, which were compared pairwise : A) the group of students diagnosed simultaneously with two problems; B) the group of students diagnosed with the first problem studied only, and C) the group of students, who did not experience any of the problems studied in the particular comparison. In this way, all parties to every comparison included the clinical population. With the exception of a small number (less than 10) of cases referred for psychological assessment for giftedness, all referrals concern children and adolescents, who encounter some difficulties in their school performance and/or at home.

2. Individual problems in the above mentioned areas which interfered with academic performance were identified and diagnosed by student-clinicians based on clinical history, behavioral observations made during the assessment and outside the clinic, as well as test scores.

3. The term Learning Disability (LD) is used throughout the text as synonymous with Learning Disorder (DSM-IV, 1994). The former term has been and still is widely used in the educational assessment field, which justifies its preference over the latter term. LD refers to learning difficulties resulting in failure to meet school standards of achievement in the areas of reading (word) recognition, reading comprehension, and mathematical operations as measured by standardized achievement instruments. A learning disability was considered being present, if a discrepancy of

one standard deviation (15 points) or more exists between the individual's WISC-III Full Scale IQ and one or more of the achievement scores in the above mentioned areas.

4. The study is descriptive in nature and detailed discussion of the theoretical basis for and implications of the test and its use is considered beyond its scope. The analysis was focused on the comparison between mean test scores obtained by the different groups included in the study and on looking for any significant differences between these scores.

Limitations of the Study

1. Because of the insufficient number of appropriate subjects for the creation of problem and control groups by random sampling, all the groups in this study were created using "convenience sampling". There was no match for age, sex, and grade attempted between the control and problem groups, as no significant differences on these variables were observed. Generalizing the results outside of the clinic-referred population should be done with caution.

2. No demographic information (e.g., socioeconomic status, race, religion, etc.) has been considered in this study because of problems with representation. However, the general review of the demographic data from the files suggests that the majority of the subjects referred to the clinic come from white, middle class, protestant environments

and this should be taken into consideration when generalizing the results.

3. The lack of standardized assessment instruments for diagnosing certain problems and the use of different achievement, Visual-Motor Integration (VMI), and behavior/personality tests (as described below) to determine the presence of learning and other problems of functioning may have reduced the precision of the creation of the different groups.

4. The use of data provided by more than one diagnostician may account for some of the differences observed, mainly in the administration and scoring of the tests, as well as in assigning group membership. That is, the personal biases of the different clinicians may be reflected in: 1) the subjects' test scores, which are directly used in the formation of the LD groups; 2) the diagnosis primarily based on clinical observations (e.g., AD/HD and to some extent behavioral/emotional problems), which determines the subjects' participation in the respective groups.

Statement of the Problem

The purpose of this research is to provide clinicians and users of the WISC-III with more facts, which would help them to make better informed diagnostic decisions and in this way to contribute to the improvement of the process and the results of psychoeducational diagnosis.

The present study will explore the diagnostic usefulness of the Processing Speed factor of the WISC-III. In other words, the general question to be answered is: Can we distinguish reliably between different population groups based on their Processing Speed index scores?

More specifically, a first question is: Do children, who have problems in the areas of AD/HD, behavior/emotions, physical health, visual-motor integration (VMI) problems, and bilingual subjects, as well as combinations of the above, show significantly different mean scores on the Processing Speed index of the WISC-III, when compared to children without problems in the above areas? A second question to be answered is: What is the relationship between the mean number of bonus points (as a measure of processing speed) assigned on some WISC-III subtests for quick performance and the WISC-III Processing Speed index?

The accomplishment of such a task will bring test users a little closer to understanding the wide possibilities for interpretation of the results of intelligence testing done with the WISC-III. It can also serve as a guideline to be used in making diagnostic decisions for educational purposes, providing that some reliable differences between groups are found.

CHAPTER TWO

REVIEW OF THE LITERATURE

Research on processing speed - history

Among the first modern time psychologists to point out the importance of reaction time in their theories are Sir Francis Galton and Charles Spearman who initiated the experimental study in the area. The Galtonian mental speed tradition began the ongoing search for experimental evidence in support of its main assumption: namely, that performance on elementary cognitive tasks might provide good indices of mental ability (Beauducel & Brocke, 1993). As early as 1909, Burt used a version of today's "inspection time" test, called "spot pattern", and found a correlation of .83 between the test scores and intelligence (Eysenck, 1987, p. 25). By the late 1920's the research in this area was gradually abandoned. After the 1930's the interest in the issue of information-processing speed decreased and there was no significant development observed in its study until recently. The past 15-20 years witnessed a revival of the research and development of theories concerning the relationship between individual differences in intelligence on one hand, and speed of information-processing, mental speed, and reaction times (RT) on the other.

Experimental apparatus for measuring RT

The most common apparatus used to measure the subject's reaction time was introduced by Jensen (1982, 1987). A newer version is described in Jensen and Reed (1990). It consists of a board with a central "on/off" button placed in the middle, close to the subject, called also the "home key". Around the "home key", at an equal distance of about 15 cm (6 in) from it, are placed 8 stimulus lights, each of which is paired with an "on/off" button. In later versions, each "on/off" button itself contained a stimulus light.

The subject, whose information-processing speed is being measured, is instructed to keep the central button depressed, using his/her preferred hand. After 1 second, the beginning of the trial is announced by a preparatory signal (1 second long "beep"), followed by a time interval randomly selected by a computer, lasting between 1 and 4 seconds. After that a (green) stimulus light comes on, at which moment the subject has to release the home button as quickly as possible and depress the button of the activated stimulus light, which in turn turns that light off. The stimulus lights can be covered with templates, so that either 1, 2, 4 or 8 of them are exposed, corresponding to 0, 1, 2, and 3 bits of information respectively.

Reaction time (RT), measured in milliseconds, is the time expired between the onset of a stimulus light and the moment the "home key" is released by the subject. RT is also being referred to as decision time (DT). Movement time (MT) is the time expired between the onset of the stimulus light and the moment the button of that light has been depressed, minus RT. In this way RT and MT are experimentally independent. When only one stimulus light is being exposed, the measured parameter is called simple RT; when either two, four, or eight stimulus lights are being used, the measured parameter is referred to as choice RT (Jensen, 1987).

There are two types of tasks used to measure choice RT with 8 stimulus lights exposed: in the first case, the stimulus lights are activated one per each trial; in the second one, called the "odd man" task, three stimulus lights are activated simultaneously. Two of them are next to each other and the third one, the "odd man", is separated from the fist two by at least one "off" light in between. The subject is instructed to depress the button representing the "odd man", thereby increasing the task complexity. With eight lights exposed, the stimulus pattern unsystematically varied from trial to trial has a possible oddity of 44 (Jensen & Reed, 1990).

Reaction time and intelligence

The measurements of RT were initiated by the proponents of the low level cognitive determination of individual differences in intelligence (see below). They introduced the hypothesis that the basis for the correlations between simple information-processing tasks and psychometrically measured intelligence is their common reliance on processing speed. The major assumption serving as a base for the RT tasks is that they are fairly simple and provide a "pure" measure of information-processing speed. This means that the task presented to the subjects is assumed to be knowledge-free, that is, not affected by differences in the subjects' knowledge or knowledge use, which would introduce the influence of higher order cognitive systems.

The Hick Paradigm. The study of the relationship between RT and the number of alternative stimuli "n" resulted in the so called Hick's Law or the Hick Paradigm. Hick (1952) presented in terms of the theory of information what was discovered and formulated mathematically: "RT increases as a linear function of the logarithm of *n* (Jensen, 1987, p. 103).

As Jensen (1987) points out, Roth (1964) made the link between Hick's Law and the research conducted in the area of intelligence. In an experimental study he found

> a correlation -0.39 between the *slope* of the regression of RT on log2 *n*, or bits [of information], and a psychometric measure of general intelligence. That is, the more intelligent subjects showed a lower rate of increase in RT with increasing bits of

information than the less intelligent subjects (Jensen, 1987, p. 105-106).

For group data this translates into the fact that more intelligent individuals show less variability in choice reaction time (Jensen, 1982). As Detterman (1987) points out subjects with lower IQ, for example "mentally retarded subjects are more variable" (p. 194).

Since then, many researchers, using different theoretical models, have either replicated Roth's study with different samples or designed and conducted more or less similar experiments, aiming at clarification of the relationship between speed of information processing and individual differences in intelligence (Carlson & Widaman, 1987; Detterman, 1987; Eysenck, 1987; Horn, 1987; Jensen, 1982, 1987; Jensen & Reed, 1990; Keating & MacLean, 1987; Marr & Sternberg, 1987; Nettelbeck, 1987; Neubauer, 1990; Vernon, 1983, 1985, 1987; Vernon & Kantor, 1986; Vernon & Weese, 1993; Vernon, Nador, & Kantor, 1985). The results and findings of the studies differ from each other, in certain cases a great deal.

Detterman (1987) found that decision time was negatively correlated with IQ: -.30. However, he did not state firmly whether this should be considered a strong relationship or not or what the explanation for it might be. As far as Hick's Law is concerned, the same author summarized that "the slope of decision time appears to have little relationship to intelligence. Though Hick's Law may ... hold for group data, individual variations in slope do not account for intellectual differences" (p. 192). Further, the results show that "movement time has a variable but significant relationship to intelligence" (p. 192).

Vernon (1987) found that "RT's and speed of information-processing are reliably and quite highly correlated with measures of intelligence" (p. 18). In the same study certain sex differences in verbal, spatial, and mathematical abilities were found. However, there were some problems with the samples (certain samples were of a size too small to allow for generalizations), which prevented the author from drawing definitive conclusions.

Vernon, Nador and Kantor (1985b) studied 81 subjects using the Multidimensional Aptitude Battery (MAB) under both timed and untimed conditions and found no significant difference in the measures of intelligence between the two. Vernon and Kantor (1986) administered the MAB to 113 high school students under timed (5 minutes per subtest allowed) and untimed conditions; after that all subjects were administered a battery of RT tests used by Vernon et al. (1985a). The results indicated slightly higher multiple correlations of untimed MAB scores with RT than the timed scores. Similar findings are reported by Jensen (1987).

The authors of the above studies restrained themselves from making generalizations based on their findings, stating that "recent research on RT's have challenged a number of long-standing 'truths' about intelligence" (Vernon, 1987, p. 18).

Commenting on the findings of the research, studying the relationship between processing speed and intelligence, Eysenck (1987) indicates the great variability of results reported. One of his findings suggests that Hick's Law could not be applied universally and straightforwardly across different populations: "Hick's Law is not obeyed by all subjects, and as many as 20 % or more may show widely differing regressions" (p. 58). The author concludes that some of the probable causes for this situation lie in the size of the samples used, the instrumentation, as well as the statistical analyses.

Contrary to Eysenck (1987), Keating and MacLean (1987), making an overview of research of the relationship between intelligence and processing speed, conclude: "In most cases, the researchers have reported moderate to substantial intercorrelations of the parameters of general processing speed or efficiency, and the measures of general cognitive ability" (p. 252). Further, they report that most experimental studies support Hick's Law.

Vernon and Weese (1993) summarize that zero-order correlations of approximately -0.30 describe realistically the relationship between RT measures and intelligence, "faster, or shorter RT's being associated with higher intelligence test scores" (p. 413). It has to be noted that Vernon (1988), using multiple measures, found multiple correlations as high as 0.70 between the above variables.

RT task complexity and intelligence. A major line of RT-related research is the issue of the varying relationship between intelligence and RT tasks, depending on the task complexity. This includes the previously mentioned choice RT measures using 2 or more bits of information. One general finding in that area was that "as RT task increases in complexity or the amount of information processing required, the RT increases and so does its correlation with IQ" (Jensen & Reed, 1990, p. 377). The same has been confirmed by Vernon and Weese (1993) among others.

Further studies, however, showed that this holds true only for relatively simple tasks with RT's of 1,000 msec or less, later corrected to mean RT of approximately 2 seconds (Beauducel & Brocke, 1993). Jensen (1982) called this phenomenon "test-speed paradox", assuming that after the above mentioned period factors other than the pure information processing come into play.

Neubauer (1990) reports findings, which generally support Jensen's hypothesis of the test-speed paradox, using the Advanced Progressive Matrices (Raven, 1958). He further found that for items requiring response latencies of 70 seconds or more, the speed-IQ correlation approached unity, and for very difficult items, with a mean response latency of

133 seconds, it showed a tendency in the opposite direction. His explanation of the phenomenon suggests that "processing speed in the Hick Paradigm and response times in intelligence test reflect different processes" (p. 152).

Contrary to the test-speed paradox stands a "complexity hypothesis" (Cohn, Carlson, & Jensen, 1985), according to which "the more complex each elementary cognitive task (ECT) is, the closer the relations between RT and intelligence become" (Beauducel & Brocke, 1993, p. 634). The same authors report a correlation of up to 0.60 obtained when performing ECT's with mean RT of 3 sec.

To summarize: The majority of the studies including RT tasks and measures of intelligence have resulted in correlations between information processing speed and IQ, estimated at a minimum of 0.30. The variety of tasks used in the research and the fact that subjects with lower IQ, for example mentally retarded, are capable of responding accurately to the RT paradigm, although they take, on average, about 100 milliseconds longer, suggests that processing speed is probably fundamental to intelligence and intelligence appears to be fundamental to knowledge. As Anderson (1992) indicates "intelligence must be a processing parameter underlying knowledge, knowledge use, and knowledge acquisition" (p. 44).

Inspection time and intelligence

The assumption that the RT tasks are fairly simple and provide a pure measure of information-processing speed has been challenged by Longstreth (1984, 1986) and Detterman (1987), who view the RT tasks as quite complicated, involving a complex processing system, which includes attention, motivation, visual search, and encoding among its components.

Rabbitt (1985) points at the necessity of monitoring and controlling responding speed, created by the typical task instructions: to go as fast as possible and, at the same time, to make as few errors as possible. This situation presents the subjects with the complex problem of developing a strategy, in which speed and accuracy must be traded off for achieving optimal performance.

In answer to the critiques, the defenders of the lower order processing standpoint followed the natural way to simplify the task used to measure RT, which lead to the creation of the inspection time task. In this task subjects have to discriminate between two stimuli, represented by two markedly different lines, exposed for very brief durations (milliseconds) (Anderson, 1989). This task is simpler than the one used to measure RT, because no fast responding is required, only accuracy. The speed in this case is attributed to the stimulus and it is not a dependent variable.

Inspection time (IT) is hypothesized to reflect the minimum time required to make a single inspection of the sensory input (Vickers & Smith, 1986). IT is used as an estimate of the shortest stimulus exposure at which performance is virtually error-free.

Research has shown that the shortest duration of the exposure at which the subjects can reliably perform the task is related to intelligence in a manner similar to RT tasks: IT is negatively correlated to IQ. That is, more intelligent subjects can maintain error-free performance at shorter-exposure durations than less intelligent subjects and conversely: less intelligent subjects require longer stimulus exposures (Nettelbeck, 1987). Studies conducted in Adelaide (Australia) and Edinburgh (U. K.) invariably found negative and in most cases significant relationship between different measures of IQ and IT (measured with different apparatus and involving different sensory modalities) (Anderson, 1992).

A summary of nine studies done by Nettelbeck (1987) showed that in seven of them there were significant correlations observed between IT and Performance IQ from either WAIS or WAIS-R. The absence of significant correlations of IT with Verbal IQ from the same test was tentatively explained by the author as probably due to "some basic limitations in rate of perceptual sampling", which "might particularly influence outcome of tasks, like the PIQ subtests, where time limits apply and which involve visual organization and integration" (p. 307).

Nettelbeck's conclusions are that IT can be used as a reliable indicator of individual differences in accuracy; however, "its validity as a measure of ... speed at which mental processes operate is problematical" (p. 332). He also points out the difficulty in explaining the IT - IQ association. In the same study the author has estimated the value of the true population correlation between IT and IQ at about 0.5, this time based on data from 29 studies.

The interpretation of these findings seems to support the idea that individual differences in intelligence are due to a great extent to the speed, or efficiency of low level cognitive, or neural, processes (Jensen, 1987).

IT tasks have been subject to critiques, somewhat similar to the ones aimed at RT tasks and also coming from the proponents of the higher order cognitive determination of the individual differences in intelligence. The critiques include the cumulative distribution of sensory magnitudes presented over trials and sensory adaptation, as factors possibly interfering with the measured performance differences (Anderson, 1992). Detterman (1987) also mentions that IT can be influenced by various subjective variables associated with personality differences, sensitivity, concentration, adaptation, etc.

The critiques lead to further simplifying the tasks measuring information processing speed through wider computer involvement (See Hertzog, 1987; Small, Raney, & Knapp, 1987) and studying the relationship between evoked potentials and intelligence - research at the level of neuronal functioning. The rationale behind it is, again, to exclude possible influence of higher cognitive functions on the task performance.

Evoked potentials and intelligence

Evoked or event-related potentials represent the electrical fields created by the brain activity in response to a stimulus, which is present or, if absent, at least expected. For research purposes evoked potentials are measured by EEG (electroencephalogram) in a waking, normal subject, who is asked to perform a variety of tasks. It has been established for a fact that cognitive processes (tasks requiring "thinking") can have differential effects on EEG activity of adults (Donchin & Coles, 1988) and also in infants (Hofmann, Salapatek, & Kuskowski, 1981).

In the typical experimental situation, the subject is placed in a dark room in order to reduce potentially distracting sensori input to a minimum. Recording electrodes are attached to the subject's scalp in order to obtain an EEG. The most commonly used stimuli are a flashing light or an audible tone.

Initially the research looking for a relationship between information processing speed and intelligence concentrated on the parameter neuronal speed of conductivity, which lead to measuring latency of the evoked potentials and its comparison with measures of intelligence. The correlations reported in these studies were of the order of approximately -0.3 (Schucard & Horn, 1972), thus being no larger than the ones obtained for other low level cognitive measures.

The picture changed radically when the research focus was moved from measuring latency to measuring wave-form, which brought in the parameter "average evoked potential" (AEP). This parameter resulted from several recordings of wave-forms produced in response to the same stimulus, after which the wave-forms were added to each other. A piece of string was placed alongside the wave-form contour and its length was measured. The lengths obtained in this way were found to correlate with IQ at about 0.8 (Blinkhorn & Hendrickson, 1982; Robinson, Haier, Braden, & Krengel, 1984). The fact that more intelligent subjects produced longer (spikier) wave-forms lead to the hypothesis that higher IQ was a result of "superior fidelity in neural transmission" (Anderson, 1992, p. 52), a concept related to information-processing speed.

Carlson and Widaman (1987) describe the work of different researchers in the area of evoked potentials: the correlations obtained between IQ and average evoked potential wave-form ranged from 0.10 to 0.66. The findings were qualified by the authors as inconclusive and the need for extension of the research was stated.

There are problems with the interpretation of the evoked potentials research findings, both of biological and psychological character. As far as the former is concerned, it has been indicated that a distortion of electrical potentials due to skull peculiarities, conductivity of the cerebral spinal fluid, skin properties, etc., can all contribute to variation in evoked potentials. Among the psychological factors possibly affecting the performance on an evoked potentials task are variations in processing strategies, which already have been mentioned on more than one occasion and which may be knowledge-based, the probability of occurrence of the stimulus, as well as the attention state of the subject (Anderson, 1992).

In summary: the comparative studies involving evoked potentials and their relationship to intelligence initially failed to provide the expected indisputable evidence in favor of the lower processing determination of intelligence. The strong relationship between the above variables found in AEP research is not demonstrated in an unambiguous way and can not easily be defended against interpretations, other than the original one suggested.

<u>Theoretical explanations</u>

The attempts at theoretical explanation of the relationship between intelligence and speed of information-processing, as already suggested above, have divided the researchers into two camps, reflecting the classic sides of the perennial argument about the biological versus the environmental/social determination of human development.

On one side are those, who believe that differences in intelligence are due, to a major extent, to differences in low-level cognitive mechanisms (represented by Eysenck, Jensen, Vernon). On the other side are the supporters of the opinion that differences in intelligence are based on differences in high-level cognitive systems, influenced by the social and cultural environment of the individual (represented by Sternberg, Marr).

Another major issue included in the discussion is the structure of intelligence. The authors of the first group generally support the existence of a general intelligence plus specific abilities. The researchers from the second group tend to embrace standpoints antithetical to the notion of general intelligence. The exchange of arguments is often extended outside of the purely theoretical field, pointing at some methodological difficulties, reflected also in research.

In a theoretical study, Marr and Sternberg (1987) explore the evidence for the relationship between intelligence and mental speed by applying a "triarchic" theory. The latter consists of contextual, componential, and experiential subtheories, in this way integrating and providing newer perspectives to the attempts at explanation of the research findings in the field. An examination of the infant habituation rate and the speed with which individuals automatize repetitive sequences of mental operations lead the authors to the conclusion that "there seems to be little doubt that the speed of cognitive *response* is related to performance on many psychometric measures of intelligence" (p. 275).

The same authors indicate some problems evident in the research of the relationship between intelligence and processing speed. Their concern about possible contamination of the measures of mental speed by individual differences in information-processing strategies, perceptual skills, motivation, and attention are shared by most of the other researchers working in the field.

The present (at least until recently) theoretical situation is probably best summarized by Jensen (1987). Commenting on the results of his extensive study of Hick's Law, he points out:

> In view of all the evidence I have presented ...., I doubt that, at present, we have an adequate theory to explain all of the now quite well established facts of individual differences in Hick variables and their relation to psychometric *g* (p. 168).

The data analysis leads the author to the conclusion that "some quite general factor in the speed or efficiency of performance is reflected in all aspects of the Hick Paradigm" (p. 168). And further along the same line of thought:

> One might even go so far as to hypothesize that the general factor of a large and diverse battery of RT tasks (that is, all the RT and MT parameters derived from them) is one and the same general factor as found in the factor analysis of any large and diverse battery of conventional psychometric tests of mental ability (p. 168).

Vernon (1983) hypothesizes that "individual differences in intelligence may, to some extent, be the result of differences in the efficiency or speed with which individuals can perform these basic components of information-processing" (p. 54). An indirect confirmation of his hypothesis is found in a study of the heritability of information-processing speed measures done by the same author (Vernon, 1989).

Lindley, Smith and Thomas (1988) also support Vernon's hypothesis. They studied the relationship between processing speed and IQ using measures of processing speed obtained from substitution paper-and-pencil tests, which were compared to IQ scores from Shipley-Hartford and Whimbey Analytic Skills Inventory. The results serve as a base for the hypothesis that "substitution tests measure IQ because they measure speed of information processing" (p. 24).

A similar line of thought has been pursued by Eysenck (1988), who concludes that there is a need for a specific theory to account for the recent evidence showing high correlations between elementary physiological (evoked potentials) and perceptual-motor processes (reaction times, movement times, inspection times) on one side, and IQ on the other side. Such a theory "regards speed of cognitive processing as the fundamental variable underlying differences in general intelligence" (p. 14). Its general foundations are represented by the author's views of the structure of intelligence (Eysenck, 1982).

The cognitive theory of Anderson. From the standpoints briefly outlined above, it already becomes evident that there is a tendency to attribute a common underlying factor accountable for both general intelligence and speed of information-processing. Eysenck (1988) even goes so far as to place processing speed on the basis of the individual differences in intelligence. The above hypothesis is extensively elaborated by Anderson (1992). In his theoretical work he argues that general intelligence is based firmly, if not only, on information-processing speed. He bases his views on analysis of data from research done in the areas of psychometrics, RT and IT, neuropsychology, and evoked potentials.

Following the recently expressed ideas suggesting the existence of modular brain structure (see for example Gazzaniga, 1985), which present an alternative to the dichotomous (conscious/unconscious) mind structure, the author proposes a model of the minimal cognitive architecture of the mind, represented in Fig. 1 (p. 26).

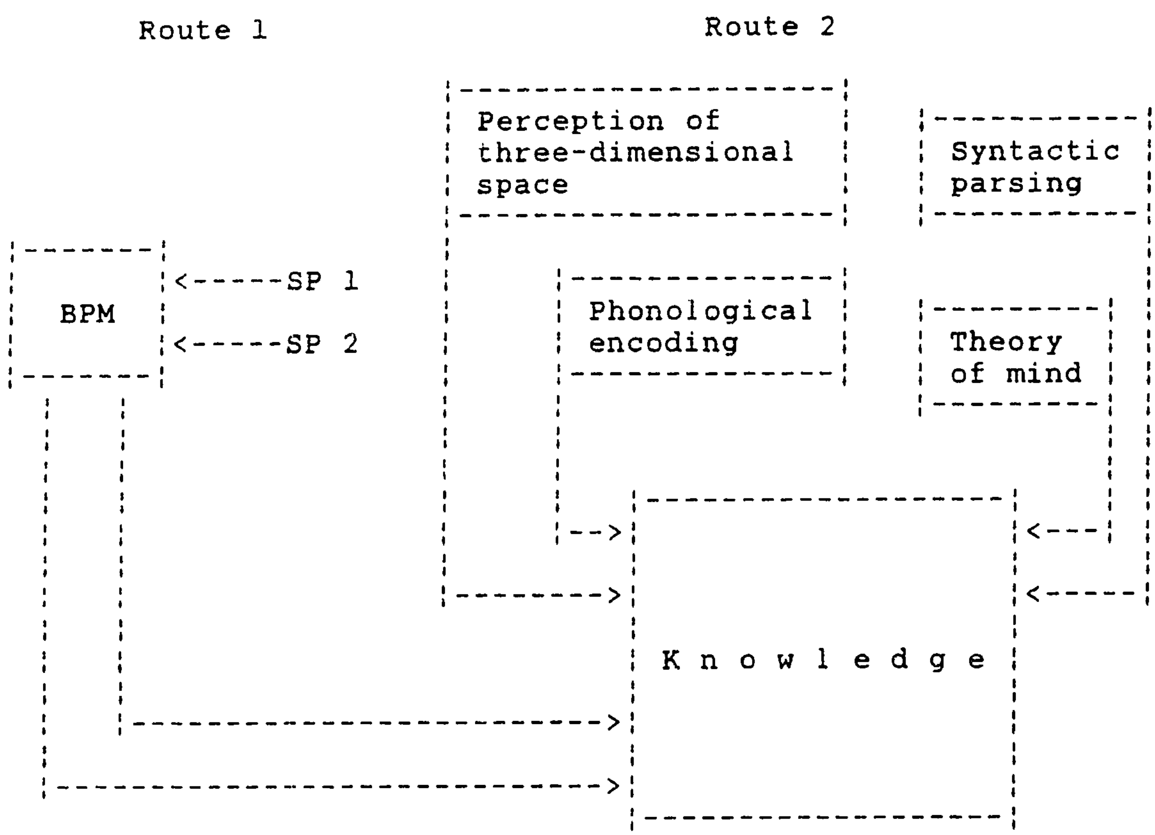

Fig. 1: Minimal cognitive architecture of the mind, adapted from Anderson (1992, p. 191), whose components are as follows:

BPM - Basic processing mechanism
SP 1 - Specific processor 1 (Verbal)
SP 2 - Specific processor 2 (Nonverbal)

Perception of three-dimensional space }
Syntactic parsing }
Phonological encoding }
Theory of mind }
Dedicated modules (the list is not comprehensive)

Route 1 and Route 2 represent the different ways, which are followed by the process of knowledge acquisition. Route 1 illustrates the process of thinking: knowledge is acquired "by the implementation of an algorithm generated by a specific processor" (p. 206). The two specific processors identified so far are verbal and nonverbal. Thus, the information input (of verbal or nonverbal character) is transferred through the respective specific processor to the basic processing mechanism, whose speed constrains the implementation of algorithms.

The basic processing mechanism represents the foundation of the functioning mind and is responsible for individual differences in intelligence. "The basic processing mechanism represents a knowledge-free, biological constraint on thought, and is responsible for the phenomenon psychometricians know as general intelligence ... the speed of the basic processing mechanism is unchanging with cognitive development" (p. 206).

According to the author, a slow basic processing mechanism leads to low intelligence (in the sense of individual differences), because of its lower capabilities of information transfer to the knowledge store (memory), which means that more information available to the sensori input is lost (See Eysenck, 1987; Jensen, 1987 for more detail concerning this process). "Individuals with a slcw basic processing mechanism will be incapable of achieving the complexity of thought possible for individuals with fast basic processing mechanisms. In other words, for individuals of low intelligence some thoughts are unthinkable" (p. 170).

In the process of knowledge acquisition via Route 2, "knowledge is directly given by the dedicated modules" (p. 206). The modules have been shaped and perfected during the process of the evolution of the species. They provide the individual with information which could not be provided by the mechanisms of thought, yet is essential for coping with the environment and, thus, for survival. The maturation of the modules is the main cause of cognitive development. From the model it can be seen that the functioning of the modules is not restrained by the processing speed of the basic processing mechanism.

In this way, Anderson postulates that individual differences in intelligence and cognitive development are based on two different and unrelated cognitive mechanisms. According to him, however, individual differences in intelligence affect cognitive development also through knowledge elaboration, a secondary developmental process. Knowledge elaboration occurs using Route 1, in which case more powerful Route 1 mechanisms are reflected in more elaborate knowledge structures. The maturation of different modules also affects knowledge elaboration by providing more advanced representational systems and alternative representational formats, leading to increased sophistication of the "language of thought" (p. 207). Finally, knowledge elaboration is influenced by the range of individual experiences and as such is a function of age.

Using this model, explanations for some individual differences in abilities and their relation to intelligence can be found. For example, a possible cause for language or mathematics related Learning Disabilities can consist of underdevelopment of the module(s) in charge of the respective operation(s). At the same time, the separate and normally developed basic processing mechanism will be reflected in relatively higher than the restricted ability IQ. In the case of mental retardation or idiots savants, one or more well developed and mature modules can possibly account for the relatively adequate level of the observed ability or abilities, coexisting with a slow basic processing mechanism, which can explain the individual's relatively low IQ.

The theory of Anderson is one of the most comprehensive attempts at explanation of the relationship between intelligence and processing speed to date. It appears to give good arguments supporting the representatives of the opinion that intelligence, or at least the part of it that has to do with processing speed, is to a major extent based on lower level cognitive mechanisms.

Processing speed in the WISC-III

Until recently, as the research reviewed above shows, measures of intelligence were compared with measures of processing speed (reaction time). With its introduction in 1991, the Wechsler Intelligence Scale for Children - Third edition, follows on the American psychometric tradition (Guilford, 1966) and the example of the British Ability Scales (Elliot, 1983) in incorporating a processing speed measure, which becomes a part of the general measure of intelligence. The addition of a new subtest Symbol Search to the second, revised edition of the Wechsler Intelligence Scale for Children, WISC-R, together with the revised and new test items, brought to life a new Processing Speed factor in the four-factor solution, yielded by the factor analysis performed by the test authors (Wechsler, 1991). According to them, the factor accounts for 4-5 % of the variance (p. 190). The same source quotes several studies confirming the best fit of a four-factor solution for the data. Whitworth and Sutton (1993) also describe four factors to be used in interpretation of WISC-III results.

Both Coding and Symbol Search (SS) subtests have loadings on the Processing Speed factor between a low of .52 (SS for age group 11-13 years) and a high of .98 (Coding for age group 6-7 years). The only interruption of the pattern is the loading of .30 of SS for age group 6-7, which is at the limits of non-significance (Wechsler, 1991, p. 191-193). Based on research demonstrating "the stability of factor scores and the stability of the third [Freedom from

Distractibility] and fourth factors across samples" (p. 191), the authors of the WISC-III make a statement in favour of reporting all four factor index scores.

There are, however, different results from other studies. In a factor analysis performed by Sattler (1992), the Processing Speed factor accounts for 10 % of the variance in a three-factor solution (p. 1044). The same author provides us with a theoretical interpretation of the psychological and psychometric meaning of the factor in question, not found in the manual for the WISC-III:

> The term *Processing Speed* describes the hypothesized ability underlying the factor for both item content (perceptual processing) and mental process (speed). This factor appears to reflect the ability to employ a high degree of concentration and attention in processing information rapidly by scanning an array. For the total sample, Coding and Symbol Search have high loadings on the Processing Speed factor (p. 1044-1046).

And further. "The Processing Speed factor score measures the ability to process visually perceived nonverbal information quickly. Concentration and rapid eye-hand coordination may be important components of the Processing Speed factor" (p. 1049).

Sattler does not support the authors of the WISC-III in their recommendation to report factor scores. His advice to clinicians is to "use *them only for evaluating the child's strengths and weaknesses and for generating hypotheses about the child's abilities*" (p. 1050). Little (1992) expresses a similar opinion.

Other problems with assessing individual performance speed are indicated by Kaufman (1992) in his criticism of assigning bonus points for speed in the WISC-III, especially to preschool children. He states that "there is a great variability in the ability levels of individuals who solve problems at different rates of speed ... due largely to non-intellective factors" (p. 157).

The major role speed plays in the WISC-III is likely to have a negative influence on the IQ scores of the children with reflective cognitive style (power thinkers). Possibly in part related to that is the fact that comparative studies found FSIQ, VIQ, and PIQ scores on the WISC-III to be 5 to 7 points lower than the respective WISC-R scores (Post & Mitchell, 1993; Wechsler, 1991).

Prewett and Matavich (1994) did a study of 73 students (50 male, 23 female; 34 white, 39 black) from a large urban school district of low and low-middle socioeconomic status, who were administered the Stanford Binet Intelligence Scale: Fourth Edition (S-B:IV) and the WISC-III for the purpose of comparison. They report that the WISC-III Processing Speed (PS) index score correlated significantly ($p < .01$) with the

S-B:IV Abstract/Visual Reasoning (.41) and Quantitative Reasoning (.44) area scores, as well as with the Test Composite (.41). Saklofske, Schwean, Yackulic, and Quinn (1994) studied 45 children diagnosed with Attention Deficit/ Hyperactivity Disorder (AD/HD), who were administered the WISC-III for the purpose of reassessment after treatment with methylphenidate. They found that the PS index correlated significantly with the index scores of Perceptual Organization (.51) and Freedom from Distractibility (.46). Two of the five lowest subtest scores were on Coding and Symbol Search, which comprise the Processing Speed factor.

Lower than the normal sample Processing Speed index scores of children with unspecified learning disabilities (n = 65) and with Reading Disorder (n = 34), as well as with AD/HD (n = 68) are also reported in the WISC-III manual (Wechsler, 1991). In view of the above Kaufman (1993) expresses the need for more research in order to determine what the new Symbol Search subtest and the new factor measure.

Despite all the criticism, the WISC-III is a reality. It joins successfully the other Wechsler Scales and is being widely used, mostly for psychoeducational purposes. After all, it has excellent reliability, it is easy to use, and its use is certain to continue.

Summary

Experimental studies of the speed of information processing were reviewed. A description of the most commonly used measuring apparatus and terminological definitions were provided. The results of the experimental studies, as well as the conclusions about the possible links between intelligence and speed of information processing are differing and ambiguous.

The explanation of these results, as outlined in the theoretical attempts reviewed, is inconclusive and leads to reiteration of the old argument, in which the predominantly biological determinists of human development are confronted with the representatives of the environmental/social determinism. A cognitive theory, which views speed of information processing as the basis of intelligence is briefly outlined.

Research concerning the new Processing Speed factor of the WISC-III is reviewed. The opinion, that the Processing Speed factor reflects an attempt to integrate a measure of processing speed within a global measure of intelligence, is expressed.

Research Questions

The purpose of the present study is to investigate the diagnostic value of the WISC-III Processing Speed factor score by differentiating between groups of students, who experience a variety of problems interfering in a direct or indirect way with their academic performance and general functioning. The following questions formed the basis for the study:

1. Do the mean scores, obtained by the groups of students diagnosed with a single problem on the variables based on the PS index, as well as on the Cd and SS subtests, which comprise the WISC-III PS factor score, differ significantly from the mean scores obtained by the rest of the sample, consisting of subjects not experiencing the respective problem?

2. Do the mean scores on the variables PS, Cd and SS obtained by the 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 any of the two respective areas studied in each comparison; B) are diagnosed with problems in only one of the two respective areas?

3. What are the correlations between the measures of information processing speed, represented by the amounts of bonus points assigned for quick performance on the WISC-III subtests: Arithmetic, Block Design, Coding, Mazes, Object Assembly, and Picture Completion?

Hypothesis 1: The group of students diagnosed with Visual-Motor Integration (VMI) difficulties is expected to achieve significantly lower mean scores than the rest of the sample on the WISC-III PS index, as well as on both, the Cd and SS subtests.

This is expected to be so, because the problems with perceptual input and visual-motor output are likely to lead to impairment in the overall performance.

Hypothesis 2: The groups of subjects diagnosed with problems in two areas, especially where VMI deficiencies are involved, are expected to achieve significantly lower mean scores on the measures of information processing speed (PS, Cd, and SS variables), when compared to the rest of the sample, not diagnosed with any problems in the two respective areas.

This hypothesis is based on the expectation that more severe overall intellectual impairment will reflect in general decrease of speed of information processing, which is thought to permeate all aspects of intellectual functioning.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

Subjects

The research was done with a clinical non-random sample consisting of 311 elementary, junior high, and high school students referred to the Education Clinic at the University of Alberta for psychological assessment during the years 1992, 1993 and 1994. The typical reasons for referral were low school achievement, behavioral and/or emotional problems, suspected Attention- Deficit/Hyperactivity Disorder, as well as a few cases in which a testing for giftedness was required.

The subjects were between 6-years 1-month and 16-years 7-months of age (average age 10-years and 5-months); 204 males (65.6 %) and 107 females (34.4 %). (See Table 1, Appendix A). The highest number of subjects in the same age group was 63 (20.3 %) - students between 9 and 10 years of age. The lowest number of students of the same age - 8 subjects (2.6 %), was in the age group 16 years and older. Table 2, Appendix A, represents the distribution of the total clinical sample by age. The highest number of students enrolled in the same grade was 64 (20.6 %) - in Grade 4; the lowest - 4 (1.3 %) in Grade 11. Table 3, Appendix A, shows the total sample distribution by school grade. Table 4, Appendix A, shows the number of subjects tested in each year.

Instrumentation

Every subject has been administered the Wechsler Intelligence Scale for Children - Third Edition (WISC-III), as well as an academic achievement test, listed below. All IQ and achievement scores used for comparison are standard with Mean = 100 and Standard Deviation = 15 points. Most of the subjects included in the study have also been administered the Developmental Test of Visual-Motor Integration (Beery) or the Bender Gestalt Perceptual Motor Test. Subjects referred for behavioral/emotional reasons have been administered a behavior or a personality test (e.g., Child Behavior Check List, Behavior Assessment System for Children or similar).

WISC-III. The WISC-III is designed for assessment of children and adolescents between 6 and 16 years of age. It was standardized on a sample of 2,200 children and adolescents, divided into 11 age groups with 100 boys and 100 girls in each age group. It consists of 13 subtests, grouped into 2 scales, as follows:

VERBAL SCALE	PERFORMANCE SCALE
Information	Picture Completion
Similarities	Coding
Arithmetic	Picture Arrangement
Vocabulary	Block Design
Comprehension	Object Assembly
Digit Span*	Symbol Search*
	Mazes*

* Designates a supplementary test

Reliability of the WISC-III. The WISC-III has excellent reliability with coefficients for all 11 age groups ranging between .94 and .97 for the Full Scale IQ, between .92 and .96 for the Verbal Scale IQ, and between .89 and .94 for the Performance Scale IQ. The internal consistency reliabilities of the subtests are lower than those of the three main scales.

The highest average reliability coefficient for the 11 age groups within the Verbal Scale subtests is .87 for Vocabulary; the lowest is .77 for Comprehension. Within the Performance Scale, the respective subtest reliability coefficients range from a high of .79 for Coding to a low of .69 for Object Assembly.

The WISC-III manual (Wechsler, 1991) provides test-retest reliability data for three age groups: 6-7, 10-11, and 14-15. The coefficients reported are respectively .92,

.95, and .94 for the Full Scale; .90, .94, and .94 for the Verbal Scale; and .86, .88, and .87 for the Performance Scale.

Validity of the WISC-III. Some of the factor-analytical studies and their findings for the different age groups, as quoted in the WISC-III manual (Wechsler, 1991) and as done by Sattler (1992), were already mentioned. In addition, criterion validity studies reported the following correlations between the WISC-III Full Scale IQ and the WRAT-R subtest scores: .53 with Reading, .58 with Arithmetic, and .28 with Spelling. There are correlations in the high .50's and .60's reported between the Full Scale IQ from the WISC-III and achievement tests administered in group settings (Wechsler, 1991).

Intercorrelations between the subtests were higher within the Verbal Scale (Mdn r = .55) than within the Performance Scale (Mdn r = .33). The average correlations for the different age groups between the subtests and the Full Scale IQ ranged between .31 and .74 with Mdn r = .58. The five standard subtests from the Verbal Scale correlated higher with Full Scale IQ, as also did Block Design from the Performance Scale. The Vocabulary subtest showed the highest correlation coefficient (.78) with the Verbal Scale IQ; Block Design had the highest correlation coefficient with the Performance Scale IQ.

Achievement Tests. Each subject's individual achievement on school related tasks has been measured using the Canada QUick Individual Educational Test (Canada QUIET), KeyMath Diagnostic Arithmetic Test, Safran Reading Comprehension Test, Wechsler Individual Achievement Test (WIAT), Wide Range Achievement Test - Revised (WRAT-R), Woodcock-Johnson Psycho-Educational Battery (W-J PEB), and Woodcock Reading Mastery Tests - Revised (WRMT-R). The achievement tests administered to the subjects were chosen by the clinicians as responding best to the specific reasons for referral.

For the purposes of this study, results from achievement tests have been used in order to distinguish the subjects with Learning Disabilities (LD) from the rest of the sample. The procedure of determining the presence of LD is described below. In view of the fact that LD is only one of the problematic areas included in this study, only a brief review of the achievement tests' statistical properties is considered sufficient.

Canada QUIET. From the Canada QUIET, the results of the following subtests were used: Arithmetic with reliability coefficient $r = .84$ reported in the test manual (Wormeli & Carter, 1991); Word Identification with $r = .94$, and Passage Comprehension with $r = .84$. Content validity was ascertained by including test items based on Canadian school curriculum and teaching materials, as well as performing empirical item analysis.

WIAT. The test results used from the WIAT are from the subtests Basic Reading, Mathematics Reasoning, and Reading Comprehension. In the test manual (Wechsler, 1992), the reported test-retest correlation coefficients range between .81 and .92 for the subtests. The manual also reports results from studies which found the validity to be adequate. Expert judgement and empirical item analysis was used in assessing the content validity. A comparison with other achievement measures was used to determine the construct validity: the correlations reported range between .42 and .88 (.79 to .87 with Mdn r = .82 for the Basic Reading subtest).

WRAT-R. The results from both Level 1 and Level 2 of the WRAT-R subtests Reading and Arithmetic were used. The test-retest correlation coefficients reported in the test manual (Jastak & Wilkinson, 1984) are .96 for Reading and .94 for Arithmetic (Level 1); .90 for Reading and .79 for Arithmetic (Level 2). Comparative studies with other achievement measures yielded concurrent validity correlation coefficients ranging in the .60's to .80's.

Visual-Motor Integration (VMI) tests. The Developmental Test of Visual-Motor Integration (Beery) and the Bender Visual Motor Gestalt Test (Bender) are the most widely used VMI tests in the assessment field today. They have been in use for several decades with minor revisions and their popularity seems to remain high, based on acceptable reliability. Different scoring systems are used for the

Bender, the most popular of which is the one by Kaufman, which was used also with the sample of this study.

Behavior/Personality Tests. A variety of behavior and personality tests have been administered to the subjects of this study. Although their psychometric properties vary, depending on which behavioral/personality aspect they emphasize, the general opinion, partially confirmed by research, is that their reliability is not very high. This is particularly true of interrater reliability, where information provided by different sources is compared. The same can be said about their validity. Newer measures, like the Behavior Assessment System for Children (BASC, 1992) appear to be better organized and to represent more and well systematized information. More research is needed to provide evidence of the psychometric properties of such measures. That is why, in order to assure higher reliability, a diagnosis based on a behavior and/or a personality test is also compared to the clinical observations and to as many supplementary sources of information as possible.

Procedures and data analysis

The data for the research was collected from the clients' files with the permission of the clinic authorities in charge. All parents or guardians, and the subjects who were 16 years of age and older themselves, have expressed in writing prior to the assessment an agreement for test data from their files to be used for research purposes.

In order to protect anonymity, the files were not removed outside of the premises of the Education Clinic at U of A. The data was entered in a computer spreadsheet using Excel 3 computer software and analyzed using SPSS computer software. The names of the subjects were kept, for reference only, in a different computer file which was never included in any statistical procedures.

The subjects have been assessed at the Education Clinic of the University of Alberta by student-clinicians enrolled in 500- and 600-level courses in individual assessment. All subjects have been administered the WISC-III as a measure of intelligence, an achievement test as a measure of academic performance, and a test of visual-motor integration (VMI). In certain cases, where the referral question suggested the necessity, a behavior or a personality test (behavior checklist or similar) have also been administered.

All testing protocols and assessment reports have been examined by competent supervisors appointed by the Department of Educational Psychology at the U of A for accuracy of administration, scoring, and reporting the test results.

Step 1 Group Division

The clinical sample has been divided into different groups for the purpose of making comparisons between the group mean scores from the intelligence test. In every case the comparison was made between two groups, one of which consisted of subjects diagnosed with a certain disorder/ disturbance in one of the areas mentioned previously, and the other group - of subjects not diagnosed with any of these particular problems. That is, there was not one constant control group consisting of the same subjects. This approach was chosen, because the majority of the subjects (250 - 80.3 % out of 311, as can be expected of a clinical sample) have been diagnosed at least with one problem interfering with their academic and/or social functioning. Also, tnis type of classification provides for a broader basis of comparison.

LD Group. The presence of a Learning Disability (LD) has been determined when a subject demonstrated:

1. Average or above average intellectual abilities as measured by the WISC-III Full Scale IQ, which responds to a score of at least 85 or higher.
2. An achievement (Reading and/or Arithmetic) test score of at least one Standard Deviation (15 points) lower than the measure of intellectual ability.
3. Absence of perceptual (visual, hearing) and/or motor disturbances, as well as other conditions leading to possible impairment like mental retardation, behavioral and emotional problems, or diminished educational opportunities.

Based on the traditional comparison mentioned in point 2 between Full Scale IQ (FSIQ) scores and achievement scores, an individual's achievement score in either Reading Recognition or Reading Comprehension, which was more than one Standard Deviation lower than the same individual's FSIQ (16 points or more), puts this individual in the group of Reading LD. A similar discrepancy between an Arithmetic achievement score and FSIQ results in a placement of the individual whose scores are compared in the group of Arithmetic LD.

Siegel (1990) objects to the use of the IQ-achievement discrepancy in determining the presence of LD, pointing out that there are children with lower IQ who can read at an age appropriate level, "so a low IQ score is not a *cause* of poor reading" (p. 126). She proposes instead a cut-off IQ score of 80 to be used in the diagnosis of LD. Siegel appears to be supported by Mishra (1983), who compared factor scores from the WISC-R with achievement scores from the WRAT and found low correlations (.09 to .31) between them. The arguments about the definition of a Learning Disability are beyond the scope of the present study. It seems appropriate, however, to mention that Reschly and Reschly (1979) found that the same WISC-R factor scores, studied by Mishra (1983), were significantly related to achievement as measured by the Metropolitan Achievement Test. Studies done by other authors (Juliano, Haddad & Carroll, 1988; Waldron & Saphire, 1990) appear to support the definition of LD given by Kolligan and Sternberg (1987), which serves as a basis of this research: it "refers to individuals who have a deficit in a specific domain of intellectual functioning, such as reading, calculating, or spelling, yet who also have average or above-average general intelligence" (p. 8).

For the purposes of this study, a group with a spelling LD was not formed because many of the subjects from the sample have not been administered a spelling achievement test. Table 5, Appendix B represents the distribution of the subjects with LD.

AD/HD Group. The diagnosis of AD/HD with or without hyperactivity was made by the student-clinicians based on the previous history provided by the parents/guardians, teachers, physicians and other sources of information, as well as on the clinical observations. For the purposes of comparison, the whole sample was divided twice on the basis of the AD/HD criterion: 1) division based on the presence or absence of AD/HD without hyperactivity; 2) division based on the presence or absence of AD/HD with hyperactivity. Table 6, Appendix B, represents the distribution of the AD/HD subjects.

Behavior/Emotional Problems Group. Both types of problems were included in the same group because of their close (usually causal) relatedness. The diagnosis of behavioral problems was made by the student-clinicians on the basis of behavior and/or personality tests, which were briefly described above, as well as based on previous history and clinical observations. Still, the division of the whole sample on the basis of this criterion is considered less reliable than the other criteria, which represent more readily observable and easier to diagnose conditions. Therefore, the findings related to this group have to be considered with caution. Table 7, Appendix B, represents the membership in this group.

Physical Health Problems Group. The term physical health problem is used in this research as synonymous with General Medical Condition (DSM-IV, 1994). The presence of a health problem was determined on the basis of a diagnosis made by a physician, which was reported and included in the previous history of the subject. This should translate into high reliability of the sample division according to this criterion. However, the possibility of subjects with present health problems, which were not diagnosed and/or not reported at the time of the testing, therefore not included in this group, should also be considered. The membership in this group is included in Table 8, Appendix B.

Visual-Motor Integration (VMI) Deficiencies Group. The subjects included in this group have scored significantly below the level expected on the basis of their age, thus showing at least 1 year developmental delay on a test measuring the level of VMI. The most common tests used to diagnose such problems in the present sample are the Developmental Test of Visual-Motor Integration (Beery) and the Bender Visual Motor Gestalt Test (Bender), which are briefly referred to above. The sample distribution according to this criterion is presented in Table 10, Appendix B.

Bilingual Group. This group differs from the others by virtue of the fact that bilingualism is not considered a diagnosis in the usual sense and in the sense of the above criteria. This group was formed in order to find, whether the condition of being bilingual would influence the speed of information processing on the WISC-III. It includes three types of subjects: 1) subjects born in a country, whose official language is not English; they are commonly described as English as a Second Language (ESL); 2) subjects born in Canada, whose first language is French; 3) subjects, whose first language is English, however, at the time of testing and for at least 1 year prior to that moment they have been enrolled in a French Immersion school. The number of bilingual subjects is presented in Table 9, Appendix B.

All of the comparisons within and between groups at this stage of the analysis were made using One-Way Analysis of Variance (ANOVA) from the Statistical Package for Social Sciences (SPSS), a computer program developed specifically for analyzing data from social science research (Norusis, 1990). This particular statistical method was used, because it is statistically equivalent to a T-test, which is the most appropriate and economical method used for comparison between mean scores of two groups (Glass & Hopkins, 1984). As mentioned previously, the latter was the type of comparison employed in the present study, as best serving the research purpose.

Step 2 Group Division

After completing the above mentioned process and performing statistical analysis, the sample was divided in groups with combined problems, which included subjects simultaneou[illegible] diagnosed with problems in two of the previousl[illegible]ed areas. Since such a process of group integratio[illegible]urally expected to lead to a reduction of the groups[illegible]e, several groups were eliminated. For similar reasons the different LD groups were put together and formed a group with unspecified LD, which is included in the analysis below. In order to preserve some degree of generalizability of the results from the comparisons between group means, 6 combined problem groups were included in the data analysis:

- AD/HD + LD (24 subjects)
- AD/HD + VMI problems (29)
- Behavioral/Emotional problems + LD (36)
- Behavioral/Emotional + VMI problems (27)
- Bilingualism + LD (19)
- LD + VMI problems (38).

Tables 11 to 16, Appendix C, show the distribution of the subjects in the combined problems groups.

At this stage of the analysis were employed a One-Way

ANOVA and the statistical method of multiple comparisons. For every comparison, the whole sample was divided into 3 groups:

A) a group consisting of subjects simultaneously diagnosed with problems in two of the areas described above;

B) a group consisting of subjects, who did not experience any of the particular problems in group A, and

C) a group consisting of subjects, who were diagnosed only with the first problem, as pointed out in group A - this group was included in the analysis in order to account for and remove the influence of the residual of the first variable (presented by the first problem diagnosed) over the rest of the sample (presented by group B) and, thus, to contribute to purer comparison between groups A and B.

For this part of the research was chosen the Newman-Keuls (NK) method of multiple comparisons, which in its first step is identical to the widely used Tukey method and includes all pairs of means in the post hoc contrast analysis. However, in the NK method, the critical value used to determine the significance of the difference between the group means is not constant and changes depending on the number of means in the comparison. In this way, in the second step of its application, the NK method has a smaller critical value resulting in a higher likelihood of showing significance, and "does not suffer from the overconservatism of the Tukey test, caused by utilizing just a single critical value" (Glass & Hopkins, 1984, p. 376). This method, like the other methods of multiple comparisons, uses the studentized range statistic in the analysis and has been shown to yield accurate results also with unequal group sizes

Bonus Points

As mentioned previously, the WISC-III scoring system emphasizes more strongly than earlier editions of the test the assignment of bonus points for quicker performance. As the system of assignment of bonus points has been designed by the WISC-III authors (Wechsler, 1991) as a measure of processing speed, the differences in the mean numbers of bonus points obtained by the subjects in the different groups were compared for significance. In order to do that with the present sample, variables were created reflecting each subject's amounts of bonus points obtained on the different subtests. These subtests are: one from the Verbal Scale - Arithmetic, and five from the Performance Scale - Block Design, Coding, Mazes, Object Assembly, and Picture Arrangement.

In the case of Coding, bonus points are assigned only to 6 and 7-year old children, whose number amounted to 56 subjects of the total sample. Only 5 children were assigned bonus points. That is why the variable based on the Coding bonus points was not used in further analysis. Tables 17 to 22, Appendix D, show the distribution of the total sample according to the bonus points assigned to the subjects for fast responding.

In order to determine the relationship between the measures of information-processing speed, represented by the bonus points assigned for quick performance on the different WISC-III subtests, Pearson Product-Moment correlations, as well as multiple regression between the Processing Speed index scores and the bonus points variables, were computed.

CHAPTER FOUR

RESULTS

General Characteristics of the Whole Sample

The clinical sample used in this study approximates in its WISC-III scores the sample used by the test authors in the standardization process (Wechsler, 1991). Table 23, Appendix E, presents the mean Full Scale (FSIQ), Verbal (VIQ) and Performance (PIQ) Intelligence Quotients (IQ), the 4 factor index scores, as well as subtests scores of the whole sample (N = 311). From the table is evident that the mean FSIQ (98.88) and the VIQ (98.30) are non-significantly lower than the standardization sample average of 100, and the PIQ (100.02) is at that average. The PIQ has the largest (still non-significantly larger than the average) variance, as expressed by the standard deviation (SD) of 16.39, as long as FSIQ (15.42) and VIQ (15.55) show SD's very close to the standardization sample.

The largest mean score among the four factor scores is the Perceptual Organization (PO) Index, which is slightly above average (Mean = 102.01, SD = 16.42). The other three factor scores were non-significantly lower than the average for the standardization sample: from larger to smaller means: Verbal Comprehension (VC) Index (Mean = 99.00, SD = 15.78), Freedom from Distractibility (FD) Index (Mean = 96.28, SD = 13.53), and Processing Speed (PS) Index (Mean = 96.25, SD =

16.31). As evident from the four factors' SD's, the POI and PSI show the largest variances, and the FDI has the smallest variance. All scores are well within the standard deviations and do not differ significantly from the average SD = 15 for the standardization sample.

The thirteen subtests' mean scores range between a low of 8.75 (Coding) and a high of 11.01 (Picture Completion). All of them are within the SD = 3 suggested by the WISC-III authors as a cut off point of significant difference and do not differ significantly from the Mean = 10 for the standardization sample (Wechsler, 1991). The mean subtest scores fall within the Average range in the classification system of ability levels for individual WISC-III subtest scores introduced by Kramer (1993). The subtest SD's range from a low of 2.69 (Digit Span) to a high of 3.82 (Coding).

Thus, one of the two subtests comprising the PS factor (subject of this study), Coding (Cd), has the lowest overall mean subtest score (Mean = 8.75) and the largest variance among all subtests (SD = 3.82). The other subtest serving as a base for the PS factor, Symbol Search (SS) has a Mean = 9.51 and an SD = 3.33, which are closer to the average scores of the standardization sample.

These results show that the sample used in this study is similar to the standardization sample described by the authors of the WISC-III (Wechsler. 1991) and, therefore, the research results can be generalized to a wider population.

However, keeping in mind the fact that the sample consists of clinical referrals, it seems more appropriate that the generalizability of these findings be limited to clinical population.

Tests of Homogeneity of Variance

The Levene Test for homogeneity of variance was performed because of the difference in the sizes of the groups of subjects included in the different comparisons, in order to determine whether One-Way ANOVA would be an appropriate method for statistical analysis. The results did not indicate any significant differences on the PS index, Cd or SS subtest scores.

One-Way ANOVA was calculated in each case of comparison in order to determine possible significant differences between the PS index group mean scores. The same method was applied in the comparisons of the mean scores on Cd and SS subtests in order to determine their relative contribution to any significant difference found on the PS index. As indicated previously, the Newman-Keuls method of multiple comparisons was chosen where three group means were compared, as in the case of the groups derived in stage 2 (Chapter 3). The ANOVA and Newman-Keuls multiple range tests results are presented in Tables 24 to 32, Appendix E, and Tables 33 to 68, Appendix F.

The One-Way ANOVA analysis included the variables Sex and Grade, as well. The results indicate that significant differences on the PS index were produced between male and female subjects. The comparison performed between the groups of male (n = 204) and female (n = 107) subjects showed that the male group obtained significantly lower scores than the female group on both, the PS index (Males: Mean = 94.26 vs. Females: Mean = 100.38; p = .0017) and the Cd subtest (Males: Mean = 8.20 vs. Females: Mean = 9.89; p = .0002). The ANOVA results are presented in Tables 24 to 26, Appendix E.

The overall comparison of the means of the 11 groups, formed according to Grade membership, yielded results approaching significance only on the variable Cd (p = .0693). The multiple pairwise comparisons using the Newman-Keuls method did not yield any significant differences on this variable.

<u>Research Question 1:</u>

Do the mean scores obtained by the groups of students diagnosed with a single problem on the variables based on the PS index, as well as on the Cd and SS subtests, which comprise the WISC-III PS factor score, differ significantly from the mean scores obtained by the rest of the sample consisting of subjects not experiencing the respective problem?

In order to answer the above question a series of comparisons between group means on the Processing Speed (PS) index and the subtests Coding (Cd) and Symbol Search (SS) was performed. Each comparison was made between 2 group means using the method One-Way ANOVA from the SPSS (Norusis, 1990). The first group in every comparison consisted of subjects diagnosed with a single problem in the areas of AD/HD, behavioral/emotional problems, physical health problems, LD's, and VMI deficiencies, as well a group of bilingual subjects. The second group in each comparison consisted of the subjects from the rest of the sample, who did not experience the respective problem. In two cases were found significant differences between group means.

In the first case, the group of subjects, who have been diagnosed with various physical health problems (n = 27) achieved scores significantly lower than the rest of the sample (n = 284) not experiencing any reported health problems, on all three variables. On the PS index the group with health problems obtained a Mean = 88.44, compared to the Mean = 97.11 for the rest of the sample (p = .0084). The respective numbers for the subtest scores are:

Cd: Mean = 7.03 for the health problems group vs. Mean = 8.95 for the rest (p = .0134), and

SS: Mean = 8.22 vs. Mean = 9.64 (p = .0335).

The results of this comparison are presented in detail in Tables 27 to 29, Appendix E.

The second comparison yielding significant difference in this part of the research was between the group of subjects diagnosed with VMI deficiencies (n = 112) and the rest of the sample (n = 199), who did not experience difficulties in this area. The group with VMI problems scored significantly lower than the rest of the sample on all three variables, as follows:

PS index: Mean = 89.83 for the VMI problems group vs. Mean = 100.04 for the rest (p = .0000);

Cd: Mean = 7.42 for the VMI problems group vs. Mean = 9.54 for the rest (p = .0000);

SS: Mean = 8.32 for the VMI problems group vs. Mean = 10.20 for the rest (p = .0000).

As indicated by the probability level, the differences are highly significant on all three variables. For more detailed results of this comparison, see Tables 30 to 32, Appendix E.

In summary, the ANOVA performed so far indicated that three comparisons between group means produced significant differences on the variables measuring speed of information processing (PS index, Cd, and SS):

1) male subjects scored significantly lower than female subjects on the PS index and on the Cd subtest;

2) the groups based on a single-problem diagnosis produced significant differences, as follows:

A) subjects diagnosed with problems related to physical health achieved significantly lower scores than subjects without health problems on all three variables;

B) subjects diagnosed with VMI deficiencies scored significantly lower than subjects not experiencing problems in this area on all three variables.

Research Question 2:

Do the mean scores on the variables PS index, Cd and SS obtained by the 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 any of the two respective areas studied in each comparison; B) are diagnosed with problems in only one of the two respective areas?

In order to answer this question, a series of One-Way ANOVA as well as multiple comparisons were performed using the Newman-Keuls (NK) method, which was chosen for reasons described in Chapter 3. Each comparison was made on one of the three variables (PS index, Cd and SS) between the mean scores of three types of groups:

A) subjects diagnosed simultaneously with problems in two of the previously described areas, which changed with every comparison;

B) subjects not diagnosed with problems in any of the respective two areas;

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

Significant differences were found in seven cases involving a dual diagnosis in two of the following areas: AD/HD, behavior/emotional problems (BEP), LD, VMI deficiencies and one case including bilingual subjects.

Three of the double-diagnosis groups appear twice in the analysis. These include subjects diagnosed with:
1) AD/HD and VMI deficiencies (AD/HD + VMI or VMI + AD/HD);
2) BEP and VMI deficiencies (BEP + VMI or VMI + BEP; and
3) LD and VMI deficiencies (LD + VMI or VMI + LD).
This is so, because the above identical couples of groups were compared to different non-diagnosis groups (without the respective dual diagnosis in the different cases). In the first part of the analysis, including the first three comparisons described below, the non-diagnosis groups were formed by accounting for the residual influence of the first problem area. For example, in the case, where AD/HD + VMI group is compared to a non-diagnosis group, the influence of the group diagnosed with AD/HD but not VMI problems is accounted for.

In the second case (the last three comparisons), where VMI + AD/HD group is compared to a non-diagnosis group, the influence of the group diagnosed with VMI but not AD/HD is accounted for. This resulted in differences between group sizes and subjects included in the non-diagnosis groups in the first three and the last three comparisons.

The first comparison, which produced significant differences, was made between the mean scores of the following groups:

A) subjects diagnosed with AD/HD and VMI problems (AD/HD + VMI, n = 29);

B) subjects not diagnosed with either AD/HD or VMI (Neither, n = 254);

C) subjects diagnosed with AD/HD but not VMI difficulties (AD/HD no VMI, n = 28).

The results from the One-Way ANOVA yielded significant overall differences between the group means on the variables PS (p = .0147) and SS (p = .0173). The comparison closely approached significance on the variable Cd (p = .0578). The pairwise NK comparisons indicated that the dual diagnosis group (AD/HD + VMI) scored significantly lower than the single-diagnosis group (AD/HD no VMI) and the group without a diagnosis on the PS and SS variables, as follows:

AD/HD + VMI: PS Mean = 91.72, SS Mean = 8.52;
AD/HD no VMI: PS Mean = 102.43, SS Mean = 10.61;
Neither: PS Mean = 101.65, SS Mean = 10.13.

The results are presented in Tables 33 to 36, Appendix F.

The second comparison, which indicated significant differences, was made between:

A) subjects diagnosed with behavior/emotional + VMI problems (BEP + VMI, n = 27);

B) subjects not diagnosed with problems in either of the above areas (Neither, n = 229); and

C) subjects diagnosed with behavior/emotional but not VMI problems (BEP no VMI, n = 55).

The above quoted comparison using One-Way ANOVA yielded significant difference between the three group means on the variables PS (p = .0064) and Cd (p = .0040). The pairwise comparisons with the NK method showed that the subjects diagnosed with problems in both behavior/emotional and VMI areas (PS Mean = 88.92; Cd Mean = 6.96) scored significantly lower than the two remaining groups: the subjects without any of the above diagnosis (Neither: PS Mean = 96.13; Cd Mean = 8.72) and the subjects diagnosed with behavior/emotional but not VMI problems (BEP no VMI: PS Mean = 101.00; Cd Mean = 9.93). In addition, the second group (Neither) showed significantly lower scores than the third group (BEP no VMI). The ANOVA and multiple comparisons results are presented in Tables 37 to 40, Appendix F.

The third comparison yielding significant differences was between the following groups:

A) subjects diagnosed with unspecified LD + VMI problems (LD + VMI, n = 38);

B) subjects not diagnosed with problems in any of these two areas (Neither, n = 1[illegible] ; and

C) subjects diagnosed with unspecified LD but not VMI problems (LD no VMI, n = 89).

The One-Way ANOVA showed highly significant differences between the group means on all three variables: PS (p = .0000), Cd (p = .0001) and SS (p = .0023). The NK pairwise comparisons indicated that the group diagnosed with LD but not VMI problems scored significantly higher than bot other groups, as follows:

LD no VMI: PS Mean = 102.77, Cd Mean = 10.21, SS Mean = 10.4

Neither: PS Mean = 94.52, Cd Mean = 8.36, SS Mean = 9.3

LD + VMI: PS Mean = 90.28, Cd Mean = 7.47, SS Mean = 8.42

These result are presented in more detail in Tables 41 to 46 Appendix F.

The fourth comparison was made between the bilingual subjects diagnosed with unspecified LD (n = 19) and the two groups of subjects who were:

A) non-bilingual diagnosed with LD (n = 108), and

B) non-bilingual without LD (Neither, n = 184).

The r sults only approached significance on the variables PS (p = .0550) and Cd (p = .0662). However, the NK multiple comparisons revealed a somewhat unexpected result: the non-bilingual subjects diagnosed with LD scored significantly higher on both PS and Cd variables than the subjects, who neither had LD nor were bilingual. The non-bilingual LD grou obtained a PS Mean = 98.86 and a Cd Mean = 9.36 vs. the PS Mean = 94.52 and a Cd Mean = 8.36 for the other group (Neither). These results are presented in Tables 47 to 50, Appendix F.

The fifth comparison yielding significant difference was between the mean scores achieved by the following groups

A) subjects diagnosed with VMI problems and AD/HD

(VMI + AD/HD, n = 29);

B) subjects not diagnosed with problems in any of those two areas (Neither, n = 199), and

C) subjects diagnosed with VMI deficiencies but not with AD/HD (VMI no AD/HD, n = 83).

The results indicated highly significant overall difference between the three means for all three variables (p = .0000 for PS, Cd and SS). The NK pairwise comparisons showed that the subjects, who did not have any of the above diagnoses (Neither) scored significantly higher than the other two groups on all three variables The respective means were as follows:

Neither: PS Mean = 100.04, Cd Mean = 9.54, SS Mean = 10.20;
VMI + AD/HD: PS Mean = 91.72, Cd Mean = 7.93, SS Mean = 8.52;
VMI only: PS Mean = 89.18, Cd Mean = 7.25, SS Mean = 8.25.
These results are presented in more detail in Tables 51 to 56, Appendix F.

The sixth comparison resulting in significant differences was made between the mean scores of the groups of:

A) subjects diagnosed with VMI and behavior/emotional problems (VMI + BEP, n = 27);

B) subjects not diagnosed with problems in either of those areas (Neither, n = 199); and

C) subjects diagnosed with VMI but not behavior/emotional problems (VMI no BEP, n = 85).

Again, as in the previous case, the overall difference variables (p = .0000 for PS, Cd and SS). The NK pairwise comparisons indicated that the group without diagnosis in an of the two areas (Neither: PS Mean = 100.04, Cd Mean = 9.54, SS Mean = 10.20) achieved significantly higher scores than the other two groups on all three variables. The group C (VMI no BEP) achieved PS Mean = 90.12, Cd Mean = 7.57 and SS Mean = 8.29. The dual diagnosis group A (VMI + BEP) obtaine lowest means of all three groups: PS Mean = 88.92, Cd Mean 6.96 and SS Mean = 8.40. The results of this comparison are presented in Tables 57 to 62, Appendix F.

The seventh and last comparison producing significant differences was made between the means of the following groups:

A) subjects diagnosed with VMI problems and unspecified LD (VMI + LD, n = 38);

B) subjects without a diagnosis in any of these two areas (Neither, n = 199), and

C) subjects diagnosed with VMI problems but not with LD (VMI no LD, n = 74).

As in the previous two cases, the overall comparison between the three group means showed highly significant differences on all three variables (p =.0000 for PS, Cd, and SS). The mean scores for the three groups are as follows:

Neither: PS Mean = 100.04, Cd Mean = 9.54, SS Mean = 10.20;
VMI + LD: PS Mean = 90.28, Cd Mean = 7.47, SS Mean = 8.42;

VMI no LD: PS Mean = 89.60, Cd Mean = 7.40, SS Mean = 8.27. The NK pairwise comparisons indicated that the group without any diagnosis in the above areas (Neither) scored significantly higher than the other two groups (with a dual and a single diagnosis) on all three variables. These results are presented in Tables 63 to 68, Appendix F.

In summary, seven cases of comparison between mean scores on PS index, Cd, and SS variables obtained by groups based on dual diagnosis using One-Way ANOVA and Newman-Keuls multiple comparisons method produced significant differences:

1) subjects diagnosed with AD/HD and VMI problems scored significantly lower than subjects diagnosed with AD/HD but not VMI difficulties and subjects not diagnosed with problems in either of the two areas;

2) subjects diagnosed with behavior/emotional problems (BEP) and VMI deficiencies scored significantly lower on PS and Cd variables than subjects not diagnosed with any of the above, as well as subjects experiencing behavior/emotional but not VMI problems; subjects not diagnosed in any of the two areas scored significantly lower on PS and Cd variables than subjects diagnosed with BEP but not with VMI difficulties;

3) subjects diagnosed with unspecified LD, who did not experience VMI deficiencies, scored significantly higher than subjects diagnosed with both LD and VMI problems and subjects not having either of the two diagnoses on all three

measures of processing speed;

4) non-bilingual subjects diagnosed with LD scored significantly higher on the PS and Cd variables than the non-bilingual subjects without the LD diagnosis;

5) subjects diagnosed with VMI and AD/HD and subjects diagnosed with VMI without AD/HD scored significantly lower than subjects not having either of the two diagnosis on all three variables;

6) subjects diagnosed with VMI and behavioral emotional problems (BEP) and subjects diagnosed with VMI without BEP scored significantly lower than subjects without any of the two diagnoses on all three variables;

7) subjects diagnosed with VMI and unspecified LD and subjects diagnosed with VMI without LD scored significantly lower than subjects without a diagnosis in either of the two areas.

<u>Research Question 3:</u>

What are the correlations between the WISC-III Processing Speed Index and the measures of information-processing speed, represented by the amounts of bonus points assigned for quick performance on the WISC-III subtests: Arithmetic, Block Design, Coding, Mazes, Object Assembly, and Picture Completion?

In order to answer this question Pearson Product-Moment correlations were computed between all the bonus points variables and the PS index for the whole sample. For comparison only, a variable based on the Full Scale IQ scores was included. Although the results for the bonus points variable based on the Coding subtest are reported below, they are not considered generalizable, as the number of subjects, who were eligible to receive bonus points on this subtest were n = 56 (6 and 7-year old students only) out of the whole sample of N = 311, and only 5 subjects actually were assigned bonus points on this subtest.

The variables based on the bonus points assigned on the subtests Coding (Cd_BP), Block Design (BD_BP), and Picture Arrangement (PA_BP) showed low but significant correlations with the subjects' PS factor scores at the 95 % level of significance ($p < .05$). The correlations of the bonus points variables with the PS index had the following values: Cd_BP ($r = .28$, $p = .035$), BD_BP ($r = .13$, $p = .022$), PA_BP ($r = .16$, $p = .006$). Table 69, Appendix F, represents the correlations between the Processing Speed factor scores and the bonus points variables.

The variable based on the bonus points assigned on the Mazes subtest correlated negatively ($r = -.01$, $p = .772$), though not significantly with the PS index. A Multiple Regression Equation method was employed in order to find out what portion of the PS index can be predicted from the bonus points variables. The results indicated that the bonus points variables accounted for 24.19 % of the variance of the

Processing Speed factor.

For comparison only, the variable based on the WISC-III FSIQ correlated significantly with all bonus points variables except Coding (r = -.20, p = .138). The highest significant correlation of FSIQ was with BD_BP (r = .41, p = .000), the lowest - with Mazes_BP (r = .16, p = .005). The bonus points variables accounted for 44.56 % of the FSIQ variance.

Hypothesis 1:

The group of students diagnosed with Visual-Motor Integration (VMI) difficulties is expected to achieve significantly lower mean scores than the rest of the sample on the WISC-III PS index, as well as on both Cd and SS subtests.

This hypothesis was substantiated by the results of the study obtained in the first part of the analysis. As pointed out earlier in ' chapter, under Research Question 1, he group of subjects diagnosed with VMI deficiencies (n = 11.) scored significantly lower than the group without the above diagnosis (n = 199) on all three measures of information-processing speed. On the PS index the VMI group achieved a Mean = 89.83 vs. Mean = 100.04 for the non-VMI group. The respective mean scores for the Cd subtest are Mean = 7.42 (VMI group) vs. Mean = 9.54 (non-VMI group) and for the SS subtest Mean = 8.32 (VMI group) vs. Mean = 10.20

(non-VMI group). The differences in all three cases are highly significant, as indicated by the significance probability level of p = .0000 for the PS index, Cd, and SS variables. These results are presented in more detail in Tables 30 to 32, Appendix E

The above finding gives more credibility and support the assumption that the presence of deficiencies in the area of visual-motor integration can lead to lower information-processing speed, as measured by the WISC-III PS index and the scores on the two subtests, which comprise the Processing Speed factor.

<u>Hypothesis 2:</u>

The groups of subjects diagnosed with problems in two areas, especially where VMI deficiencies are involved, are expected to achieve significantly lower mean scores on the measures of information-processing speed (PS, Cd, and SS variables), when compared to the rest of the sample not diagnosed with any problems in the respective two areas.

This hypothesis was supported in part by the results from the comparisons between group means described earlier in this chapter under Research Question 2. The groups of subjects simultaneously diagnosed with problems in two of the following areas: AD/HD, behavioral/emotional problems (BEP), unspecified LD, and VMI deficiencies, produced significant differences on the PS, Cd, and SS variables.

In three cases, subjects, whose first diagnosis was in the area of VMI deficiencies and whose second diagnosis involved either AD/HD, BEP, or LD, showed significantly lower scores than subjects with no diagnosis in either of the two areas on all three variables, when the influence of a single diagnosis with VMI deficiencies was accounted for in the comparative analysis (Tables 51 to 68, Appendix F).

In two additional cases: 1) subjects diagnosed with AD/HD and VMI problems scored significantly lower than subjects without either diagnosis on the PS and SS variables, when the influence of a single AD/HD diagnosis was accounted for (Tables 33 to 36, Appendix F); 2) subjects diagnosed with BEP and VMI problems scored significantly lower than subjects without any diagnosis in both areas on the PS and Cd variables, when the influence of a single BEP diagnosis was accounted for (Tables 37 to 40, Appendix F).

The above five cases, which involve invariably a diagnosis of VMI difficulties, support hypothesis 2 as far as the PS index is concerned and also, to a big extent (four cases each), as far as Cd and SS variables are concerned. They support further the previously stated (in hypothesis 1) notion that VMI deficiencies may be associated with decrease in the speed of information-processing and provide some foundation for the consideration that multiple impairments (involving more than one area of the individual's functioning) can also be related to such decrease. This finding can be regarded as supporting the notion of the fundamental role, which information-processing speed is thought to play in the overall cognitive functioning of the mind, expressed by Anderson (1992).

However, some of the findings were unexpected and do not support, if not directly oppose, the hypothesis. They involve two cases of comparison between group means, included in this chapter under Research Question 2. Both cases involve a diagnosis of LD:

1) subjects with a single diagnosis of unspecified LD scored significantly higher than subjects having both LD and VMI diagnosis (as expected) and also significantly higher than subjects not having either diagnosis on all three variables (Tables 41 to 46, Appendix F);

2) unilingual subjects diagnosed with unspecified LD scored higher than unilingual subjects without LD on the PS and Cd variables after the influence of the bilingual group diagnosed with unspecified LD has been accounted for (Tables 47 to 50, Appendix F).

Somewhat paradoxically, the last two cases demonstrate that a diagnosis of unspecified LD is associated with the presence of increase in information-processing speed, as measured by the WISC-III Processing Speed factor.

<u>Summary</u>

The sample used in the present study approximates the

WISC-III standardization sample in its IQ, factor, and subtest scores. The group mean scores on the variables PS index, and in most cases Cd and SS subtests, which are under study in this research, showed significantly lower values in the groups of males compared to females, and in two cases of a single-area diagnosis: subjects diagnosed with either physical health or VMI problems compared to groups of subjects without diagnosis in the respective areas.

Subjects simultaneously diagnosed with deficiencies in two areas (dual diagnosis) produced significant differences on the above variables in seven cases. Six of them include VMI problems with other areas involved being AD/HD, behavior/emotional problems, and unspecified LD. The dual diagnosis groups obtained significantly lower mean scores when compared to groups of subjects who were not diagnosed with problems in either of the two respective areas.

Hypothesis 1, stating that subjects experiencing VMI deficiencies were expected to achieve significantly lower scores on the variables measuring speed of information-processing, was confirmed by the results from the analysis included in Research Question 1.

Hypothesis 2, according to which subjects with a dual diagnosis, especially in cases involving VMI difficulties, were expected to show significantly lower scores than subjects without any diagnosis in the respective two areas on the above variables, was confirmed in part by the results from the analysis included in Research Question 2. Unexpectedly, subjects with a single diagnosis in the area of unspecified LD scored significantly higher than subjects without an LD diagnosis (in one case on PS and Cd and in one case on all three variables).

The variables based on the bonus points assigned for quick performance on six of the thirteen WISC-III subtests (one verbal and five non-verbal) showed low but significant correlations with the PS factor scores on three occasions (Block Design, Coding, and Picture Arrangement). The bonus points variables accounted for 24.19 % of the Processing Speed factor variance.

CHAPTER FIVE

DISCUSSION

The purpose of the present study was to examine the diagnostic power of the WISC-III Processing Speed Index to distinguish between groups of subjects diagnosed with difficulties in various areas, interfering with their academic functioning. The problem areas included in the study were Attention Deficit/Hyperactivity Disorder, behavior/emotional difficulties, Learning Disabilities, physical health problems, and Visual-Motor Integration deficiencies. Bilingual subjects were included as a separate group. The relationship between the variables created on the basis of the bonus points assigned for quick performance and the WISC-III Processing Speed factor was also examined.

This chapter will discuss the following: comparison of the present results to previous research, related to the WISC-III Processing Speed factor, possible causes leading to the results, and implications for the practice of psychoeducational assessment.

Comparison of current findings to previous research

At present few studies concerning different aspects of the performance on the WISC-III have been published, therefore studies of the WISC-R will be referred to as well. Although some authors report results from a thorough research conducted on the WISC-III (Kamphaus & Platt, 1992; Kramer, 1993), neither of them covers in great detail the Processing Speed factor and related findings. Recently two Master's theses studying groups with Learning Disabilities and using a sample similar to the one used in the present study have been completed (Everall, 1994; Schoepp, 1994). Therefore, comparing some of the their findings with results of this study is found to be in order.

Everall (1994) reports that no significant differences were found between a control group and two groups diagnosed with reading (RD) and mathematics (MD) Learning Disabilities on the Processing Speed Index (PSI), as well as on any of the subtests, which concurs with the present study. She also found that subjects from the MD and the control groups achieved their lowest factor scores on the PS index and lowest subtest scores on Coding, which is consistent with the findings for the present sample as a whole. Schoepp's (1994) findings include lowest mean subtest scores on Coding for the control group and the group diagnosed with Spelling LD, and also lowest mean score on the Symbol Search subtest for the MD group. The performance on the mentioned subtests is ranked in the lower half among the subtest scores for all LD groups included in the latter study, which places them among the five most difficult ones. In a study done by Saklofske et al. (1994), using a sample of 45 children diagnosed with AD/HD, two of the five lowest subtest scores are achieved on

Coding and Symbol Search.

Similarly, in the present study the clinical sample as a whole achieved its lowest mean subtest performance on the Coding subtest (Mean = 8.75), as long as the mean score on the Symbol Search subtest (Mean = 9.51) was closer to the one achieved by the WISC-III standardization sample (Wechsler, 1991). If we adopt the individual characteristics/abilities the different WISC-III subtests are thought to measure, as presented by Sattler (1992), the above fact leads to the conclusion that subjects from this sample, which represents clinical population, experience as a major drawback the ability to learn a code rapidly. This suggests the presence in the clinical population of problems related to speed and accuracy of eye-hand coordination, short-term memory, and attention skills, as well as lower rate of motor activity, assuming that the level of motivation during testing was normal.

Processing Speed Index

As mentioned previously, the PSI was the lowest of all factor scores for this sample. The different groups with various single and dual diagnoses included in this study showed PSI mean scores between a low of 88.44 for the subjects diagnosed with physical health problems and a high of 91.72 for the subjects diagnosed with AD/HD and VMI problems. This indicates a difference of 7 to 11 points (as least 1/2 standard deviation) below the standard mean of 100 and represents a significant difference for each group with a single or dual diagnosis included in the study. The PSI mean scores of the control groups (no respective diagnosis) used in each comparison ranged from 96.13 to 101.65. It appears that a PSI score of one half standard deviation or more below the standard mean (100) is to be expected from approximately 1/3 to 1/2 of the subjects from clinical population, who have been administered the WISC-III. In roughly 1/2 of these cases, there is a high likelihood of a diagnosis in the areas of physical health or Visual-Motor Integration difficulties.

Physical Health Problems. Although no significant differences were found between the PSI mean scores obtained by the groups with different single and dual diagnoses, the results indicate that the information processing speed of subjects, who experience various physical health problems, appear to be negatively affected to a largest extent (PSI Mean = 88.44, lowest of all groups with a diagnosis). It has to be noted that this group does not include health problems related to visual perception and motor output difficulties, which are paid special attention to in the next section of this chapter, under VMI deficiencies.

The small number of subjects from the whole sample with physical health diagnosis (n = 27) did not allow for further group formation according to more specific general health conditions, without compromising the generalizability of the findings. For the same reason the general area of physical health could not participate and had to be omitted from the second part of the analysis performed with the groups with dual diagnosis.

The above situation makes the possible causes for the findings of this study concerning the health problems group subject to speculations only. One possible cause leading to a decrease of the speed of information-processing in subjects who experience physical health problems can be the stage of their illness. An illness in active phase often leads to lowering the level of the overall functioning of the individual, especially if it is accompanied by pain. A similar outcome is reached when an excessive amount of attention is devoted to the illness by the subject him/herself and others from his/her environment, leading to concentration on the personal condition of morbidity and poor performance on many kinds of tasks, including intelligence tests.

Unfortunately, information stating whether a particular illness experienced by a certain individual was in a stage of remission or an active stage during the assessment was not available for the subjects included in this group. Thus, distinguishing between possible physical and psychological causes of the subjects' performance on the WISC-III could not be reached. The highest variability of all groups (PSI SD = 17.25), shown by the physical health problems group suggests that particular subjects have experienced relatively great impairment in executing processing speed related tasks resulting in very low scores, which has contributed to the overall low group mean score. The types of their health problems and the stages of illness remains to be determined in future research with greater number of subjects.

Visual-Motor Integration Problems. The most important finding of this study is the fact that a diagnosis of Visual-Motor Integration (VMI) deficiencies is associated with lower speed of information-processing as far as group data are concerned. This was reflected in significant differences produced on seven occasions: once, when comparing the mean PSI scores of subjects diagnosed with VMI difficulties to those of subjects without that diagnosis, and six times in similar comparisons made between groups representing different cases of dual diagnosis, which invariably involved the area of VMI problems.

In four cases of comparison between PSI group means, the groups with a dual diagnosis scored significantly lower than the groups without any diagnosis in the respective two areas. Three of those cases include subjects diagnosed with VMI and: 1) AD/HD; 2) BEP, and 3) unspecified LD, in which the residual influence of the single diagnosis of VMI problems was accounted for. The fourth one is the case of the group subjects diagnosed with AD/HD and VMI deficiencies, in which the influence of the residual represented by the single diagnosis of AD/HD was accounted for.

The explanation of the above findings points at possible deficiencies experienced by the subjects included in the mentioned groups. According to Sattler (1992), good performance on tests measuring the level of Visual-Motor Integration of an individual requires at least three well developed abilities: "fine motor development, perceptual discrimination ability, and ability to integrate perceptual and motor processes" (p. 361). Copying designs, which is included in both the Beery and the Bender used in this study, involves also shifting of attention between the original design and the copy drawn by the test-taker. All of these abilities are also required for good performance on the Coding and the Symbol Search subtests, which comprise the WISC-III Processing Speed factor.

Therefore, deficiencies in any of the above areas can result in poor performance on VMI tests, as well as on the WISC-III measures of information-processing speed. These may include:

1) problems with input, like misperception or faulty interpretation of the design to be copied;
2) difficulties with output or execution, reflected in faulty or incorrect fine motor response;
3) deficiencies with the integrative or central processing, like faulty short-term memory storage and retrieval systems (Sattler, 1992).

Based on the theory of the minimal cognitive architecture of the mind proposed by Anderson (1992) (previously outlined in Chapter 2, p. 26), it may be hypothesized that subjects who are diagnosed with VMI deficiencies could experience difficulties in both Route 1 and Route 2 of knowledge acquisition. Via Route 1, an impairment can occur at the onset of the process of visual perception. The visual input, presented by the VMI test as a drawing to be copied, enters through the nonverbal specific processor (SP 2) and is acquired through the application of an algorithm generated by this processor. From there, it moves to the Basic processing mechanism (BPM), whose speed constrains the amount of information going through.

As subjects with VMI deficiencies have been shown in this study to operate with significantly lower information-processing speeds than non-VMI diagnosed subjects, it may be assumed that this is due to the lower speeds of their BPM's. Hence, less visual input information is transferred to the knowledge store (memory) and more sensori input is lost (Eysenck, 1987 and Jensen, 1987, provide more details about this process). This creates unfavorable conditions for good performance on VMI tests at the very onset of the perceptual process and can explain the possible nature of the perceptual problems, as well as the integrative and central processing difficulties indicated by Sattler (1992).

The speed of the Basic processing mechanism puts constraints not only on the acquisition, but also on the elaboration of knowledge, thus resulting in individual differences in intelligence. According to Anderson (1992), knowledge elaboration is a secondary developmental process, which occurs via Route 1 and, hence, more powerful Route 1 mechanisms will result in more elaborate knowledge structures. It can be hypothesized that a failure to establish such structures, together with lower speed of information-processing, can also be related to the central processing difficulties leading to poor performance on VMI tests.

An alternative explanation of the presence of VMI deficiencies, not related to information-processing speed could be possible by following the Route 2 of knowledge acquisition described by Anderson (1992). It might be plausible to assume that the module proposed by the author and named "Perception of three-dimensional space" is somehow related to individual's performance on VMI tests. Namely, a delay of its maturation may be referred to as developmental delay, which equals poor score on a VMI test. However, the lack of extensive elaboration concerning the mechanisms of operation of the modules, as well as the fact that the list of modules is incomplete, makes this line of thought at present difficult to follow.

In summary, the theory of the minimal cognitive architecture of the mind proposed by Anderson (1992) appears to provide a relevant basis for the explanation of the results found in the present study, as far as the lower speed of information-processing of subjects diagnosed with VMI deficiencies is concerned. Applied to the information-processing model proposed by Sattler (1992), it seems probable that the low processing speed of these subjects contributes to the limitation of the amount of information let through the sensori input and available for sensori storage and perceptual encoding (p. 600). It may be also plausible to assume that less elaborated knowledge structures restrict the functions of the central processing and the response selection mechanisms of these individuals. The relationship between information-processing speed and motor output on VMI tests appears to be remote and no clear hypothesis in that reference could be formulated.

Other findings

Behavior/Emotional Problems. On two occasions involving BEP and LD the findings were less straightforward and somewhat unexpected. In the first case, the group diagnosed with BEP and VMI problems scored significantly below the group with neither diagnosis, when the influence of the single diagnosis of BEP was accounted for. At the same time, the BEP only group scored significantly higher than the group diagnosed neither with BEP nor with VMI deficiencies. In this case it appears that a diagnosis of behavioral/ emotional problems can be associated with some increase in information-processing speed.

A possible explanation of that fact may be found in the one-on-one character of the testing situation, whose conditions provide a great deal of attention to the test-taker and also limit possible distracters, present in most other situations. All this is expected to bring about (and often does) a temporary symptom relief and in this way to contribute to improved motivation of the individual and diminished influence of the debilitating factors on the test performance. For example, this is very likely in cases of behavior problems associated with mild to moderate anxiety and depression, and this can be a possible scenario relevant to the majority of the subjects represented in this clinical sample, where mild or moderate diagnoses are most common. However, further specification and group formation according to the type or character of the behavioral and/or emotional problems was not performed because of insufficient number of subjects (n = 55) in the BEP group as a whole), which would lead to compromising the generalizability of the findings.

Unspecified Learning Disabilities. Two groups of subjects diagnosed with unspecified LD scored significantly higher than the groups without an LD diagnosis on the PS index:

1) Subjects diagnosed with unspecified LD achieved significantly higher scores than subjects diagnosed with LD and VMI deficiencies, and also higher than the group having

neither of the two diagnoses.

2) Similarly, a group of unilingual subjects with a single diagnosis of LD scored significantly higher than unilingual subjects without an LD diagnosis.

This shows, somewhat paradoxically, that a diagnosis of LD can be associated with increase in speed of information-processing. The present findings are somewhat contrary to the results reported about LD subjects by Kavale and Nye (1985-86). Based on research done on the WISC-R, they report that students diagnosed with LD showed lower level of development of certain abilities, among which is psychomotor speed. The conclusions were based on different score patterns, as the Processing Speed factor was not part of that edition of the Wechsler Intelligence Scale for Children.

The possible explanation of this finding lies in the comparison between the hypothesized nature of the difficulties encountered by subjects diagnosed with LD and the requirements of the subtests measuring processing speed. It has to be noted that, although the nature of the LD in this group is not specified, the group consists of subjects diagnosed either with reading LD, mathematics LD or a combined reading and mathematics LD.

Subjects diagnosed with LD are generally thought to encounter difficulties of mnemonic character, attention difficulties reflected in inadequate executive control functions, and, probably the major problem, inability to analyze tasks resulting in the use of less effective strategies (Wielkiewicz, 1990; Sattler, 1992). However, the study of LD has been focused mainly on deficiencies related to reading and mathematics, both of which rely heavily on language. The notion of non-verbal learning disabilities (Rourke, Del Dotto, Rourke, & Casey, 1990) appears to need more research support.

At the same time, the subtests Coding and Symbol Search, which measure the speed of information-processing, are included in the Performance Scale of the WISC-III and therefore require minimal, if any, knowledge and abilities related to language, except the ability to recognize the written digits in Coding. Rather, the prerequisite for good performance on these subtests are well developed visual-spatial and motor skills. This fact, as well as the assumption based on Anderson's (1992) cognitive theory, that the difficulties experienced by subjects with LD can be related to maturational delay in one or more specific modules, and not a slow Basic processing mechanism, can provide us with some basis to conclude that a diagnosis of LD does not necessarily mean lower processing speed.

This hypothesis appears to be supported by the findings of Schoepp (1994), who used a sample similar to the present one. He reports that the WISC-III Processing Speed index did not correlate significantly with any achievement scores and concludes that probably the PS index measures a trait quite distinct from the skills related to reading, mathematics, and spelling.

The same author also reports that a suppressed PS index mean score is characteristic of LD groups, although, actually the reading LD group scored non-significantly higher (Mean = 97.7) than the control group (Mean = 96.8). The other LD groups: Math LD (Mean = 94.6), Spelling LD (Mean = 93.5), and Combined LD (Mean = 93.4) also did not seem to have scored significantly lower than the control group on the PS index. Similar is the case with the Coding subtest scores in the above study, where the Reading LD group achieved a Mean = 9.3 vs. a Mean = 8.8 for the control and Mathematics LD group, with other LD group mean scores of 7.5 (Spelling LD) and 8.1 (Combined LD). The difference appears somewhat larger on the Symbol Search subtest, where the control group obtained a Mean = 9.7 vs. Mean = 9.5 for the Spelling LD, Mean = 9.0 for the Reading and Combined LD, and Mean = 8.7 for the Mathematics LD group.

It is difficult to explain without speculating why these subjects would achieve significantly higher scores than groups without a diagnosis of LD on the processing speed measures. It is possible that the subjects with reading LD included in this study experienced more auditory-linguistic, as opposed to visual-spatial deficits, which was also pointed out by Schoepp (1994). It can also be hypothesized (although with great caution in view of the lack of data) that the module designated by Anderson (1992) "Perception of three-dimensional space" or other modules with related functions are sufficiently mature or quite well developed in the LD subjects from this sample.

Coding and Symbol Search Results

All of the above described cases of comparison between group means resulted in significant differences on the PS index. In all cases, except one, they also showed significant differences on the variable based on the Coding subtest. The exception is the group of subjects diagnosed with AD/HD and VMI deficiencies, which scored significantly lower than the group without that dual diagnosis on both the PS index and the SS subtest, but not on the Coding subtest. This indicates that the SS subtest was the main contributing factor in distinguishing between the two groups.

Good performance on the Coding and Symbol Search subtests is thought to require similar abilities, namely speed and accuracy, attention and concentration, and short-term memory (Sattler, 1992). The one essential difference in the required abilities appears to be the higher demand for perceptual discrimination placed on the individual by the Symbol Search subtest. This suggests that subjects, who are diagnosed with both AD/HD and VMI difficulties, may experience problems mainly in this area, when compared with subjects without that dual diagnosis. The same can be said about cognitive flexibility (in this case, the ability to shift attention between symbols), which appears to be necessary and, when underdeveloped, may influence the individual's performance on the Symbol Search subtest in a negative direction.

The opposite of the above case is represented by the group diagnosed with both behavioral/emotional problems (BEP) and VMI deficiencies. The subjects from this group scored significantly below the group without the respective dual diagnosis on the PS index and Cd, but not on the SS variable. In this case the major contribution to the significant difference between the group means on the Processing Speed factor score is due to the different performance on the Coding subtest. The observed difference can be explained by the hypothesis that subjects diagnosed with BEP and VMI deficiencies have slower motor output (which will be true, for example, in the case of depression), as well as that they possibly encounter difficulties in the use of the strategy of memorizing the key with the symbols, which normally would lead to higher scores on the Coding subtest. It has to be noted that memorizing is not explicitly suggested, although it exists as an open option for the test-takers.

Bonus Points

The Pearson Product Moment correlations computed for the whole sample between the variable based on the WISC-III

PS index and the variables based on the bonus points assigned to the individuals for quick performance on six subtests showed generally weak, although in some cases significant correlations at the 95 % level of significance ($p < .05$). These include the subtests Block Design ($r = .13$, $p = .022$), Coding ($r = .28$, $p = 035$), and Picture Arrangement ($r = .15$, $p = 006$). The results concerning the Coding subtest are not considered generalizable because of the small sample size, as explained in chapter 4. In the case of the variable based on the bonus points assigned on the Mazes subtest, the correlation with the PS index was negative, though not significant. All of these correlations are commonly considered as quite low and indicate that the WISC-III Processing Speed index and the bonus points from the six subtests measure different abilities.

For comparison, the Pearson Product-Moment correlations were also computed between a variable based on the WISC-III FSIQ and the same bonus points variables. The results indicate higher and significant correlations at the 95 % significance level between FSIQ and all bonus points variables except for Coding, which was negative and non-significant. The highest correlation of FSIQ was with Block Design ($r = .41$, $p = .000$), the lowest - with Mazes ($r = .16$, $p = 005$). It has to be noted that four of the five significant correlations were above .30, which can be considered a moderately strong relationship.

The multiple regression method was employed in the cases of both the WISC-III PS index and the FSIQ in order to determine what portion of the variance can be predicted from the bonus points variables. The results indicate that 24.19 % of the PS index variance was accounted for by the bonus points variables. In the case of FSIQ, this portion was 44.56 %.

From the above findings, it appears that for the clinical sample used in this study the bonus points assigned for quick performance measure a process, which seems to be more closely related to general intelligence than to information-processing speed. They are almost twice as reliable in predicting the overall general ability, measured by the FSIQ, than in accounting for the variance of the speed of information-processing, and thus seem to be more closely associated with "**g**" than with performance speed.

Practical Implications

The results of this study have to be considered with caution, as research related to the WISC-III Processing Speed factor is in its initial stage. More data to be collected and hypotheses to be formulated in this area are necessary before any definitive conclusions can be made. Until then, using factor and subtest scores related to information-processing speed as a basis for diagnostic hypotheses should be made in a careful manner.

The present results concerning the diagnosis of LD raise the awareness to the fact that looking for less general problems (e.g., speed of information-processing) and instead, attempting to pinpoint more specific difficulties experienced by the individuals, will contribute to concrete diagnosis and relevant planning of remediation, which then can be expected to be more effective. The basis for that appears to be provided by the cognitive theory of Anderson (1992) outlined above.

When the process of psychoeducational assessment establishes a diagnosis of VMI deficiencies, this can be compared for confirmation with the individual's WISC-III Processing Speed factor score. In order to generate more detailed hypotheses about the possible nature of the underlying cognitive problems, modifications of the existing testing procedures can be applied. For example, observing the individual's performance on the Coding subtest and noticing the frequency with which the test-taker refers to the key can provide valuable information about the speed of learning and memorizing a code. An idea about the same can be obtained through asking questions about the strategies used by the individual in working on this subtest.

The subtests can be administered without the time limits, which can yield more information indicating whether the nature of the difficulties experienced by the individual is related to processing speed. The extra time taken in the testing session provides valuable data for planning remediation.

In addition, the key of the Coding subtest can be presented to the subject after completion of all WISC-III subtests for a period of 30 seconds to 1 minute. After that, it can be taken away and the subject can be given a blank sheet with all the digits on it and asked to reproduce the codes for each digit. The subject's performance may serve as a basis for assessing his/her short-term sensory abilities and memory. Such data can suggest the possible need for additional assessment and subsequently be compared, for example, to results from neuropsychological instruments for confirmation only.

Kane (1992) offers a number of vision therapy activities to improve the skills measured by the different WISC-III subtests. They can be applied as specific remediation techniques in order to address the various needs of subjects diagnosed with VMI deficiencies.

Implications for Future Research

The need for further study of subjects diagnosed with various physical health problems seems to be warranted, as the information-processing speed of these subjects appear to be influenced in a negative direction to the greatest extent in comparison with all other groups with diagnoses included in this study. Such research can include utilization of matched samples and groups formed according to specific general medical conditions or, if availability of subjects is a problem, groups of diagnoses including related areas of physical health problems. By doing this, the areas associated with the decrease of information- processing speed can be narrowed down and specific recommendations for remediation can be outlined.

The above can also be stated concerning the study of subjects diagnosed with various behavioral and/or emotional problems, who in the present research were included in one group. Performing comparisons on the information-processing speed variables between the mean scores obtained by groups with more specific diagnoses (or groups of diagnoses) in this area can shed more light on the relationship between these two parameters.

Research comparing the types of groups used in this study to a control group will contribute new information on the subject of speed of information-processing and also contribute to obtaining wider generalization of the data outside the clinical population. More specific information can further be obtained through the application of the method of case study to individuals, who appear to demonstrate difficulties related to low speed of information- processing. This method has been successfully applied and found useful in the study of LD (Hooper & Willis, 1989; Rourke et al., 1990).

Summary

The WISC-III Processing Speed Index score of the present sample representing clinical population was the lowest of all four factor scores. This is likely due to the fact that the subjects from the sample as a whole experienced as a major drawback the ability to learn a code rapidly, which is reflected in the fact that the mean score on Coding was the lowest of all subtest scores obtained on the WISC-III.

The groups with various single and dual diagnoses scored between 7 and 12 points lower on the PS index than the control groups without the respective diagnoses, although no significant differences were observed between groups with diagnoses on the same variable. Based on these findings, one third to one half of the clinical population is expected to achieve a PS index score of at least 1/2 Standard Deviation below the standard mean of 100 and approximately 1/2 of these subjects are likely to have a diagnosis of physical health problems or Visual-Motor Integration deficiencies.

There is a need of careful evaluation of subjects diagnosed with physical health problems to distinguish between physical and psychological causes in cases of low performance on the information-processing speed measures. The stage of the illness has to be taken into consideration as well.

The diagnosis of Visual-Motor Integration deficiencies appears to be a major factor associated with a decrease of the speed of information-processing. A possible explanation of the above finding is offered on the basis of the theory of the minimal cognitive architecture of the mind introduced by Anderson (1992). The explanation is focused mainly on problems with perceptual input and, to an extent, on difficulties with integrative or central processing.

Two unexpected findings were observed, in which groups with a single diagnosis scored higher than the control groups without the respective diagnosis on the measures of information-processing speed. These were the cases of subjects diagnosed with behavior/emotional problems and with unspecified Learning Disabilities. The first case was tentatively explained with the beneficial conditions usually created by the testing situation. Anderson's (1992) cognitive theory served again as a framework for the explanation in the second case. The theory postulates independence between intelligence and development and includes specific modules in the structure of the mind, which are in charge of different cognitive abilities. It is assumed that the modules are not influenced by the individual speed of information- processing, which is a characteristic of the so called Basic processing mechanism and remains unchanging during the lifetime.

Subjects diagnosed with AD/HD and VMI deficiencies appear to encounter predominantly perceptual discrimination difficulties reflected in significantly lower scores than the control group on the Symbol Search subtest, but not on Coding. The opposite scoring pattern was observed in subjects diagnosed with behavior/emotional and VMI problems, which is probably due to slower motor output and also to difficulties in the use of the strategy of memorizing.

The variables based on the bonus points assigned on six WISC-III subtests for quick performance showed low, although in three cases significant correlations with the Processing Speed index. It appears that the bonus points measure individual characteristics and processes, which are more closely related to the construct of general intelligence, reflected in the WISC-III Full Scale IQ, than to speed of information-processing.

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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	204	65.5
Female	107	34.5
Total	310	100.0

TABLE 2

Distribution of the total sample by **Age**

Age*	Number of subjects	Percent
6	12	3.9
7	43	13.9
8	40	12.9
9	63	20.3
10	39	12.3
11	31	10.0
12	28	9.0
13	15	4.8
14	20	6.5
15	12	3.9
16	8	2.6
Total	311	100.0

* Age rounded to the lowest year

TABLE 3

Distribution of the total sample by **School Grade**

Grade	Number of subjects	Percent
1	19	5.8
2	43	13.9
3	50	16.1
4	64	20.6
5	36	11.6
6	27	8.7
7	26	8.4
8	17	5.5
9	17	5.5
10	8	2.6
11	4	1.3
Total	311	100.0

TABLE 4

Distribution of the total sample by **Year** of the WISC-III administration

Year tested	Number of subjects	Percent
1992	84	27.1
1993	212	68.1
1994	15	4.8
Total	311	100.0

APPENDIX B

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

TABLE 5

Distribution of the subjects with **LD*** of the total sample

Description	Number of subjects	Percent
No LD	184	58.7
Reading LD*	49	15.8
Mathematics LD*	34	11.0
Reading + Mathematics LD*	44	14.2
Total	311	100.0

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

TABLE 6

Distribution of the subjects with **AD/HD** of the total sample

Description	Number of subjects	Percent
No AD/HD	254	81.6
AD/HD Hyperactivity*	29	9.4
AD/HD Inattention**	28	9.0
Total	311	100.0

* AD/HD Hyperactivity refers to AD/HD, Predominantly Hyperactive-Impulsive type (DSM-IV, 1994);

** AD/HD Inattention refers to AD/HD, Predominantly Inattentive Type (DSM-IV, 1994).

TABLE 7

Distribution of the subjects with **Behavior/Emotional*** problems of the total sample

Description	Number of subjects	Percent
No	229	73.5
Yes	82	26.5
Total	311	100.0

* Behavior/Emotional problems refers to a diagnosis in that broad area made by the student-clinicians based on results from Behaviour Check Lists and Personality Tests, as well as previous history and clinical observations.

TABLE 8

Distribution of the subjects with **Physical Health*** (General medical condition) problems of the total sample

Description	Number of subjects	Percent
No	284	91.3
Yes	27	8.7
Total	311	100.0

* Physical Health problems refer to General Medical Condition (DSM-IV, 1994), a diagnosis made by a physician, reported and included in the previous history of the subject.

TABLE 9

Distribution of the **Bilingual*** subjects of the total sample

Description	Number of subjects	Percent
No	282	90.6
Yes	29	9.4
Total	311	100.0

* Bilingualism refers to three types of subjects:

1) Subjects, whose first language is not English, described as English as a Second Language (ESL);

2) Subjects born in Canada, whose first language is French;

3) Subjects, whose first language is English, however, they have been enrolled in French Immersion Schools for a period of at least 1 year prior to testing.

TABLE 10

Distribution of the subjects with **Visual-Motor Integration*** problems of the total sample

Description	Number of subjects	Percent
No	199	63.9
Yes	112	36.1
Total	311	100.0

* The presence of Visual-Motor Integration problems is suggested by a score on a relevant test (mostly Beery or Bender), which indicates at least 1 year developmental delay.

APPENDIX C

Summary statistics (frequencies) of the dual diagnoses groups

TABLE 11

Distribution of the subjects with **AD/HD** + unspecified **LD** of the total sample

Description	Number of subjects	Percent
No	287	92.3
Yes	24	7.7
Total	311	100.0

TABLE 12

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

Description	Number of subjects	Percent
No	282	90.7
Yes	29	9.3
Total	311	100.0

TABLE 13

Distribution of the subjects with **Behavior/Emotional** problems + unspecified **LD** of the total sample

Description	Number of subjects	Percent
No	275	88.4
Yes	36	11.6
Total	311	100.0

TABLE 14

Distribution of the subjects with **Behavior/Emotional** + **VMI** problems of the total sample

Description	Number of subjects	Percent
No	284	91.3
Yes	27	8.7
Total	311	100.0

TABLE 15

Distribution of the **Bilingual** subjects diagnosed with unspecified **LD** of the total sample

Description	Number of subjects	Percent
No	292	93.9
Yes	19	6.1
Total	311	100.0

TABLE 16

Distribution of the subjects with unspecified **LD + VMI** problems of the total sample

Description	Number of subjects	Percent
No	273	87.8
Yes	38	12.2
Total	311	100.0

APPENDIX D

Summary statistics (frequencies) of the total sample by bonus points

TABLE 17

Distribution of the total sample by bonus points (BP) on the **Arithmetic** subtest

Amount BP	Number of subjects	Percent
0	261	84.7
1	29	9.4
2	8	2.6
3	7	2.3
4	3	1.0
Missing data	3	1.0
Total	311	100.0

Total number of subjects with BP assigned: 47 (15.1 %)

Mean = .253 S.D. = .704

TABLE 18

Distribution of the total sample by bonus points (BP) on the Block Design subtest

Amount BP	Number of subjects	Percent
0	2	.6
1	3	1.0
2	13	4.2
3	30	9.6
4	27	8.7
5	23	7.4
6	29	9.3
7	26	8.4
8	22	7.1
9	11	3.5
10	17	5.5
11	17	5.5
12	13	4.2
13	9	2.9
14	12	3.9
15	7	2.3
16	10	3.2
17	7	2.3
18	9	2.9
19	4	1.3
20	2	.6
21	5	1.6
22	5	1.6
24	4	1.3
25	1	.3
Missing data	3	1.0
Total	311	100.0

Total number of subjects with BP assigned: 310 (99.7 %)

Mean = 8.990 S.D. = 5.542

TABLE 19

Distribution of the total sample by bonus points (BP) on the **Coding*** (Form A) subtest

Amount BP	Number of subjects	Percent
0	51	16.4
2	1	.3
3	2	.6
4	1	.3
5	1	.3
Missing data	255	82.1
Total	311	100.0

Total number of subjects with BP assigned: 5 (1.5 %)

Mean = .304 S. D. = 1.025

* The Coding (Form A) subtest is administered only to 6 and 7-year old students, whose total number of the whole sample was 56 (18.0 %). That is, only these subjects can receive BP on this subtest.

TABLE 20

Distribution of the total sample by bonus points (BP) on the **Mazes** subtest

Amount BP	Number of subjects	Percent
0	4	1.3
3	4	1.3
4	18	5.8
5	24	7.7
6	28	9.0
7	20	6.4
8	26	8.4
9	22	7.1
10	30	9.6
11	34	10.9
12	16	5.1
13	24	7.7
14	19	6.1
15	19	6.1
16	7	2.3
17	5	1.6
18	2	.6
Missing data	9	2.9
Total	311	100.0

Total number of subjects with BP assigned: 299 (96.1 %)

Mean = 9.536   S. D. = 3.758

TABLE 21

Distribution of the total sample by bonus points (BP) on the **Object Assembly** subtest

Amount BP	Number of subjects	Percent
0	146	46.9
1	48	15.4
2	25	8.0
3	22	7.1
4	21	6.8
5	14	4.5
6	11	3.5
7	10	3.2
8	3	1.0
9	2	.6
10	2	.6
11	2	.6
12	2	.6
Missing data	3	1.0
Total	311	100.0

Total number of subjects with BP assigned: 162 (52.1 %)

Mean = 1.825   S. D. = 2.537

TABLE 22

Distribution of the total sample by bonus points (BP) on the **Picture Arrangement** subtest

Amount BP	Number of subjects	Percent
0	1	.3
1	8	2.6
2	27	8.7
3	23	7.4
4	21	6.8
5	21	6.8
6	19	6.1
7	20	6.4
8	10	3.2
9	15	4.8
10	10	3.2
11	8	2.6
12	12	3.9
13	7	2.3
14	14	4.5
15	17	5.1
16	3	1.0
17	8	2.6
18	8	2.6
19	6	1.9
20	8	2.6
21	10	3.2
22	2	.6
23	4	1.3
24	8	2.6
25	4	1.3
26	6	1.9
29	6	1.9
30	1	.3
32	1	.3
35	1	.3
Missing data	3	1.0
Total	311	100.0

Total number of subjects with BP assigned: 307 (98.7 %)

Mean = 10.763 S. D. = 7.686

APPENDIX E

Mean WISC-III scores and One-Way Analysis of Variance for the total sample on the variables PS index, Cd, and SS by the variables Sex, Health, and VMI

TABLE 23

WISC-III average scores for the whole sample (N=311)

WISC-III score	Mean	Standard Deviation
Full Scale IQ	98.80	15.42
Verbal IQ	98.30	15.55
Performance IQ	100.02	16.39
VCI*	99.00	15.78
POI*	102.01	16.42
FDI*	96.28	13.53
PSI*	96.25	16.31
Verbal Subtests:		
Information	9.39	3.18
Similarities	9.95	3.55
Arithmetic	9.28	3.16
Vocabulary	9.49	3.33
Comprehension	10.11	3.61
Digit Span	9.08	2.69
Performance Subtests:		
Picture Completion	11.01	3.21
Coding	8.75	3.82
Picture Arrangement	10.37	3.76
Block Design	9.84	3.60
Object Assembly	9.64	3.23
Symbol Search	9.51	3.33
Mazes	10.33	3.57

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

TABLES 24 - 26

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

TABLE 24

One-Way Analysis of Variance - Variables PS by SEX

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	2631.6921	2631.6921	10.0657	.0017
Within Groups	309	80788.5201	261.4515		
Total	310	83420.2122			

TABLE 25

One-Way Analysis of Variance - Variables CD by SEX

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	201.9370	201.9370	14.1795	.0002
Within Groups	309	4400.6290	14.2415		
Total	310	4602.5659			

TABLE 26

One-Way Analysis of Variance - Variables SS by SEX

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	36.9417	36.9417	3.3488	.0682
Within Groups	309	3408.6275	11.0312		
Total	310	3445.5691			

TABLES 27 - 29

One-Way Analysis of Variance on the WISC-III variables PS index, Cd, and SS by the variable **HEALTH** (Physical Health problems)

TABLE 27

One-Way Analysis of Variance - Variables PS by HEALTH

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	1855.6160	1855.6160	7.0298	.0084
Within Groups	309	81564.5962	263.9631		
Total	310	83420.2122			

TABLE 28

One-Way Analysis of Variance - Variables CD by HEALTH

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	90.2931	90.2931	6.1833	.0134
Within Groups	309	4512.2728	14.6028		
Total	310	4602.5659			

TABLE 29

One-Way Analysis of Variance - Variables SS by HEALTH

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	50.1137	50.1137	4.5605	.0335
Within Groups	309	3395.4554	10.9885		
Total	310	3445.5691			

TABLES 30 - 32

One-Way Analysis of Variance on the WISC-III variables PS index, Cd, and SS by the **VMI** (Variable Visual-Motor Integration deficiencies)

TABLE 30

One-Way Analysis of Variance - Variables PS by VMI

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	7457.4267	7457.4267	30.3352	.0000
Within Groups	309	75962.7855	245.8343		
Total	310	83420.2122			

TABLE 31

One-Way Analysis of Variance - Variables CD by VMI

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	321.8409	321.8409	23.2318	.0000
Within Groups	309	4280.7251	13.8535		
Total	310	4602.5659			

TABLE 32

One-Way Analysis of Variance - Variables SS by VMI

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	253.1808	253.1808	24.5061	.0000
Within Groups	309	3192.3884	10.3314		
Total	310	3445.5691			

APPENDIX F

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

TABLES 33 - 36

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS index and SS by the variable **ADHD_VMI** (Attention Deficit/Hyperactivity Disorder and Visual-Motor Integration problems)

TABLE 33

One-Way Analysis of Variance - Variables PS by ADHD_VMI

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	2632.3322	2632.3322	6.3498	.0147
Within Groups	308	74138.6502	257.0664		
Total	310	85770.9825			

TABLE 34

One-Way Analysis of Variance - Variables SS by ADHD_VMI

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	162.2204	62.2204	6.0257	.0173
Within Groups	308	3567.9200	10.3258		
Total	310	4630.1404			

TABLE 35

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

Mean	Group	AD/HD + VMI	NEITHER	AD/HD NO VMI
91.72	AD/HD + VMI			
101.65	NEITHER			
102.43	AD/HD NO VMI	*	*	

TABLE 36

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

Mean	Group	AD/HD + VMI	NEITHER	AD/HD NO VMI
8.52	AD/HD + VMI			
10.13	NEITHER			
10.60	AD/HD NO VMI	*	*	

TABLES 37 - 40

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS index, Cd, and SS by the variable **BEP_VMI** (Behavior/Emotional and Visual-Motor Integration problems)

TABLE 37

One-Way Analysis of Variance - Variables PS by BEP_VMI

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	2688.2905	1344.1452	5.1280	.0064
Within Groups	308	80731.9217	262.1166		
Total	310	83420.2122			

TABLE 38

One-Way Analysis of Variance - Variables CD by BEP_VMI

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	162.2257	81.1129	5.6263	.0040
Within Groups	308	4440.3402	14.4167		
Total	310	4602.5659			

TABLE 39

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

Mean	Group	BEP + VMI	NEITHER	BEP NO VMI
88.93	BEP + VMI			
96.13	NEITHER	*		
101.00	BEP NO VMI	*	*	

TABLE 40

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

Mean	Group	BEP + VMI	NEITHER	BEP NO VMI
6.96	BEP + VMI			
8.72	NEITHER	*		
9.93	BEP NO VMI	*	*	

TABLES 41 - 46

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS index, Cd, and SS by the variable **LD_VMI** (Nonspecified Learning Disability and Visual-Motor Integration problems)

TABLE 41

One-Way Analysis of Variance - Variables PS by LD_VMI

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	5684.9778	2842.4889	11.2624	.0000
Within Groups	308	77735.2345	252.3871		
Total	310	83420.2122			

TABLE 42

One-Way Analysis of Variance - Variables CD by LD_VMI

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	279.5452	139.7726	9.9583	.0001
Within Groups	308	4323.0208	14.0358		
Total	310	4602.5659			

TABLE 43

One-Way Analysis of Variance - Variables SS by LD_VMI

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	133.6338	66.8169	6.2138	.0023
Within Groups	308	3311.9353	10.7530		
Total	310	3445.5691			

TABLE 44

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

Mean	Group	LD + VMI	NEITHER	LD NO VMI
90.29	LD + VMI			
94.52	NEITHER			
102.78	LD NO VMI	*	*	

TABLE 45

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

Mean	Group	LD + VMI	NEITHER	LD NO VMI
7.47	LD + VMI			
8.36	NEITHER			
10.21	LD NO VMI	*	*	

TABLE 46

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

Mean	Group	LD + VMI	NEITHER	LD NO VMI
8.42	LD + VMI			
9.30	NEITHER			
10.46	LD NO VMI	*	*	

TABLES 47 - 50

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS index and Cd by the variable LD_LANG (Bilingual subjects with unspecified LD)

TABLE 47

One-Way Analysis of Variance - Variables PS by LD_LANG

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	1556.4351	778.2176	2.9279	.0550
Within Groups	308	81863.7771	265.7915		
Total	310	83420.2122			

TABLE 48

One-Way Analysis of Variance - Variables CD by LD_LANG

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	80.4144	40.2072	2.7385	.0662
Within Groups	308	4522.1515	14.6823		
Total	310	4602.5659			

TABLE 49

Student-Newman-Keuls test of Comparison -
Variable PS by Variable LD_LANG

Mean	Group	NEITHER	LD NO LANG	LD + LANG
94.5217	NEITHER			
98.8611	LD NO LANG	*		
100.0526	LD + LANG			

TABLE 50

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

Mean	Group	NEITHER	LD NO LANG	LD + LANG
8.36	NEITHER			
9.36	LD NO LANG	*		
9.57	LD + LANG			

TABLES 51 - 56

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS index, Cd, and SS by the variable **VMI_ADHD** (Visual-Motor Integration problems and AD/HD)

TABLE 51

One-Way Analysis of Veriance - Variables PS by VMI_ADHD

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	7596.4516	3798.2258	15.4286	.0000
Within Groups	308	75823.7607	246.1810		
Total	310	83420.2122			

TABLE 52

One-Way Analysis of Variance - Variables CD by VMI_ADHD

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	331.7206	165.8603	11.9613	.0000
Within Groups	308	4270.8453	13.8664		
Total	310	4602.5659			

TABLE 53

One-Way Analysis of Variance - Variables SS by VMI_ADHD

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	254.6812	127.3406	12.2915	.0000
Within Groups	308	3190.8879	10.3600		
Total	310	3445.5691			

TABLE 54

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

Mean	Group	VMI NO ADHD	VMI + ADHD	NEITHER
89.18	VMI NO ADHD			
91.72	VMI + ADHD			
100.04	NEITHER	*	*	

TABLE 55

Student-Newman-Keuls Test of Comparison - variable CD by Variable VMI_ADHD

Mean	Group	VMI NO ADHD	VMI + ADHD	NEITHER
7.25	VMI NO ADHD			
7.93	VMI + ADHD			
9.55	NEITHER	*	*	

TABLE 56

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

Mean	Group	VMI NO ADHD	VMI + ADHD	NEITHER
8.25	VMI NO ADHD			
8.52	VMI + ADHD			
10.20	NEITHER	*	*	

TABLES 57 - 62

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS index, Cd, and SS by the variable **VMI_BEP** (Visual-Motor + Behavior/Emotional problems)

TABLE 57

One-Way Analysis of Variance - Variables PS by VMI_BEP

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	7487.1055	3743.5528	15.1846	.0000
Within Groups	308	75933.1067	246.5361		
Total	310	83420.2122			

TABLE 58

One-Way Analysis of Variance - Variables CD by VMI_BEP

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	329.5535	164.7768	11.8772	.0000
Within Groups	308	4273.0124	13.8734		
Total	310	4602.5659			

TABLE 59

One-Way Analysis of Variance - Variables SS by VMI_BEP

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	253.4438	126.7219	12.2271	.0000
Within Groups	308	3192.1254	10.3640		
Total	310	3445.5691			

TABLE 60

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

Mean	Group	VMI + BEP	VMI NO BEP	NEITHER
88.93	VMI + BEP			
90.13	VMI NO BEP			
100.04	NEITHER	*	*	

TABLE 61

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

Mean	Group	VMI + BEP	VMI NO BEP	NEITHER
6.96	VMI + BEP			
7.58	VMI NO BEP			
9.55	NEITHER	*	*	

TABLE 62

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

Mean	Group	VMI NO BEP	VMI + BEP	NEITHER
8.29	VMI NO BEP			
8.41	VMI + BEP			
10.21	NEITHER	*	*	

TABLES 63 - 68

One-Way Analysis of Variance and Newman-Keuls multiple comparisons tests on the variables PS index, Cd, and SS by the variable **VMI_LD** (Visual-Motor Integration problems + unspecified Learning Disability)

TABLE 63

One-Way Analysis of Variance - Variables PS by VMI_LD

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	7469.0829	3734.5415	15.1445	.0000
Within Groups	308	75951.1293	246.5946		
Total	310	83420.2122			

TABLE 64

One-Way Analysis of Variance - Variables CD by VMI_LD

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	321.9579	160.9790	11.5828	.0000
Within Groups	308	4280.6080	13.8981		
Total	310	4602.5659			

TABLE 65

One-Way Anlysis of Variance - Variables SS by VMI_LD

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	253.7516	126.8758	12.2431	.0000
Within Groups	308	3191.8176	10.3630		
Total	310	3445.5691			

TABLE 66

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

Mean	Group	VMI NO LD	VMI + LD	NEITHER
89.61	VMI NO LD			
90.29	VMI + LD			
100.04	NEITHER	*	*	

TABLE 67

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

Mean	Group	VMI NO LD	VMI + LD	NEITHER
7.41	VMI NO LD			
7.47	VMI + LD			
9.55	NEITHER	*	*	

TABLE 68

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

Mean	Group	VMI NO LD	VMI + LD	NEITHER
8.27	VMI NO LD			
8.42	VMI + LD			
10.20	NEITHER	*	*	

APPENDIX G

Relationship between the WISC-III Processing Speed factor and the bonus points

TABLE 69

Pearson Product-moment correlation coefficients between the subjects' **Processing Speed Index** (PSI) scores and the **bonus points** (BP) variables

	ARI_BP	BD_BP	CD_BP	MZ_BP	OA_BP	PA_BP
PSI	.05 p=.377	.13* p=.022	.28* p=.035	-.02 p=.772	.08 p=.160	.15* p=.006
FSIQ	.30* p=.000	.41* p=.000	-.20 p=.138	.16* p=.005	.35* p=.000	.38* p=.000
ARI_BP		.49* p=.000	. p= .	.25* p=.000	.45* p=.000	.36* p=.000
BD_BP			.21 p=.118	.46* p=.000	.71* p=. 000	.64* p=.000
CD_BP				-.19 p=.180	.02 p=.859	.31* p=.020
MZ_BP					.39* p=.000	.37* p=.000
OA_BP						.63* p=.000

* Designates significance at p=.05 level

"." is printed if a coefficient cannot be computed

Subtests:
ARI - Arithmetic
BD - Block Design
CD - Coding (Form A)
MZ - Mazes
OA - Object Assembly
PA - Picture Arrangement