University of Alberta

WISC-III Processing Speed and Freedom from Distractibility Factors in Learning Disabled and ADHD Populations

by

Carmen H. Swanson ©

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Dedication

To John

None of this would have been possible without your

love, support, and encouragement.

Thank you.

Abstract

This study examined the WISC-III Processing Speed (PS) and Freedom from Distractibility (FD) factors in children with pure verbal learning disabilities in reading or writing/spelling (LD), pure ADHD (ADHD), combined verbal learning disability and ADHD (LD/ADHD), and no Diagnosis. Do these four groups show significantly different mean PS and/or FD factor subtest scores? The sample involved 224 male and female children aged 6 to 16 years. Results indicated that subjects with LD, ADHD, or LD/ADHD scored significantly lower than the no diagnosis subjects on the PS factor and on the SCAD subtests. Differences on the SCAD subtests are likely attributed to differences on the PS subtests. Theoretical implications of results for LD and ADHD groups are discussed within the context of information processing theory. Specifically, results for the LD group are contextualized within Baddeley's model of working memory and Borkowski et al.'s (1989) model of academic skill development. Results for the ADHD group are contextualized within Barkley's model of ADHD. Results imply that a relationship between a low score on the PS factor and LD or ADHD is not in itself diagnostic of either disorder, but knowledge of this relationship is helpful when trying to determine a child's strengths and weaknesses, and especially for remedial planning.

Preface

Biographical Sketch

This document begins with a biographical sketch and an introduction to how I became interested in the present research. The present line of research began while working towards a master's degree in the Department of Educational Psychology at the University of Alberta. My coursework and practicum experiences focused on child and adolescent psychopathology, and Dr. Janzen taught a course that focused on the psycho-educational assessment of children and adolescents. His course stimulated an interest in psycho-educational assessment and using the WISC-III to assess children's cognitive capacities, and with his guidance, I completed my master's thesis on the WISC-III and examined the WISC-III PS factor in various clinical populations.

Upon completing the coursework for my master's degree, my first work position involved completing psychological assessments on youth and adults with a variety of psychological and psychiatric disorders. This work led to an interest in the diagnosis of learning disabilities and ADHD. I was confused by the many different, and seemingly contradictory, ways of diagnosing these disorders. This interest led to my return to the University of Alberta to work on a Ph.D. in the Department of Educational Psychology.

Both my Ph.D. coursework and practicum placements focused on the assessment and treatment of children and youth with a variety of psychological and psychiatric disorders. These courses included advanced psychological assessment, personality assessment, neuropsychological assessment, as well as various treatment and intervention courses. I was a teaching assistant and clinical supervisor for the department's graduate course in psycho-educational assessment. I completed an advanced psychological assessment practicum at the Glenrose Rehabilitation Hospital in the School-Aged Neuro-developmental Assessment Unit and in the Infant and Preschool Assessment Unit. Other practicum placements included in-patient and out-patient treatment facilities for children and adolescents. A hospital-based internship demanded the assessment and treatment of children and youth experiencing severe psychiatric illness in a youth day-treatment program and in a urgent child and youth assessment unit. Upon completing my internship, I accepted a clinical child psychologist position with the provincial Child and Youth Mental Health Team. In this capacity, I now assess and treat children and youth with wide range of psychological and psychiatric disorders, including those with learning disabilities and/or ADHD.

In summary, both formal and practical experience led to my interest in using the WISC-III to assess children and youth. Kaufman (1994) notes that "The introduction of the fourth factor in the WISC-III is the most critical innovation in the Wechsler scales since the mid- 1940s when Dr. Wechsler decided that he ought to have a test just for children" (p. 209). The research literature suggests that both the PS and FD factors need to be better understood in learning disabled and ADHD populations (e.g., Prifitera & Dersh, 1994; Saklofske, Schwean, Yackulic, & Quinn, 1994; Sattler, 1992b; Schwean, Saklofske, Yackulic, & Quinn, 1993; Swanson, 1997; Ward, Ward, Hatt, Young, & Mollner, 1995; Tiholov, Zawallich, & Janzen 1996; Wechsler, 1991). The main purpose of this research is to better understand these two factors and what they are measuring in learning disabled and ADHD populations. Next, the introductory chapter provides background information regarding the WISC-III and the measurement of children's intelligence.

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A special thanks to my supervisory (Dr. Stewin & Dr. Goldberg) and examining (Dr. Everall & Dr. Leroy) committee, and especially my supervisor, Dr. H.L. Janzen. My committee's support and encouragement were invaluable throughout this process.

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Chapter One

Introduction

Chapter One introduces the WISC-III and the measurement of children's intelligence. Dr. Wechsler's view of intelligence and a history of the WISC-III are provided, followed by the purpose of the study. Lastly, relevant study definitions are reviewed.

Measuring Children's Intelligence

Psychologists have long been interested in examining children's intelligence (Hunt, 1999; Sattler, 1992). One of the most long-standing and popular ways of assessing children's cognitive capacities has been through the Wechsler Intelligence Scales for Children (e.g., WISC; WISC-R; WISC-III) (Sattler, 1992a, b; Kaufman, 1994). The WISC was created in the late 1940's when Dr. Wechsler extended his intelligence scale for adults (i.e., Wechsler-Bellevue Intelligence Scale for Adults) to include easier items for children.

Dr. Wechsler viewed intelligence as a global construct made up of qualitatively different abilities such as abstract reasoning, short-term memory, and social comprehension (Wechsler, 1991). Rather than equaling the *sum* of these abilities, he defined intelligence as *how* these abilities were combined, as well as considering motivational factors as important to understanding intelligence. Importantly, Wechsler emphasized that although psychologists can measure various components of intelligence, intelligence *test scores are not equivalent to intelligent behaviour.*

Prior to Wechsler's creation of the WISC during the 1940's, the only intelligence tests for children were the 1916 and 1937 versions of the Stanford-Binet Intelligence Scale. The Stanford-Binet Intelligence Scales were age-scale formatted which meant that the test items were standardized on groups of different aged children. Test items that were passed by most of the children at a certain age level were determined as appropriate for that age level. Wechsler's interest in developing intelligence scales was motivated by creating a point-scale format. A point-scale format measures the same behaviours or functions at each age and assigns points for correctness, quality, and speed of response.

The WISC evolved into the WISC-R in 1974. Similar to its predecessor (as well as the adult version), the WISC-R consisted of three separate IQ scores: a Full Scale IQ (FSIQ), a Verbal Scale IQ (VIQ), and a Performance Scale IQ (PIQ). A large number of WISC test items (i.e., 72%) were retained in the WISC-R. The WISC-R was standardized on 2200 children across the 6 to 16 year age span (Sattler, 1992). In addition to the three IQ scores, a factor analysis indicated the following three factors: 1) Verbal Comprehension (VC) (measuring informal and formal verbal knowledge), 2) Perceptual Organization (PO) (measuring the interpretation of visual information within a limited time), and 3) Freedom from Distractibility (FD) (measuring the ability to attend, focus and concentrate to auditory/verbal material).

In 1991, the WISC-R was revised into the WISC-III, and in the year 2001, the Wechsler Intelligence Scales for Children continue to be one of psychology's most important instruments for assessing children's cognitive capacities. The WISC-III is a popular choice for clinicians for a variety of reasons. It has excellent reliability, good validity, and is viewed as a good measure of intelligence (Gunter, Sapp, & Green, 1995; Kaufman, 1994; Sattler, 1992b; Wechsler, 1991). It is easy to use. The overlap between the Wechsler Adult Intelligence Scales (e.g., WAIS-III) and the WISC-III makes it relatively easy to compare performance at different age levels. The test items are modern and clearly presented. There are also Canadian norms. WISC-III scores can be compared to achievement test scores on the Wechsler Individual Achievement Test (WIAT) to determine if an individual is learning disabled. Moreover, scores on the WISC-III can now be compared to scores on the Children's Memory Scale (CMS) in order to determine whether a child has memory deficits or neuropsychological dysfunction.

The revision of the WISC-R changed the factor structure of the WISC-III. A particular goal of the test makers was to flesh out the role of the FD factor (Wechsler, 1991). Test-makers were very interested in the attentional and memory aspects of the FD factor. To clarify the role of the FD factor, they added the Symbol Search (SS) subtest to the WISC-III. The design of the SS subtest was based on memory-scanning capacity and controlled attention research (Wechsler, 1991). Rather than clarifying the role of the FD factor, however, the SS subtest clouded the WISC-III factor structure and led to the advent of the PS factor. The advent of the PS factor has been described as the "most critical innovation in a Wechsler scale since the mid-1940s when Dr. Wechsler decided that he ought to have a test just for children" (Kaufman, 1994, p. 209).

Presently, the factor structure of the WISC-III is somewhat controversial. Although the three IQ scores (FSIQ, Verbal IQ, and Performance IQ) continue to exist, Wechsler's (1991) factor analysis indicated a four-factor model consisting of the VC, PO, FD, and PS factors. In contrast to Wechsler's (1991) four-factor model, Sattler's (1992b) factor analysis indicated that the following three-factor model best fit the data: Verbal Comprehension, PO and PS. Regardless of whether one relies on Wechsler's (1991) four-factor model or Sattler's (1992b) three-factor model, the factor structure includes the new PS factor. In both the four-factor and three-factor models, the Coding (CD) and SS subtests load heavily on the PS factor.

With the advent of the PS factor, the WISC-III more heavily emphasizes the youth's speed of response in determining scores (Sattler, 1992b; Kaufman, 1994). Sattler (1992b) defines the PS factor as follows:

> 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. (Sattler, 1992b, p. 1045-1046)

Thus, it is believed that this factor requires perceptual processing, concentration, attention, and mental speed. Although not mentioned in this definition, this factor also measures motor speed, eye-hand coordination (Kaufman, 1994), and non-verbal or visual working memory.

Examining WISC subtest patterns has been of interest to educational psychologists for many years. The goal of many studies has been to examine whether WISC profiles can be used to determine if an individual has a diagnosis such as a learning disability or ADHD (Kaufman, 1994). The research literature supports the need to better understand the WISC-III PS factor (Kaufman, 1994; Sattler, 1992b): the PS factor "needs to be researched to better understand what it measures for different individuals" (Kaufman, 1994, p. 250). The present study aims to contribute to the body of knowledge examining the WISC-III PS and FD factor scores in clinical populations such as learning disabled and ADHD children (e.g., Anastopoulos, Spisto, & Maher, 1994; Daley & Nagle, 1996; Donders, 1995; Donders, 1997; Prifitera, Weiss, & Saklofske, 1998; Prifitera & Dersh, 1993; Riccio, Cohen, Hall, & Ross, 1997; Saklofske et al., 1994; Schwean & Saklofske, 1998; Schwean et al., 1993; Swanson, 1997; Tiholov et al., 1996; Ward et al., 1995; Wechsler, 1991; Williams, Zolten, Rickert, Spence, & Ashcraft, 1993).

The present research study focused on examining the WISC-III PS and FD factor scores in learning disabled and attention-deficit hyperactivity disordered (ADHD) populations. Some research suggests that children with learning disabilities (e.g., Ackerman & Dykman, 1995; Prifitera et al. 1998; Daley & Nagle, 1996; Wechsler, 1991; Williams et al., 1993) or ADHD (Ehlers et al., 1997; Saklofske et al., 1994; Swanson, 1997; Wechsler, 1991) have relatively low PS factor scores. As well, some research has indicated weak performance on the FD subtests in children with learning disabilities (e.g., Ackerman & Dykman, 1995; Spafford, 1989; Vargo, Grosser, & Spafford, 1995) or ADHD (e.g., Anastopoulos et al., 1994; Ehlers et al., 1997; Kaufman, 1994; Lufi et al., 1990; Reinecke et al., 1999; Rispens et al., 1997). Research related to the SS, CD, Arithmetic (AR), and Digit Span (DS) subtests (SCAD profile) suggests that children with learning disabilities and/or ADHD have lower scores on the PS and FD factors than 'normal' children (i.e., Kaufman, 1994; Prifitera & Dersh, 1993; Schwean & Saklofske, 1998; Wechsler, 1991). Thus, the purpose of the present study is to examine whether children with learning disabilities and/or ADHD show lower PS and/or FD factor scores in comparison to a clinical sample of children without a formal psycho-educational diagnosis.

Purpose of the Study

The purpose of this study is to investigate children's scores on the PS and FD factors in the following four populations: a) learning disabled (reading or written expression), b) ADHD (combined type or predominantly hyperactive-impulsive type), c) comorbid learning disabled and ADHD, and d) no diagnosis. Are the WISC-III PS and FD factor scores lower in children with a pure learning disability, pure ADHD, or a combined learning and ADHD, in comparison to children without a behavioural, educational or emotional diagnosis? The specific research questions examined in this study are provided at the end of the literature review.

This study is exploratory in nature and it aimed to provide more information about the third and fourth WISC-III factors. This research is considered a first step in determining whether there are differences on the PS and FD factors in pure samples of learning disabled, ADHD, comorbid learning disabled and ADHD, and no diagnosis groups. This study did not aim to give definitive answers as to whether the PS or FD factors discriminate between diagnostic groups.

This research also strived to improve clinicians' understanding of cognitive capacities of learning disabled children. A better understanding of learning disabilities is important for several reasons. There is a relatively high prevalence rate of learning disabilities in school aged-children (e.g., APA, 1994; Hallahan & Kaufman, 1994; Lerner, 1993; Wong, 1996). Depending on the definition, the prevalence rate of learning disabilities in the general population ranges from about 2% to 10% (APA, 1994), although most studies indicate about a 4% to 5% prevalence rate (Hallahan & Kaufman, 1994). The prevalence rate of learning disabilities has increased from the 1970's when it was about 1% to 3% (Lerner, 1993), and reasons for the increase can be attributed increased public awareness, improved assessment, and reduced public misconceptions about learning disabilities (Wong, 1996).

Not only do learning disabilities impact a large number of children, but they also have strong social, academic, and economic consequences (APA, 1994; Kronenberger & Meyer, 1996; Sattler, 1992; Thompson & Kronenberger, 1990; Wong, 1996). Learning disabilities are associated with low social skills and low self-esteem (APA, 1994). Nearly 40% of children with learning disabilities drop out of school before graduating (APA, 1994), and thus these children are impacted later in life in terms of economic and occupational functioning. Since learning disabilities affect a large number of children and have long-lasting social, occupational and economical impact, the accurate and reliable diagnosis of learning disabilities is important.

Not only is a better understanding of learning disabilities important, but a better understanding of ADHD is also important given the large number of children affected by ADHD (APA, 1994; Barkley, 1997, 1998). The epidemiological literature suggests that the ADHD prevalence rate is about 3% to 5% (APA, 1994; Barkley, 1998). However, this figure depends on the definition used, the assessment measures used, and the geographic location of the study (Barkley, 1997, 1998). The boy to girl ratio is about 3 to 1 (Barkley, 1998), and although both sexes present with similar symptoms, boys tend to present with more aggressive behaviours than girls. Although ADHD is difficult to diagnose in children younger than five years of age (APA, 1994), psychologists can determine which children are at risk for developing the disorder (Barkley, 1998; Campbell, Pierce, March, Ewing, & Szomowski, 1994). These predicting factors include early activity level (e.g., high), critical parental behaviors toward the child, and a family history of ADHD (Campbell et al., 1994).

Not only is it important to study ADHD because it affects so many children, but also because of its long-reaching developmental implications (Barkley, 1997, 1998; Barkley, DuPaul, & McMurray, 1990; Barkley, Murphy, & Kwasnik, 1996; Biederman, Wilens, Mick, Milberger, Spencer, & Faraone, 1995; Moffit, 1990; Weiss & Hechtman, 1993; Wilson & Marcotte, 1996). Approximately 70% of children diagnosed with ADHD in childhood continue to have cognitive and attentional problems in adolescence and adulthood (Weiss & Hechtman, 1993; Wilson & Marcotte, 1996). They are often restless, overactive, and likely to be suspended or drop out of high school (Barkley et al., 1990). They have low self-esteem and are often viewed by peers as socially immature. They have problems in school, both academically and behaviorally. They are more likely to engage in antisocial behaviour, drug and alcohol use. As adults, they have difficulty working independently and they often do not achieve their full occupational or economic potential (Wilson & Marcotte, 1996). As adults, they have a greater likelihood of lifetime diagnoses of anxiety, oppositional, conduct, and antisocial-personality disorders (Barkley et al., 1996), as well as a greater likelihood of drug and alcohol dependence (Biederman et al., 1995). In summary, the research literature suggests that as children with ADHD grow older, they continue to have difficulty in many important areas of functioning.

Given the high prevalence rates and the long-lasting impact of learning disabilities and/or ADHD, the accurate and reliable diagnosis of these disorders is a continuing concern for psychologists, educators, children, and families (Daley & Nagle, 1996). Since a significant number of referrals to child psychologists are to determine whether a child has a learning disability and/or ADHD, this study endeavors not only to contribute to our understanding of these disorders, but to assist psychologists in making more reliable and valid diagnostic interpretations using the WISC-III. Thus, this research aims to yield findings that will inform psycho-educational assessment and ultimately the intervention of child and youth with learning disabilities and/or ADHD. This work seeks to help researchers determine the usefulness of the WISC-III PS and FD factors as potential screening mechanisms for learning disabilities or ADHD, and assist clinicians in determining whether more extensive (and expensive) testing is required. This research also strives to help psychologists and educators better understand the cognitive capacities of learning disabled and/or ADHD children.

Definitions

For the purposes of this paper, the following definitions are used.

WISC-III.

The Wechsler Intelligence Scale for Children—Third Edition (WISC-III) was published in 1991 and it was designed to assess the cognitive abilities of children and youth from 6 through 16 years. The WISC-III has three IQ scores: a FSIQ, a VIQ, and a PIQ score. It has 13 subtests: there are six subtests in the Verbal Scale and seven subtests in the Performance Scale. The test is well standardized, has excellent reliability, and good validity. Overall, the WISC-III is considered a good measure of general intelligence (Sattler, 1992b). Wechsler (1991) suggests that a four-factor model best fits the WISC-III: the VC factor, the PO factor, the FD factor, and the PS factor. Sattler, on the other hand, suggests that a three-factor model best characterizes the WISC-III: the VC factor, the PO factor, and the Processing Speed factor.

PS factor.

A new WISC-III factor consisting of the CD and SS subtests. While Wechsler's (1991) four-factor model suggests that the PS factor accounts for 4-5 percent of the test variance, Sattler's (1992b) three-factor model suggests that the PS factor accounts for 10 percent of the test variance. This factor is believed to measure visual perception, visual discrimination, eye-hand coordination, and visual short-term memory.

Coding subtest (CD).

A WISC-III subtest measuring visual perception of abstract stimuli (i.e., designs and symbols). The CD subtest also measures auditory perception of complex verbal stimuli (i.e., the child's ability to follow verbal directions) (Kaufman, 1994). The CD subtest requires the child to learn a code quickly. The subtest presents the child with a key that pairs symbols with other symbols. The child is then shown one part of the pair of symbols and is told to copy the appropriate symbol in the blank space. Sattler (1992b) maintains that CD the test gives good information regarding "speed and accuracy of eye-hand coordination, short-term memory, and attentional skills" (p. 1123). This subtest also examines motivation and motor activity rate (Kaufman, 1994; Sattler, 1992b).

Symbol Search subtest (SS).

A WISC-III subtest measuring visual discrimination and visual-perceptual scanning of abstract symbols. The SS subtest also measures auditory perception of complex verbal stimuli (i.e., the child's ability to follow instructions) (Kaufman, 1994). This subtest requires the child to look at a symbol(s) and determine whether an array of symbols contains that particular symbol(s). The child must mark a 'yes' or a 'no' box indicating his or her answer. Sattler (1992b) notes that the subtest gives good information regarding the child's "perceptual discrimination, speed and accuracy, attention and concentration, and short-term memory" (p. 1124). He also notes that motor activity, motivation, and perhaps cognitive flexibility (i.e., the capability to shift between a target symbol and a group of symbols) likely influence performance on the SS subtest.

FD factor.

A WISC-III factor consisting of the AR and DSsubtests. Both FD subtests require auditory short-term memory, attention, and concentration, as well as the ability to mentally manipulate material obtained in an auditory format (Kaufman, 1994).

Arithmetic subtest (AR).

A WISC-III subtest examining mental arithmetic computation abilities (i.e., mental arithmetic). This subtest requires the child to listen to verbal arithmetic questions and answer the questions using numerical operations. This subtest is a measure of attention, concentration, and mental arithmetic abilities (Sattler, 1992b).

Digit Span subtest (DS).

A WISC-III supplementary subtest that requires the child to listen to a series of numbers and repeat them back to the examiner. There are two parts to the DS subtest: Digits Forward and Digits Backward. Digits Forward, as earlier described, requires the child to repeat the numbers back to the examiner in the same order as he or she has heard them. Digits Backward, on the other hand, requires the child to repeat the numbers in reverse order. Both parts of the DS subtest are believed to measure auditory attention, concentration and short-term auditory memory (Sattler, 1992b).

Learning disabilities.

The conceptual definition of learning disabilities used in the present study is provided, followed by an outline of the present study operational definition. The present study refers to the Learning Disabilities Association of Canada definition of learning disabilities:

> (It) is a generic term that refers to a heterogeneous group of disorders due to identifiable or inferred central nervous system dysfunction. Such disorders may be manifested by delays in early development and/or difficulties in any of the following areas: attention, memory, reasoning,

> coordination, communicating, reading, writing, spelling, calculation, social competence, and emotional maturation. (LDAC, 1987)

Thus, learning disabilities involve delays or problems in areas such as reading, writing, and spelling.

An operational definition for learning disabilities was based on a combination of methods that are viewed as appropriate by many researchers (Barkley, 1998; Kronenberger & Meyer, 1996; Sattler, 1992; Wong, 1996). (Please note that various possible operational definitions are discussed in Chapter Two. A detailed discussion of the specific research criteria used to classify subjects as learning disabled is provided in Chapter Three.) A brief overview of the criteria for inclusion in the learning disability group is reviewed. Firstly, an initial screening indicated that the subject's achievement test score in reading or writing/spelling was at least one standard deviation below the norm. Secondly, a regression equation was used to determine expected scores, which took into consideration the effects of regression to the mean. The regression equation determined whether the child's Z score was greater than –1.65.

ADHD.

Firstly, a conceptual definition for ADHD will be provided followed by an operational definition for ADHD. The present study refers to the DSM-IV conceptual definition of ADHD. The DSM-IV presents three different types of ADHD: 1) a combined type (at least six symptoms of inattention, and six or more symptoms of hyperactivity-impulsivity), 2) a predominantly inattentive type (six or more symptoms of inattention), and 3) a predominantly hyperactive-impulsive type (six or more symptoms of hyperactivity-impulsivity). Given that there are significant cognitive differences between the predominantly inattentive type and the predominantly hyperactive-impulsive and combined types (e.g., Barkley, 1997, 1998; DuPaul & McMurray, 1990; Goodyear & Hynd, 1992), the ***present study focused only on the predominantly hyperactive-impulsive and the combined types of ADHD.*** The DSM-IV suggests that the child's symptoms must be maladaptive and inconsistent with his or her developmental level. Symptoms must have persisted for at least 6 months and must be present prior to age 7. The child must show impaired functioning in at least two settings (e.g., home or school).

A general outline of the operational definitions for the predominantly hyperactive-impulsive and the combined types of ADHD follow. The ADHD **predominantly hyperactive-impulsive type** required fulfillment of the following criteria: 1) agreement between two different raters on the 'Hyperactivity Problems' scale on the Behavior Assessment System for Children (BASC) Parent Rating Scale (PRS) and/or the BASC Teacher Rating Scale (TRS), and 2) clinician observed indications of hyperactivity-impulsivity. The ADHD **combined type** required fulfillment of the following criteria: 1) agreement between two different raters on the 'Attention Problems' and 'Hyperactivity Problems' scales of the BASC Parent Rating Scale (PRS) and/or the Teacher Rating Scale (TRS), and 2) clinician observed symptoms of inattention and hyperactivity-impulsivity. (Please note that a detailed discussion of the specific research criteria for ADHD is provided in Chapter Three.)

Summary

Now that the reader has been introduced to the present research and has been provided with relevant study definitions, it is important to more fully examine the WISC-III as a measure of children's cognitive capacities. Chapter Two will begin by examining this issue.

Chapter Two

Literature Review

In the introduction, we examined the history of the WISC-III and Dr. Wechsler's view of intelligence. An appropriate question at this point might be whether the WISC-III is a good measure of intellectual ability and exactly what it is measuring. It is also important to discuss one of the main shortcomings of the WISC-III—it is not theory driven or based on a cohesive theory of intelligence. Then, given this gap, we must provide a current, cohesive framework for understanding intelligence, and one that can also describe some of the psychometric and neuro-scientific research data, particularly in children with learning disabilities and ADHD. First, however, we will examine whether the WISC-III is a good measure of intelligence.

The WISC-III as a Measure of Intelligence

The literature indicates that the WISC-III is a reasonable measure of general cognitive ability or 'g' (Kaufman, 1994; Sattler, 1992b; Wechsler, 1991) and about 43 percent of the test variance is attributed to 'g' or general intelligence (Prifitera et al., 1998). The WISC-III FSIQ score is considered the best measure of cognitive ability and it can be affected by many factors such as motivation, culture, genetics, attention, visual, and verbal processing (Sattler, 1992b). At this point is relevant to discuss the two IQ scores that make up the FSIQ score—the VIQ and the PIQ scores—and what cognitive abilities they measure.

The VIQ measures verbal comprehension and provides information about verbal learning, reasoning, memory, and language processing (Sattler, 1992b). The PIQ measures perceptual organization, non-verbal learning and memory, planning ability, visual processing, organizational ability and attention (Sattler, 1992b). Although the WISC-III is a good measure of general intellectual ability, there are weaknesses with this measure.

One of the main weaknesses of the WISC-III is that Dr. Wechsler did not provide nor base the test on an explicit, comprehensive theory of intelligence (Kaufman, 1994; Sattler, 1992a, b). Psychologists rely on the scientific and systematic study of human behaviour, experience, and cognition. Theory is essential to the scientific method as it provides psychologists with conceptual frameworks to organize existing knowledge and determine new research questions and ideas. Although Dr. Wechsler provided a definition of intelligence (i.e., a global construct made up of qualitatively different abilities such as abstract reasoning, short-term memory and social comprehension), he did not base the WISC-III on a comprehensive, explicit theory of intelligence. This is particularly disturbing given the advent of the PS factor and the failure of the test-makers to delineate the role of this factor within an explicit, cohesive theory of intelligence.

A comprehensive theory of intelligence is crucial to understanding not only what the WISC-III is measuring, but also to predict and explain problems and disorders in the children being assessed with this measure. Theory helps us organize our existing knowledge regarding intelligence and psychological disorders. Given that the makers of the WISC-III do not provide an explicit theory of intelligence, we must rely on other sources to help us organize our thoughts regarding intelligence.

A Current Theoretical Framework of Intelligence

One of the most current and comprehensive approaches to understanding human intelligence is the information-processing framework (Hunt, 1999; Sattler, 1992). This framework is not only applicable to the WISC-III, but it can also be used to describe the various cognitive deficits and disorders occurring in children who are measured with this instrument. The information-processing approach provides a framework for describing and explaining the cognitive problems that are occurring in children with learning disabilities and/or ADHD. First, an overview of the information-processing framework will be provided. Then, within the information-processing framework, I will review two models that are particularly important to understanding, explaining, and predicting cognitive deficits in children with learning disabilities. First, however, an overview of the information-processing approach to cognition will be provided.

Intelligence and the Information-processing Approach

The information-processing approach to intelligence is closely linked to neuroscience and focuses on the mental processing, mental representation of information, and the mental structures that sustain cognitive events (Hunt, 1999; Sattler, 1992). Hunt describes this approach as often utilizing computer science terminology, although it does not commit to the computer equaling human brain metaphor. The information-processing approach focuses on examining the information-processing qualities of humans, rather than on understanding how meaning influences human thought. As Hunt notes, "The goal of information-processing studies is to understand those aspects of human cognition only minimally dependent on the meaning of information a person is processing" (p. 6).

Although this approach does not study the influence of understanding and meaning on human thought, it does not deny the influence of meaning.

Information-processing research unites psychometric and neuro-scientific data into a theory that connects the two. The information-processing framework suggests that cognitive processing occurs through a series of distinct stages, including memory stages. For example, information is received at one end of the system (i.e., sensory memory) and is then passed on to another stage(s) for further processing (i.e., short-term memory, long-term memory). The information-processing approach views cognition as involving two key elements: 1) a structural component (i.e., specific short-term memory and long-term memory structures), and 2) a functional component (i.e., the mental operations or processes that are performed on the information). At this point, given that the focus of this research is the WISC-III PS factor, it is useful to differentiate the WISC-III PS factor from the information-processing definition of information-processing speed.

As noted in the introductory chapter, the PS factor is made up of the CD and SS subtests. The PS factor assesses factors such as visual perception, visual short-term memory, and eye-hand-coordination. On the other hand, the information-processing literature defines information-processing speed as the time needed to finish both complex and simple mental tasks. Kyllonen, Tirre, and Christal (1991) define 'processing speed' as "the speed with which facts can be retrieved and relations constructed" (p. 58). Information-processing speed is separate from accuracy and factual knowledge factors (Wright & Dennis, 1999). Information-processing speed may be a causal determinant of working memory capacity (Kyllonen & Christal, 1990; Kyllonen et al., 1991).

Information-processing speed involves at least three generally independent task-related factors: 1) motor processing, 2) perceptual processing, and 3) memory search (Ackerman, 1988; Kyllonen, 1992; Kyllonen & Christal, 1990; Kyllonen, et al., 1991). Thus, information-processing speed relies on a variety of factors such as perceptual and motor processing, and memory search. Although the PS factor may be measuring facets of information-processing speed, it is not equivalent to this term.

In summary, the information-processing approach to intelligence helps organize our knowledge of children's cognitive capacities. It is particularly useful for understanding and explaining cognitive deficits in children with learning disabilities and/or ADHD. Next, within the information-processing framework, it is important to provide an overview of an empirically based model of memory stages.

A Model of Memory Stages

There are several different models of memory stages (Lezak, 1995) and rather than subscribing to a particular model of memory stages, the writer will rely on the path led by Lezak. Lezak's model of memory stages is based on a synthesis of current cognitive, psychological, psychometric, and neuro-psychological memory research literature. This comprehensive model is based on the most current and relevant memory research. Lezak finds it most relevant to describe memory as occurring in three general stages with various substages. These *three primary stages* of memory include the following: 1) registration, 2) short-term memory, and 3) long-term memory.

The first memory stage is termed **registration** (or sensory) **memory.** **Registration memory** holds information for about 1 or 2 seconds in sensory storage. At this point, the information either decays or else it is processed into short-term memory.

Short-term memory is the second stage of the memory system and it involves three different substages. The three different short-term memory substages are viewed as a series of sub-processes. The first stage of short-term memory is termed **immediate memory**. Immediate memory takes information from registration memory. It holds about seven pieces of information at a time. Given that immediate memory holds only seven chunks of information for a brief period, the amount of information that can be processed into immediate-memory is limited. In practical terms, this stage of short-term memory is similar to the '*immediate span of attention*,' although it can last from several seconds to a few minutes (Lezak, 1995).

Lezak (1995) suggests that the second stage of short-term memory is the **working memory system** (Baddeley, 1986, 1992, 1994). The working memory system consists of a central executive and two subsystems. The first subsystem is made up of the visuospatial sketch pad, which processes visual-spatial information. The second subsystem is made up of the phonological loop, which processes language or verbal information. Essentially, working memory keeps and internalizes information that it then uses to direct behaviour. This stage of short-term memory is particularly important when discussing cognitive difficulties in children with learning disabilities and ADHD. Consequently, Baddeley's model will be later reviewed in greater depth.

The third stage of the short-term memory system is **primary memory**. Primary memory is more dependent on attention than working memory. Essentially, via a biochemical trace, reverberating neural networks help to sustain information for a short time. Lezak (1995) notes that if the electrochemical activity (or the biochemical trace) is not made more biochemically stable, then the immediate, working, and primary memory traces disappear.

Long-term memory is the last stage of the three-stage memory system. Rehearsal and repetition help to maintain a memory trace for several hours. Long-term memory involves a number of changes at the cellular level. For example, there are changes to the neuron, synapse, dendrite, and/or dendritic branches. Because the issues discussed in this dissertation are largely related to the second type of memory, short-term memory, the discussion of long-term memory is truncated.

In summary, Lezak's (1995) comprehensive model of the three main stages of memory supports three main stages of memory including sensory, short-term and long term memory. The working memory substage of the short-term memory system will become particularly important when discussing cognitive difficulties in children with learning disabilities and/or ADHD. For this reason, the working memory substage will be further examined. As mentioned earlier, Baddeley (1986, 1992,1994; Baddeley & Hitch, 1994), as well as other researchers (e.g., H. Swanson, 1993a, b, c; Morris, Grick, & Craik, 1989) have done a lot of work examining and isolating the components of the working memory system and Baddeley's model will now be reviewed.

Baddeley's model of working memory.

Baddeley's (1986, 1994) 3-component model of working memory is based on the information-processing approach to intelligence and it is a current framework for guiding some of the research in learning disabilities (e.g., H. Swanson, 1993a , b, c), as well as ADHD. Baddeley's work (i.e., Baddeley, 1986, 1994; Baddeley & Hitch, 1994) has focused on breaking down the working memory system into further subcomponents. Baddeley's (1992) definition of working memory follows: "The term working memory refers to a brain system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks as language comprehension, learning, and reasoning" (p. 556). Baddeley's model of working memory posits that only a limited amount of information can be held and manipulated in working memory (Baddeley & Hitch, 1994; Baddeley, 1986, 1992, 1994). Measures of working memory require the individual to keep material in mind while carrying out other operations at the same time (e.g., Morris et al., 1989). An example of an everyday working memory task might be listening to a story while trying to understand the meaning of the story (Swanson, 1993c).

As noted earlier, the working memory system is made up of three subcomponents: 1) a central executive that supervises the two other memory systems, 2) the visuospatial sketchpad (which is responsible for visual-spatial processing), and 3) the phonological loop (which is responsible for verbal processing). Each of these three systems will now be described.

The central executive is responsible for information-processing, brief information storage, and long-term memory retrieval. The central executive regulates information and coordinates activities between the visuospatial sketchpad and the phonological loop. The central executive is not material specific and is involved in two important capacities: 1) the ability to direct attention, and 2) the ability to direct rehearsal and information storage, as well as retrieval from long-term memory.

The visuospatial sketchpad and the phonological loop will now be described. The visuospatial sketchpad is responsible for handling and storing spatial and non-verbal information. The phonological loop, on the other hand, is responsible for dealing with and storing verbal information. The phonological loop is made up of two parts: the phonological store, a speech based storage system, and the articulatory control system, a verbal rehearsal system. The two systems appear to work independently. Although much research has been done on the phonological loop, little has been done on the central executive. The lack of research on the central executive is a central criticism of Baddeley's work.

In summary, the research literature supports an information-processing approach to examining cognitive processes in children (Hunt, 1999). This approach views cognition as occurring through a series of stages, with various operations being performed on the information as it goes through the stages. Lezak's (1995) empirically based model of memory stages supports a three stage model that includes a series of memory substages. Baddeley's model of the working memory system is particularly relevant to understanding the cognitive deficits of children with learning disabilities or ADHD.

Although Baddeley's model of the working memory system describes some of the cognitive deficits in children with learning disabilities, it is not a comprehensive description of these deficits (Wong, 1996). Unfortunately, in the area of learning disabilities, there is no single comprehensive model that sufficiently describes and explains this disorder. For this reason, we must turn to a complementary model that will help us understand and predict some of the cognitive deficits in children with learning disabilities.

Borkowski et al.'s (1989) Model of Academic Skill Development

Borkowski et al.'s (1989) model of academic skill achievement is based on the information-processing approach. This model is viewed as complementary to Baddeley's model of working memory in describing cognitive capacities in learning disabled children. The central thesis of this model is that children with learning disabilities have central executive processing problems or difficulty allocating cognitive resources.

Borkowski et al.'s (1989) model of academic skill achievement focuses on the role of metacognition in children's learning. Metacognition, according to Borkowski et al., is defined as awareness of one's cognitive processes, cognitive strengths, and cognitive weaknesses. Metacognition also involves the ability to self-regulate. According to this model, academic skill development relies on spontaneous and formally taught cognitive strategies. Spontaneous and formally taught cognitive strategies include both *conditional strategy knowledge* and *general strategy knowledge*.

As children grow older and their cognitive strategies increase in number, they develop *conditional strategy knowledge*: they learn *how, when and where* to use a certain strategy. They also develop *general strategy knowledge,* which consists of three key parts. First, children must understand that a planned, strategic approach to learning improves the probability for success. Second, children must understand that they need to expend effort in order to learn. Third, and most importantly, children must realize that they are the agents of their own learning. Their efforts contribute to successful learning through using appropriate strategies.

Through the development of conditional and general strategy knowledge, children realize that their efforts and use of good strategies result in successful learning. Attributing successful learning to one's own efforts improves *self-efficacy.* Bandura defines *self-efficacy* as a belief in one's ability to reach a goal. Recurring self-attributions (e.g., the belief that one is responsible for one's own academic success) naturally enhance self-efficacy. Borkowski et al. suggest that together children's self-attributions and sense of self-efficacy guide executive or decision-making processes in order to choose and use appropriate learning strategies. Thus, this model assigns important roles to self-attribution, self-efficacy, metacognition, and executive or decision-making processes in academic skill development. The child's metacognitive awareness, use of certain strategies, and *conditional and general* strategy knowledge direct the child in choosing and using the appropriate strategy for the task and in assuming a skillful, planned approach to learning.

There are both strengths and weaknesses to this model. A benefit of this model is that it explains how children learn new academic skills. A second benefit of the model is that it attributes importance to the role of metacognitive processes for academic skill development. A weakness of this model is that it does not fully account for the development of learning disabilities.

Now that Borkowski et al.'s model of academic skill development and Baddeley's (1986, 1994) model of working memory have been introduced, these two models will be used to examine some of the cognitive deficits in learning disabled children. Evidence related to 1) executive processing problems in learning disabled children, and 2) working memory problems in learning disabled children will be discussed. Again, this is not a comprehensive review, but an overview of some of the main research findings in these areas.

Learning Disabilities

Research findings in learning disabled children: executive processing and working memory problems.

Learning disabilities can be functionally described from an information-processing approach, specifically using two models: Borkowski et al.'s (1989) metacognitive model and Baddeley's model of working memory. Firstly, learning disabled children may be described as having problems with central executive processing or allocating cognitive resources (Swanson, 1993b, c). Specifically, learning disabled children have problems using and assigning cognitive resources. Secondly, learning disabled children may be described as having problems with working memory. Working memory is critical to understanding learning disabilities because it is believed to be an important component of reading skills, such as reading comprehension (Dixon, LeFevre, & Twilley, 1988; Turner & Engle, 1989) and learning disabilities (i.e., Siegel & Ryan, 1989b; Swanson, 1993a, b, c).

One of the most systematic researchers in the areas of executive functioning and working memory is, H. Swanson. Swanson began a research program examining whether children with learning disabilities have problems with 1) central executive processing (i.e., using and assigning cognitive resources), and 2) working memory. Swanson (1993a, 1993b, 1993c) investigated central executive processing and working memory and the results are summarized.

First, central executive processing problems will be reviewed. Swanson (1993b, c) was interested in whether children with learning disabilities have problems with central executive processing (i.e., cognitive resource allocation) and designed a research program investigating this topic. He created a task that required *high* and *low* effort remembering conditions. He made up a number of sentences (base and elaborative). For each sentence, the child responded by circling the word that completed the sentence. For example, in the *low* effort condition, the child was given a sentence such as "The woman wore a pretty ______." The child was given two word choices—dress or foot—and was told to circle the correct word. Swanson devised the task so that a low effort condition meant that the child would have a fairly easy time deciding which word best fit the sentence. For example, in the sample sentence, a child should have an easy time determining that the correct word choice is 'dress'. In contrast, in the *high* effort condition, the child's task was more difficult, as each of the two word choices could fit the sentence. For example, in the *high* effort condition, the child was given a sentence as follows: "The ______ went to school." The child was given two word choices—friends or children—and was told to circle the correct word. One can see that in the *high* effort condition, the task becomes much more difficult, as either word ('friends' or 'children') can fit the sentence.

Swanson (1993b, c) gave each child twenty sentences. The task was to determine which word was the correct one for the sentence that he or she had read. After the child had completed the twenty sentences, he or she completed a one-minute distracter task (i.e., completed mental arithmetic). Next, the child was told to recall *all of the circled* words. One minute later, the child was asked to recall all the words he or she had *not circled.* Study results indicated that children with learning disabilities recalled far less circled words than those without learning disabilities. With respect to recalling the non-circled words, in the low effort condition, the results for children with and without learning disabilities did not differ. However, in the high effort condition, children without learning disabilities performed better than children with learning disabilities. Swanson interpreted the differential performance of the learning disabled children from the non-learning disabled children, as suggesting that learning disabled children have problems using and assigning cognitive resources in high effort tasks: learning-disabled children likely have problems with central executive processing. Next, we will discuss working memory problems in children with learning disabilities.

In addition to questioning whether learning disabled children had central executive problems, Swanson (1993a) questioned whether children with learning disabilities have working memory problems. He was particularly interested in whether they have specific or generalized working memory problems.

As Siegel and Ryan (1989) note, the implicit assumption of Baddeley's theoretical model of working memory is that working memory is domain specific and that the type of material to bc remembered may determine the capacity of working memory. Working memory is believed to play a critical role in reading. During reading, it is believed that the working memory 'supervisor' or central executive retrieves linguistic information (i.e., phonological rules, word meanings, syntax information), while the subsidiary working memory system (i.e., phonological processing unit) holds onto the words or sentences as they are processed so that longer text units can be comprehended.

In order to determine whether children with learning disabilities have specific or generalized working memory deficits, he devised the following research study. Swanson (1993a) gave six verbal tasks and five non-verbal tasks to the following groups of children: 1) a group of children without learning disabilities (age matched); 2) a group of children with learning disabilities—either mathematics or reading disabled; and 3) a group of younger learning disabled children—either mathematics or reading disabled. An example of a verbal task follows. The verbal task required the child to read a paragraph about an event, such as a party. The child was asked a recognition question, such as "Who attended the party, the mother or the father?" Then, the child was asked to recall the story about the party. An example of a non-verbal task follows. One of the non-verbal tasks, for example, presented the child with a series of three shapes on a card (e.g., circle, star, square). The child viewed shapes for about thirty seconds. In the next picture, the placement of the shapes was changed. After looking at the cards, the child was presented with a new group of cards and was asked whether or not the card is a 'new' card or an 'old' card (i.e., the one that was presented). Swanson's results indicated similar performance between the two subgroups of children with learning disabilities: 1) children with learning disabilities in reading or mathematics; and 2) a younger group of subjects with reading or math disabilities. Both groups of learning disabled children showed both verbal and non-verbal memory impairments. Swanson interpreted his data as suggesting a generalized working memory deficit, rather than a specific working memory deficit, among learning disabled children, regardless of the type of learning disability.

Of note, Swanson's findings are somewhat contrary to Siegel and Ryan's (1989) research. Siegel and Ryan examined reading disabled, arithmetic disabled, attention deficit disordered (ADD), and normal children's (aged 7 to 13), performance on two working memory measures (one task involved sentences and the other involved counting). Results indicated that the children with reading disabilities had significantly lower scores on both measures of working memory, while the children with only the arithmetic disability had significantly lower scores on only the counting task. Children with ADD showed no decrease in performance on either task. Siegel and Ryan took these results as suggesting that children with reading disabilities have generalized working memory deficits, while the children with arithmetic disabilities were believed to have specific, numerically-related working memory deficits. A particular difficulty with this study included the operational definition of learning disabilities (i.e., this study did not rely on an IQ-achievement discrepancy). Rather, this study labeled children as reading disabled if their achievement test score on the Wide Range Achievement Test (WRAT) reading subtest was equal to or less than the 25th percentile. One reason this is problematic is that the WRAT is simply a measure of single word recognition and not reading comprehension. As well, these scores do not take into consideration the children's general cognitive capacities.

In summary, learning disabilities can be functionally described from an information-processing approach, specifically using Borkowski et al.'s (1989) metacognitive model and Baddeley's model of working memory. Although it is less theoretically relevant to this paper, it is still important to discuss possible etiological factors of learning disabilities.

Etiological Factors for Learning Disabilities

The etiology of learning disabilities can be described as largely arising from biological factors such as 1) nervous system damage, and 2) genetics (Kronenberger & Meyer, 1996; Wong, 1996). The neurologically based theory of learning disabilities implicates improper development of, or damage to the nervous system. This neurologically based theory suggests that pre-natal and peri-natal factors such as anoxia, seizures, and toxins contribute to neurological problems and result in learning disabilities. For example, autopsy studies have found that reading disabled individuals have larger right hemispheres than non-reading disabled individuals and that they have cell clusters located abnormally (i.e., where the cell clusters do not appear in normal non-reading disabled adults) (e.g., Galaburda, 1991). Research indicates that although peri-natal difficulties or other neurological problems (e.g., fetal alcohol syndrome, EEG abnormalities) are *associated* with learning disabilities, they do not *predict* them (APA, 1994).

The genetic theory of learning disabilities implicates the role of genetic factors as responsible for the development of learning disabilities. Support for this theory includes evidence that learning disabilities run in families and that the concordance rates for fraternal twins are lower than the concordance rates for identical twins (Hallahan & Kaufman, 1994). Learning disabilities are also more prevalent among first-degree biological relatives of children with learning disabilities (APA, 1994). In conclusion, it is difficult to decisively determine the etiology of learning disabilities, but substantial research implicates the involvement of both neurological and genetic factors.

In summary, we can functionally describe learning disabilities from an information-processing approach. We have also described some of the etiological factors implicated in the development of learning disabilities. In the introductory chapter, we provided the reader with an overview of the present study conceptual and operational definition(s)of learning disabilities. Now, it is important to revisit the conceptual definition of learning disabilities, as well as review several operational definitions.

Defining Learning Disabilities

A conceptual definition.

There is a lot of discussion in the research literature about the definition of learning disabilities and the literature is plagued with competing definitions (Ackerman & Dykman, 1993; Borkowski et al., 1989; Fletcher, Francis, Rourke, Shaywitz & Shaywitz, 1992; Hammill, 1990, 1993; Pennington, Gilger, Olson & Defries, 1992;

Siegel, 1989; Stanovich, 1991; Torgesen, 1989). In order to define something, we must "state the meaning of, to explain the nature or essential qualities of, or to make clear the form of something" (Hammill, 1993, p. 2). As Hammill (1993) notes, "proper definitions become essential if one is ever to know anything fully and completely" (p. 2). Distinction must be made between conceptual and operational definitions (Hammill, 1990, 1993). In order to provide an operational definition of learning disabilities, a first step is a conceptual definition (Hammill, 1990). The most consensual conceptual definition in the field that Canadian educators generally accept now follows (Kronenberger & Meyer, 1996; Hammill, 1990, 1993; LDAC, 1987; Sattler, 1992; Wong, 1996). See Table 1 for an outline of the detailed conceptual definition of learning disabilities.

Briefly, this definition suggests that learning disabilities are a heterogeneous group of disorders and are related to problems or delays in areas such as attention, memory, reading, writing, or spelling. They impact learning in individuals with at least *potentially* average cognitive abilities. Motor, vision or hearing problems should not account for the learning disability (although they may co-exist). Although this conceptual definition is generally accepted in Canada, when conducting research, psychologists prefer definitions that are operational or that enable us to measure the construct under examination. Next, we will review some of those operational definitions.

TABLE ONE

LEARNING DISABILITES CONCEPTUAL DEFINITION

LEARNING DISABILITIES is a generic term that refers to a heterogeneous group of disorders due to identifiable or inferred central nervous system dysfunction. Such disorders may be manifested by delays in early development and/or difficulties in any of the following areas: attention, memory, reasoning, coordination, communicating, reading, writing, spelling, calculation, social competence, and emotional maturation.
LEARNING DISABILITIES are intrinsic to the individual, and may affect learning and behaviour in any individual, including those with potentially average, average, or above average intelligence.
LEARNING DISABILITIES are not due primarily to visual, hearing, or motor handicaps; to mental retardation, emotional disturbance, or environmental disadvantage, although they may occur concurrently with any of these. Learning disabilities may arise from genetic variation, bio-chemical factors, events in the pre- to post-natal period, or any other subsequent events resulting in neurological impairment. (Learning Disabilities Association of Canada Definition, 1987)

Operational definitions.

A consensual operational definition for learning disabilities is a source of considerable tension in the field (Fletcher et al., 1992; Hammill, 1990, 1993; Kronenberger & Meyer, 1996; Pennington et al., 1992; Siegel, 1989; Torgesen, 1989; Wong, 1986, 1996). One reason for this tension is the lack of a single, specific standardized test designed to determine whether a child is learning disabled (Hammill, 1990; Kronenberger & Meyer, 1996; Wong, 1996). Although there are tests of intelligence, reading, spelling, and mathematics, there is no particular test available to measure this rather global, abstract psychological term or construct (Wong, 1996). Although no single test can measure this construct, this does not mean that we should ignore or throw away the concept. Psychologists have suggested various operational definitions and these are now reviewed.

Six operational definitions of learning disabilities are now presented (Barkley, 1998; Kronenberger & Meyer, 1996; Sattler, 1992). The first operational definition simply requires low academic achievement, regardless of the child's level of intelligence. This method is inappropriate, however, as children with mental retardation or borderline intelligence are often misclassified as learning disabled (Barkley, 1998; Kronenberger & Meyer, 1996; Sattler, 1992; Siegel, 1990).

A second closely related operational definition requires normal intelligence but grade-level deviant achievement (e.g., a grade three student performing at a grade one level in reading would be classified as learning disabled) (Fletcher et al., 1992; Kronenberger & Meyer, 1996; Sattler, 1992). This method is not appropriate as it fails to consider the concept that the same discrepancy score means something different at different grade levels (Sattler, 1992). For example, a grade two student who is two years below grade in reading has a much greater reading problem than a grade twelve student who is two years below grade in reading.

A third operational definition requires a difference between the PIQ score and the VIQ score on a test of cognitive ability, such as the WISC-III (Kronenberger & Meyer, 1996; Rourke, 1989; Sattler, 1992). However, this method of classification is inappropriate, as it does not say anything about the child's achievement level. Ultimately, learning disabilities are achievement -based disorders.

Fourth, expectancy formulas are an alternative way of determining whether or not a child has a learning disability (Sattler, 1992; Kronenberger & Meyer, 1996). In this method, the child's expected grade equivalent (not actual grade) is used to compute an achievement/ability discrepancy. This formula is based on the child's Mental Age and Chronological Age. However, one of the main difficulties in this method is the reliance on the Mental Age concept, as well as the assumption that the correlation between achievement and ability test scores is 1.0 (which is rarely so).

A fifth operational definition involves using a regression equation to determine expected scores, which takes into consideration the effects of regression to the mean (which occurs when the correlation between achievement and ability tests is less than 1.0) (Barkley, 1998; Fletcher et al., 1992; Kronenberger & Meyer, 1996; Sattler, 1992; Wong, 1996). In this method, the clinician changes the achievement and cognitive test standard scores to Z scores, and then estimates the expected achievement score with a regression equation. The regression equation uses the standard error of the estimate for the achievement test, as well as the correlation between the achievement test and the cognitive test. For a child to be classified as having a learning disability, the child's Z score must exceed -1.65.

Finally, a common and well-accepted approach in the research literature is to use a combination of diagnostic methods (Barkley, 1998; Kronenberger & Meyer, 1996; Sattler, 1992; Wong, 1996). Firstly, there must be a difference of at least one standard deviation between performance on the test of achievement and the test of cognitive abilities (e.g., 15 points). A regression equation can be used to determine the expected scores and as noted earlier, for a child to be classified as learning disabled, the Z score must exceed – 1.65. The achievement score must be below a certain value (e.g., below the 20th percentile). If this is not done, a child with an IQ of 140 may be misclassified as learning disabled if his standard score is 125 on a test of reading skills. A difficulty with this particular operational definition is selecting which IQ score to use: Full Scale, Performance Scale, or Verbal Scale (Kronenberger & Meyer, 1996). Although some clinicians use the Full Scale score regardless whether a Verbal/Performance discrepancy exists, using the FSIQ score has little meaning when there is a large Verbal/Performance split (Sattler, 1992). For this reason, some clinicians use the highest Verbal or Performance Scale score and argue that this estimates the child's best potential (Kronenberger & Meyer, 1996). However, using the Verbal or Performance Scale score as the best estimate of the child's highest potential is problematic as it is not clear if either score truly reflects the potential to be expected in classroom work. Ultimately, clinical flexibility is most important when determining whether a child is learning disabled (Kronenberger & Meyer, 1996).

The present research study used a combination of methods viewed as appropriate for diagnosing a learning disability (Barkley, 1998; Fletcher et al., 1992; Kronenberger & Meyer, 1996; Sattler, 1992; Wong, 1996). First, an initial screening indicated that the child scored at least one standard deviation below the norm on a test of achievement. Second, a regression equation determined expected scores and this equation took into consideration the effects of regression to the mean. The FSIQ score was used to determine the IQ-achievement discrepancy. The regression equation determined whether the child's Z score was greater than -1.65. The achievement score was below a certain value (e.g., SS ≤ 85). No other factors should account for the impaired learning: the child's FSIQ score > 70, the primary language was English, and the child was attending school full-time. An outline of the research criteria is provided in Table 1 of Chapter Three.

Although educators generally accept this operational definition (Barkley, 1998; Fletcher et al., 1992; Kronenberger & Meyer, 1996; Sattler, 1992; Wong, 1996), some of the main arguments against the IQ-achievement discrepancy method will be reviewed (e.g., Siegel, 1989; Stanovich, 1991).

Arguments against the IQ-achievement discrepancy method.

A strong opponent of the IQ-achievement discrepancy method, Stanovich (1991) argues that the IQ-achievement discrepancy is inappropriate for diagnosing a learning disability. He argues that achievement tests measure the same abilities as IQ tests, and that literacy fosters the very cognitive skills that are assessed on aptitude measures. Consequently, he argues that using the IQ-achievement discrepancy method is illogical. Stanovich offers an alternative method by examining the discrepancy between reading ability and verbal comprehension.

Siegel (1989) is also a critic of the IQ-achievement discrepancy model. She argues that the IQ-achievement discrepancy model implies that there is a relationship between IQ and reading ability. For example, in order to be diagnosed with a learning disability, a child must have at least potentially average intelligence test scores. In this way, reading is at least somewhat dependent on having average IQ. Siegel has two main arguments against the IQ achievement discrepancy model.

Firstly, Siegel (1989) argues that IQ –achievement discrepancy model implies that IQ scores should be able to differentiate between levels of performance in reading skills. That is, IQ scores should predict reading scores. This suggests that children with low IQ scores should be poor readers and conversely children with high IQ scores should be good readers. Siegel examined the relationship between IQ and reading skills. Siegel's research divided children into the following four IQ group levels: 1) below 80, 2) 80-90, 3) 91-109, and 4) 110 and over. Siegel's results did not show a difference in academic test performance (e.g., on reading subtests) across the four groups of IQ levels. That is, she did not find a relationship between reading and IQ scores. Siegel interpreted the lack of a significant relationship between reading skills and IQ as supporting her argument against using the IQ-achievement discrepancy method.

Although Siegel did not find a relationship between IQ scores and reading scores, strong relationships between reading and IQ have been found in the research literature. For example, Torgesen (1989) argues that there is a relationship between reading skills and IQ level. He cites data from the Peabody Individual Achievement Test, Wide Range Achievement Test, and the Woodcock-Johnson Psycho-Educational Battery manuals supporting a relationship between reading skills and IQ level (i.e., the correlation between the WRAT word reading subtest and the WISC-R FSIQ score was 0.85). As well, based on Siegel's (1989) own data, Torgesen found a significant relationship between IQ and word reading level. He argues that the reason Siegel did not find a significant relationship between reading skills and IQ was due to her faulty research design.

Siegel's (1989) second argument against using the IQ-achievement discrepancy method is the finding that some low IQ children can decode words. Siegel uses this argument to suggest that there is no relationship between reading ability and IQ. Therefore, she suggests that IQ and reading (or word recognition) are independent and that there is no relationship between the two.

In rebuttal to this argument, Torgesen (1989) suggests that simply because IQ and word reading are believed to correlate, does not mean that some low IQ children may not be able to learn to read. In order to learn how to read, other factors such as motivation, teaching, or home environment can account for some reading skills. This explains the finding that some low IQ children can learn to decode words and does not eliminate the relationship between IQ and reading.

In summary, although there are arguments against using an IQ-achievement discrepancy for diagnosis of a learning disability (Siegel, 1989; Stanovich, 1991), the present study method for diagnosing a learning disability is generally supported by educators and psychologists.

Given that this study focuses on children with learning disabilities in reading and written expression/spelling, it is important to review methods of subtyping learning disabilities and explain the present focus on verbal learning disabilities such as reading, written expression and spelling problems.

Subtyping of Learning Disabilities

There are several ways of subtyping learning disabilities, each with unique features (James & Selz, 1997; Kronenberger & Meyer, 1996; Rourke, 1989; Sattler, 1992; Ward, Ward, Glutting, & Hatt, 1999; Wong, 1996). For the purposes of this literature review, we will first focus on subtyping according to verbal and non-verbal domains. Rourke (1989) is a strong proponent of this method (James & Selz, 1997; Rourke, 1989; Wong, 1996). Then, we will focus on subtyping according to area of academic achievement.

A description between verbal and nonverbal learning disabilities follows. While verbal learning disabilities involve linguistic material, non-verbal learning disabilities involve mathematical, spatial, and social problems. Rourke (1989) implicates left cerebral hemisphere dysfunction as largely mediating *verbal* learning disabilities (although research also points at some of the right hemisphere and sub-cortical structures). On the other hand, the right cerebral hemisphere dysfunction mediates *non-verbal* learning disabilities (James & Selz, 1997; Rourke, 1989). Given the differences between verbal and non-verbal learning disabilities (e.g., Rourke, 1989), this study attempted reduced the variability of the learning disabled group by restricting study participation to verbal based learning disabilities. Since the present study focuses on verbally based learning disabilities, further discussion of verbal rather than non-verbal learning disabilities is provided.

Verbal learning disabilities are a psycholinguistic, heterogeneous group of language-based disorders that may be functionally sub-categorized as **spelling, writing** and **reading** skills (James & Selz, 1997; Rourke, 1989). James and Selz (1997) report that verbal learning disabilities likely result from problems **perceiving, processing, organizing, storing, integrating or retrieving** verbally based information. At present, the research literature supports the role of phonological processing problems in a large number of children with verbal learning disabilities (Stanovich, 1988; Torgesen, 1991; Wong, 1996).

The language-oriented view of learning disabilities argues that *phonological processing* problems are related to learning disabilities. Phonological processing refers to the sound structure of words. Wong (1996) reviews the three main types of phonological processing skills related to the development of early reading skills: 1) phonological awareness; 2) phonological memory (e.g., short-term memory); and 3) rate of access to phonological information. The literature (e.g., Stanovich, 1988; Torgesen, 1991) generally supports the importance of phonological awareness in language development, the reciprocity between phonological processes and reading development, and the relationship between a lack of phoneme awareness and later reading disabilities. Next, we will review subtyping of learning disabilities according to achievement areas.

A second way of subtyping learning disabilities is according to area of academic achievement. For example, subtyping according to achievement area such as reading, mathematics, writing and spelling (Sattler, 1992). Within each of these categories, learning disabilities may be further subcategorized (Sattler, 1992). For example, reading disabilities can be further analyzed as three primary subtypes: 1) visual-spatial, 2) auditory-linguistic, and 3) mixed visual-spatial and auditory-linguistic types. These three subtypes of reading disabilities will now be reviewed.

Visual-spatial.

Children with visual-spatial problems have problems with letter perception and/or perceiving or reading words as gestalts or wholes (Sattler, 1992). Children with the visual-spatial subtype of reading disability tend to have spatial, visual analysis/synthesis, visual sequential memory and visual discrimination problems (Kronenberger & Meyer, 1996; Sattler, 1992).

Auditory-linguistic.

Children with auditory-linguistic learning disabilities have problems integrating sounds with symbols and understanding sound/letter relationships (Kronenberger & Meyer, 1996; Sattler, 1992). They have sequencing, sound discrimination, and auditory-sequential memory problems. Children with auditory-linguistic problems tend to confuse sounds.

Visual-spatial.

Children with the third subtype of reading disability have both visual-spatial and auditory-linguistic problems. For example, they often have problems with letter perception, spatial and visual analysis. As well, they have problems with auditory discrimination, and integrating sounds with written symbols.

One of the main benefits of this tripartite method of sub-categorizing learning disabilities is that it facilitates suggestions for practical remediation that are targeted to the child's specific area of difficulty.

In summary, this section on learning disabilities has reviewed two relevant models (e.g., Baddeley's model of working memory and Borkowski et al.'s model of academic skill attainment) within the information-processing approach that are helpful for describing and explaining learning disabilities. According to these two models and the research literature, learning disabled children are believed to have problems with 1) working memory, and 2) central executive processing or using and assigning cognitive resources. We have also explored conceptual and operational definitions of learning disabilities, as well as certain etiological factors implicated in the development of learning disabilities. This section concluded with an overview of two methods of subtyping learning disabilities, and substantiated the present study focus on reading, written expression, and spelling learning disabilities. Next, it is important to provide an overview of ADHD, some of the etiological factors, and associated difficulties. Then, some of the diagnostic criteria for ADHD will be reviewed, followed by Barkley's model of ADHD.

ADHD

Within the last 20 years, Attention Deficit Hyperactivity Disorder (ADHD) has become one of the most researched and common clinical childhood disorders in North America (Barkley, 1997, 1998; Weiss & Hechtman, 1993). ADHD children show a variety of symptoms and "they represent a heterogeneous population who display considerable variation in the degree of their symptoms" (Barkley, 1998, p. 3).

The present study focused on examining the PS and FD factors in children with the ADHD combined type or ADHD predominantly hyperactive-impulsive type. The

DSM-IV provides diagnostic criteria for three types of ADHD: a combined type, a predominantly hyperactive-impulsive type, and a predominantly inattentive type. The research literature suggests that there are significant cognitive and motor differences between the ADHD predominantly inattentive type and the two other ADHD subtypes: 1) the combined type, and 2) the predominantly hyperactive-impulsive type) (Barkley, 1997; Barkley, 1998; Barkley et al., 1990; Carlson et al., 1986; Goodyear & Hynd, 1992). For example, in a meta-analytic review of research examining behavioural and neuropsychological differences between the predominantly inattentive type, and the combined and predominantly hyperactive types, Goodyear and Hynd (1992) found that 60 percent of neuropsychological studies showed significant differences between the predominantly inattentive type, and the combined and predominantly hyperactive types of ADHD.

The combined and the predominantly hyperactive-impulsive types appear to have more cognitive and motor impairment than the predominantly inattentive type of ADHD (e.g., Barkley et al., 1990; Goodyear & Hynd, 1992; Hinshaw, 1992; Morgan, Hynd, Riccio, & Hall, 1996). For example, Barkley et al. (1990) found that the combined and the predominantly hyperactive-impulsive types of ADHD tend to show reduced self-control, greater internalizing and externalizing problems (i.e., more conduct problems), greater behavioural disorganization and disinhibition, and greater impulsivity than the predominantly inattentive type. Morgan et al. (1996) also found that the combined and predominantly hyperactive-impulsive types have greater externalizing behaviour problems in comparison to the predominantly inattentive type. Given the differences between these three ADHD types and that Barkley's (1997, 1998) model of ADHD focuses on the combined and predominantly hyperactive-impulsive types, the present study focused on the combined and predominantly hyperactive-impulsive types of ADHD. Thus, when referring to ADHD in this document, only the combined and predominantly hyperactive-impulsive types of ADHD are being referred to.

This section first reviews etiological factors for ADHD. Some of the associated language, cognitive, motor, emotional, social impairments, and comorbid conditions will then be discussed. First, however, some of the etiological factors for ADHD are reviewed.

Etiological Factors for ADHD

The literature supports a neurological and/or genetic etiology for ADHD (Barkley, 1997,1998). Barkley (1997, 1998) noted that the last 100 years, problems in the prefrontal cortex of the brain have been consistently related to ADHD symptoms. In general, individuals with ADHD likely have problems in the prefrontal—striatal cortical network of the brain (Barkley, 1998).

The neurological research literature suggests the following findings in individuals with ADHD: 1) evoked cortical response patterns show that ADHD children are under-responsive to stimulation, 2) ADHD symptoms are associated with certain patterns of brain metabolic activity, and 3) MRI research suggests that individuals with ADHD have differences in certain brain areas in comparison to normal individuals (Barkley, 1997, 1998). However, some of the problems with these studies include extremely small sample sizes (Barkley, 1998).

Barkley (1997, 1998) notes that the genetic literature suggests that there is little, if any, evidence linking ADHD to chromosomal abnormalities. However, ADHD is a highly hereditary disorder and heredity is one of the strongest etiological factors for ADHD. Family aggregation studies, adoption research, twin studies, and molecular genetic research support the high degree of heredity links for ADHD (Barkley, 1997, 1998). Although social factors may influence the expression of the disorder, alone they do not account for the occurrence of the disorder. In summary, the literature consistently supports a genetic and/or neurological etiology for ADHD.

ADHD and Associated Problems

Individuals with ADHD are likely to have problems or delays in language, cognition, motor, emotional, and social development, as well as certain comorbid psychiatric and learning disorders (Barkley, 1997, 1998). These associated impairments and comorbid conditions will now be discussed.

Language delays.

Barkley (1998) summarizes the literature related to language delays and ADHD. Children with ADHD are more likely to show delayed speech development than normal children (e.g., up to 35% although this has not been a consistent finding). The literature consistently finds that children with ADHD tend to have difficulty organizing and expressing ideas (i.e., simple verbal fluency). They have weaker verbal problem solving skills and delayed internalized speech. Children with ADHD are more likely to have language delays than normal children, particularly in expressive rather than receptive language (Barkley et al., 1990). They are quite likely to have comorbid central auditory processing disorders. In summary, children with ADHD tend to have a number of language-related delays, as well as cognitive delays.

Cognitive delays.

Children with ADHD tend to exhibit the following cognitive deficits. Barkley (1997, 1998) summarizes the research literature related to cognitive deficits in ADHD children. Children with ADHD tend to have weaker verbal and non-verbal working memory than normal children. Their planning skills are often impaired. They have difficulty understanding time (e.g., estimating time). Children with ADHD often have comorbid learning disabilities (i.e., spelling disabilities (12-26%) and reading disabilities (8-39%)). They are particularly likely to have handwriting problems. Although they usually have normal intelligence, their intelligence test scores are about 7 to 10 points lower than the scores of normal children. Their verbal intelligence scores are weak (McGee, Williams, & Feehan, 1992). They have lower academic achievement scores than normal children. In general, they have problems with their schoolwork and likely under-perform in school. In conclusion, children with ADHD tend to present with a variety of cognitive delays. Not only do children with ADHD have associated cognitive delays, but motor delays have also been observed.

Motor delays.

With respect to motor development, Barkley's (1998) review of the literature suggests that children with ADHD have more "sluggish gross motor movements" than normal children. They have more soft neurological signs than normal children (i.e., poor motor coordination). The literature consistently finds that these children have problems with motor sequencing and motor coordination (Barkley, 1997, 1998). In addition to motor delays, children with ADHD also tend to show emotional and social delays.

Emotional and social problems.

Children with ADHD have a variety of emotional or social difficulties (Barkley, 1998; Greene et al., 1996). They are likely to show problems with adaptive functioning (i.e., developmentally appropriate independent, self-help behaviours) (Greene et al., 1996). For example, Greene et al. employed a common psychometric method used to classify children as learning disabled in order to determine whether children with ADHD could be classified as 'socially disabled'. Green et al. compared 140 children with ADHD and 120 children without ADHD. Based on the discrepancy between the child's estimated Full-Scale IQ score and his or her expected and obtained scores on a measure of social functioning, researchers classified children as 'socially disabled'. Greene et al.'s results indicated that children with ADHD were significantly more likely to have a 'social disability' than children without ADHD. Authors suggest that the term 'social disability' may effectively describe and identify children with ADHD at high risk for social dysfunction.

Barkley (1997, 1998) summarizes the literature emphasizing social deficits in children with ADHD. These children tend to have more problems with frustration tolerance. They have difficulty regulating their emotional states. They are more likely to have problems in their relationships with peers, parents, siblings, and teachers than normal children. They have reduced understanding of other people's intentions and this often causes problems in social interaction. They tend to have problems with rule-governed behaviour. The development of moral reasoning is often delayed. Children with ADHD are more likely to behave aggressively with their peers. They are less socially accepted than other children. They tend to be less compliant to requests from individuals in authority, such as teachers or parents. They tend to receive more punishments and reprimands than normal children (Barkley, 1998). As Hynd et al. (1991) note, children with ADHD tend to be viewed by their parents as having social skill deficits and conduct problems. In summary, children with ADHD present with a variety of social and emotional problems. Not only do children with ADHD show delays in language, cognitive, motor, social and emotional functioning, but they are also more likely to have certain comorbid psychiatric and learning disorders.

Comorbid disorders.

Children with ADHD are likely to have one or more comorbid psychiatric conditions (either externalizing or internalizing disorders) or learning disorders (Barkley, 1998). Externalizing conditions, such as conduct disorder and oppositional defiant disorder are most strongly related to ADHD. For example, Hynd et al., (1991) examined a small sample of 10 ADHD children and 10 ADD (no hyperactivity) children. Hynd et al. found that 40 percent of the children with ADHD had a comorbid conduct disorder. An obvious difficulty with this study is the very small sample size. Internalizing disorders such as anxiety and depressive disorders are also found in children with ADHD (i.e., at least 25 percent). Children with ADHD are also more likely to have learning disabilities than normal children (e.g., about 30 percent). In summary, children with ADHD tend to show a high degree of secondary comorbid psychiatric and learning disorders.

In summary, ADHD is associated with a variety of problems. These problems include language, cognitive and motor delays, as well as social and emotional difficulties. Children with ADHD are likely to have comorbid psychiatric and learning disorders. Consequently, it is very difficult to obtain a 'pure' sample of children with ADHD (Barkley, 1997, 1998). Much of the research done in the area of ADHD involves children who also have a secondary disorder and this makes it difficult to determine whether results can be attributed to ADHD, to the secondary disorder, or to the combined interaction of both disorders (Barkley, 1997, 1998). For this reason, one of the main goals of the present study was to obtain a 'pure' sample of children with ADHD.

Now that the associated impairments and disorders of ADHD have been explored, it is important to examine how Canadian clinicians diagnose ADHD.

Diagnostic Criteria for ADHD

Canadian clinicians use the primary North American diagnostic classification system for mental disorders, the Diagnostic and Statistical Manual of Mental Disorders—Fourth Edition (DSM-IV) (APA, 1994). This manual presents the DSM-IV official criteria and characteristics for ADHD. Although there are some problems related to the DSM-IV classification system for ADHD (e.g., using the same diagnostic thresholds for individuals younger than 4 years or older than 16 years; requiring symptom onset before age 7) (Applegate et al., 1997), the merits outweigh the problems (Barkley, 1998). The DSM-IV classification criteria for ADHD are similar to the European International Classification of Diseases (ICD-10) classification criteria. The DSM-IV diagnostic criteria for ADHD "are some of the most rigorous and most empirically derived criteria ever available in the history of clinical diagnosis for this disorder" (Barkley, 1998, p. 62).

> They were derived from a committee of some of the leading experts in the field, a literature review of ADHD, an informal survey of rating scales assessing the behavioural dimensions related to ADHD by the committee, and statistical analyses of the results of a field trial of the items using 380 children from 10 different sites in North America (Lahey et al., 1994) (Barkley, 1998, p. 62).

The criteria are reliable, specific, empirically based, and closer to the scientific literature than ever before (Barkley, 1997, 1998). Barkley (1998) encourages these criteria to be used in clinical practice. Please see Table 2 for the DSM-IV diagnostic criteria for ADHD. Although the operational definition for ADHD was briefly reviewed in Chapter One, an in-depth discussion of the present study operational definition for ADHD is presented in Chapter Three.

TABLE 2

DSM-IV DIAGNOSTIC CRITERIA FOR ADHD (APA, 1994)

A. Either (1) or (2):
(1) six (or more) of the following symptoms of inattention have persisted for a least six months to a degree that is maladaptive and inconsistent with developmental level:
Inattention
(a) often fails to give close attention to details or makes careless mistakes in schoolwork, work, or other activities
(b) often has difficulty sustaining attention in tasks or play activities
(c) often does not seem to listen when spoken to directly
(d) often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behaviour or failure to understand instructions)
(e) often has difficulty organizing tasks and activities
(f) often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework)
(g) often loses things necessary for tasks or activities (e.g., toys, school assignments, pencils, books, or tools)
(h) is often easily distracted by extraneous stimuli
(i) is forgetful in daily activities

(2) six (or more) of the following symptoms of hyperactivity-impulsivity have persisted for at least six months to a degree that is maladaptive and inconsistent with developmental level:
Hyperactivity
(a) often fidgets with hands or feet or squirms in seat
(b) often leaves seat in classroom or in other situations in which remaining seated is expected
(c) often runs about or climbs on excessively in situations in which it is inappropriate (in adolescents or adults, may be limited to subjective feelings of restlessness)
(d) often has difficulty playing or engaging in leisure activities quietly
(e) is often "on the go" or acts as if "driven by a motor"
(f) often talks excessively

Impulsivity
(g) often blurts out answers before questions have been completed
(h) often has difficulty awaiting turn
(i) often interrupts or intrudes on others (e.g., butts into conversations or games)

B. Some hyperactive-impulsive or inattentive symptoms that caused impairment were present before age 7 years.
C. Some impairment from the symptoms is present in two or more settings (e.g., at school (or work) and at home).
D. There must be clear evidence of clinically significant impairment in social, academic, or occupational functioning.
E. The symptoms and are not better accounted for by another mental disorder (pp. 83-85)

Although Barkley (1998) recommends that clinicians and researchers use the DSM-IV criteria for ADHD, he also notes that there is some controversy in the research literature with respect to the three types of ADHD. This controversy is now reviewed.

Controversy regarding ADHD types.

Although the DSM-IV states that there are three different types of ADHD (combined type, predominantly inattentive type, predominately hyperactive-impulsive type), the research literature queries whether there are actually three types of ADHD (Barkley, 1997, 1998). For example, it is possible that the *predominantly inattentive* type of ADHD is a *separate disorder* from the other two types of ADHD (i.e., combined type, predominantly hyperactive-impulsive type). For this reason, the present *study focused only on the 1) combined type and on the 2) predominantly hyperactive-impulsive type.* This study excluded individuals with the predominantly inattentive type of ADHD.

In addition to the lack of clarity regarding the ADHD predominantly inattentive type, the literature queries whether the ADHD *combined type* is 1) a *separate disorder* from the ADHD *predominantly hyperactive-impulsive type, or 2) a later developmental stage of the same disorder*. For example, Barkley (1997) cites research that has shown that the ADHD *predominantly hyperactive-impulsive type* is found primarily in pre-school age children, while the ADHD *combined type* is found largely in school-aged children. This finding could suggest that the combined type is a separate disorder from the predominantly hyperactive-impulsive type. Alternatively, this finding could suggest that the ADHD combined type and the predominantly hyperactive-impulsive type are *two different developmental stages* of the same disorder.

Although there is considerable variation in the symptoms across the three different types of ADHD, Barkley (1998) maintains that ADHD is a disorder distinct from other childhood disorders. The value of considering ADHD as a syndrome is not reduced:

> For now, it seems that the symptoms of ADHD, particularly those pertaining to poor behavioural inhibition, appear to be quite specific to the disorder, and are not typically shared by other child psychiatric disorders, and thus provide further evidence that ADHD can be considered a developmental or mental disorder distinct from many others. (Barkley, 1998, p. 72)

If inattentive symptoms continue to be included as part of the diagnostic criteria for ADHD, then Barkley (1998) suggests that some of the diagnostic criteria must change. For example, the age of onset for the ADHD *combined type* should be later in life than for the ADHD *predominantly hyperactive-impulsive* type. Now that some of the issues related to this disorder have been explored, Barkley's (1997, 1998) hybrid model of ADHD will be addressed.

Barkley's Hybrid Model of ADHD

Barkley's model of ADHD, although based on various neuropsychological and cognitive psychology theories, may be described as fitting within the information-processing approach. Barkley's main tenet is that *behavioural inhibition is the key deficit in ADHD* and he links behavioural inhibition to the effective functioning of the following four executive functions: 1) non-verbal working memory; 2) verbal working memory; 3) self-regulation of affect/motivation/arousal; and 4) reconstitution (Barkley, 1997). Barkley suggests that the functioning of the four executive functions relies on behavioural inhibition.

Given that there are hypothesized differences between the inattentive type and the hyperactive-impulsive and combined types of ADHD, Barkley's (1997, 1998) model of ADHD applies only to the *hyperactive-impulsive and combined types. His model excludes the predominantly inattentive type. Similarly, for this reason, the present study focused on the predominately hyperactive-impulsive and combined types of ADHD.* To repeat, this model of ADHD primarily applies to the predominantly hyperactive-impulsive and the combined types of ADHD.

Barkley's (1997, 1998) hybrid model of ADHD will now be outlined. This developmental, neuro-psychological model of ADHD is based on a variety of theories in the cognitive, psychological, and neuropsychological literature. The model is based on the role of the prefrontal region of the brain. In a nutshell, Barkley (1997) argues that "ADHD represents a developmental disorder of behavioral inhibition that interferes with self-regulation and the organization of behaviour toward the future" (p. 3).

Barkley's (1997, 1998) model consists of six parts. The first part, behavioural inhibition, consists of the following three different kinds of behavioural inhibition: 1) stopping the prepotent response, 2) interrupting an ineffective ongoing response, and 3) interference control). The next four parts of Barkley's model include the four executive functions: 1) non-verbal working memory, 2) verbal working memory, 3) self-regulation of affect/motivation/arousal, and 4) reconstitution. The last part of Barkley's model, the sixth part, is the motor control and execution component. Each of these parts of Barkley's model will be reviewed in the following order: 1) behavioral inhibition, 2) the four executive functions which consist of non-verbal working memory, verbal working memory, self-regulation of affect/motivation/arousal, and reconstitution, and 3) the motor control and execution component.

Behavioural Inhibition.

Behavioural inhibition is viewed as the first and most important part of Barkley's model. The purpose of behavioural inhibition is to slow down a response to an event. Behavioural inhibition is critical to the functioning of the four executive functions and critical to self-control. As mentioned earlier, there are three kinds of behavioural inhibition: stopping the prepotent response, interrupting an ineffective ongoing response, and interference control. Each of the three kinds of behavioural inhibition is viewed as being faulty in children with ADHD. For this reason, Barkley views them as a single construct.

Behavioural inhibition allows the four executive functions to occur. Behavioural inhibition shields the four executive functions from internal and external interference. Behavioural inhibition is not *directly* responsible for the functioning of the four executive functions. However, behavioural inhibition is responsible for *allowing the four executive functions to occur and protecting them from intrusion* (Barkley, 1998). In addition to allowing the four executive functions to occur, behavioural inhibition directly influences the motor control system. Each of the three types of behavioural inhibition will now be reviewed.

The first type of behavioural inhibition involves preventing an initial prepotent response. The second type of behavioural inhibition involves stopping an ineffective response (Barkley, 1998). These two types of behavioral inhibition delay the behavioural response and allow the relevant executive function(s) to occur. The ability to 1) stop a prepotent response, and 2) interrupt an ineffective ongoing response is critical to self-control. Stopping a behavioural response, or interrupting an ineffective ongoing behavioural response, allows information to be fed back into the system. Thus, the system becomes more flexible and able to detect potential problems. "This leads the path to self-monitoring ability, awareness of immediate past responses and their outcomes, which allows the person to examine the signs of past behaviour for information that can signal the need to change a response pattern" (Barkley, 1997, p. 160). Stopping or interrupting a behavioural response enables the person to self-monitor and determine whether a behavioural response should be changed.

The third kind of behavioral inhibition is interference control. Interference control is just as critical to self-control as the other two behavioural inhibitory processes. Interference control prevents external and internal events from interfering with the execution of the four executive functions. Interference control prevents goal directed behaviors from being disrupted by internal and external events (Barkley, 1997).

Now that the first part of Barkley's (1997, 1998) model, behavioural inhibition, has been outlined, the role of the four executive functions will be reviewed. First, a broad overview of the executive functions will be provided, followed by a description of each of the following four executive functions: 1) non-verbal working memory, 2) verbal working memory, 3) self-regulation of affect/motivation/arousal, and 4) reconstitution.

Executive Functions.

The **executive functions** help the system self-regulate (Barkley, 1998). Each of the four executive functions is interactive and inter-reliant. The four functions work together to foresee change, look to the future, and increase favorable long-term outcomes. The four executive functions "shift behaviour from control by the immediate environment to control by internally represented forms of information by their influence over the last component of the model, motor control" (Barkley, 1998, p. 229).

Barkley (1997, 1998) argues that each of the four functions were public forms of behaviour at one time in development or evolution. Over time, the four executive functions became internalized, private, and self-focused. To repeat, the four executive functions in Barkley's model consist of 1) verbal working memory (also known as speech internalization), 2) non-verbal working memory (also known as sensory-motor privatization), 3) self-regulation of arousal/motivation/emotion (also known as result of privatization of emotion), and 4) reconstitution (internalization of play).

The executive functions are responsible for directing behavior towards a goal and across time. Barkley (1998) reports, "If . . . the executive functions represent the privatization or internalization of behavior to anticipate change in the environment, that change represents essentially the concept of time" (pg. 233). The executive functions assist one in looking to the future, and controlling behaviour in accordance with both the environment and one's goals. The long-term purpose of the executive functions is to increase the individual's long-term benefits.

The executive functions have direct control over the last part of the model—the motor programming and execution system. The executive functions direct behavioural control from the external environment to the internal environment. In this way, the executive functions are responsible for self-control. Barkley (1997, 1998) hypothesizes that if any particular executive function is impaired, we should observe specific impairments in self-control. Now that a broad overview of the four executive functions has been provided, each of the four types of executive functions will be discussed in the following order: non-verbal working memory, verbal working memory, self-regulation of affect/motivation/arousal and reconstitution.

Working memory: non-verbal and verbal.

Prior to addressing non-verbal and verbal working memory specifically, an overview of working memory is provided. **Working memory** may be defined as the capacity to internally represent both non-verbal and verbal information. Working memory helps an individual regulate a response to an event. It allows feedback from a past response to be kept in mind in order to change a future response. The ability to keep feedback from a past response in mind and integrate this feedback with future potential behavioural responses increases the sensitivity of the system to errors. When a sequence of goal-directed behaviours is interrupted, working memory allows the individual to *stop the sequence of behaviors, respond, and then re-start the previous string of behaviours.* Working memory allows the plan for the goal-directed behaviour to be held in mind despite interference (Barkley, 1998). Now that an overview of working memory has been provided, non-verbal working memory will be described, followed by verbal working memory.

Barkley (1997) describes non-verbal working memory as 'covert sensing to the self' or the 're-sensing of an event'. It is the ability to keep events in mind in order to control a behavioural response (Barkley, 1997). There are many different kinds of non-verbal working memory –"all forms of sensory-motor behaviour of which humans are capable of" (Barkley, 1997, p. 162). These forms of non-verbal working memory include tactile, gustatory, olfactory, auditory and visual working memory, and combinations of these forms of working memory. Barkley suggests that auditory and visual forms of non-verbal working memory are particularly important for regulating behaviour. These two forms of non-verbal working memory will now be addressed.

Non-verbal working memory or the capacity to keep sequences of events in mind is essential to five abilities: 1) imitation of behaviour, 2) hindsight, 3) foresight, 4) attaining a sense of time, and 5) self-control. Each of these five capacities will now be addressed. First, non-verbal working memory is responsible for the ability to imitate behavior. In order to imitate behaviour, a mental representation of the behavior(s) must be kept in mind. The ability to keep sequences of events in mind helps the individual to copy other people's behaviours and thus assists with vicarious learning. Second, non-verbal working memory assists with hindsight. Hindsight is attributed to the ability to use past information in order to inform future behaviour. In order to use past information to inform future behaviour, there must be a response delay. (As noted earlier, this response delay is created by behavioural inhibition.) During the response delay, an individual can hold relevant past information in mind in order to determine the most favorable response. Third, non-verbal working memory assists with forethought. Forethought is attributed to the reactivation of prior sensory representations. The reactivation of prior sensory representations primes motor and emotional responses. Foresight helps an individual determine possible future outcomes or events. Hindsight and foresight both help the individual become aware of the present, past and future. Fourth, non-verbal working memory allows one to keep a series of events in mind. This enables the individual to compare events within a sequence and attain a sense of time. Fifth, the ability to keep a series of events in mind is critical to self-control: information fed back into the system improves self-regulation and helps the system compare between the desired outcome and the actual state of events. Such information must be kept in mind in order to help the individual determine if change is necessary. If change is necessary, then plans must be changed. The ability to hold past events in mind in order to prepare for the future is related to self-control: the individual becomes aware that he or she is control of his or her behavior. The ability to keep past events in mind ultimately functions to control motor responses.

In summary, non-verbal working memory helps the individual re-sense information during the response delay. The ability to keep sequences of events in mind guides the next response to an event. As well, the ability to keep sequences of events in mind helps the individual develop a sense of time and use this sense of time to control behaviour. This time sense can now be used to direct motor activity. Not only does non-verbal working memory allow the re-experiencing of past events, but it also helps to determine possible future events or outcomes. An individual can not only anticipate future events, but also prepare for them by structuring the necessary sequence of behaviours toward the event.

> Human behaviour is now controlled not only by a sense of time, but a sense of the past and future giving rise to goal-directed, purposive, and intentional behaviour driven to its destination by the information being internally represented in working memory. Human self-control can be said to originate here, through the mechanisms of covert self-directed sensory behaviour that comes to regulate motor actions. (Barkley, 1997, p. 174)

Now that the first executive function, non-verbal working memory, has been outlined, the second executive function, verbal working memory, will be discussed.

Barkley's view of verbal working memory is similar to Baddeley's (1986) notion of verbal working memory or the articulatory loop. (Please note that Baddeley's model of verbal working memory was discussed earlier in the literature review.) Verbal working memory refers to private speech or the ability to internalize speech. The ability to internalize speech is important to the development of self-control. Private, or internalized speech, allows an individual to reflect on an event prior to responding to the event. Internalized speech also helps self-questioning, generation of problem solving strategies, and determining and following rules.

Rule-governed behaviour is an important form of internal speech. Rule-directed behaviours help to bridge time gaps and to organize behaviour across time. Rules free behaviour from the immediate control of the external environment, and place it under internal control. In this way, Barkley argues, language controls motor behaviour. In order for the motor control execution system to function, and stop prepotent or irrelevant competing responses, verbal working memory is required to keep the rules in mind (Barkley, 1997).

As noted earlier, the four executive functions interact: they do not exist in a vacuum. Verbal working memory and non-verbal working memory interact. They assist other cognitive abilities such as reading comprehension and moral reasoning. For example, the literature supports the relationship between working memory and reading comprehension. This relationship may be explained by the need to keep in mind what one reads, if one is to understand what one is reading.

In summary, internalized speech helps with self-regulation. Internalized speech is a way to inform and control behaviour, and integrate verbal thought with behavior. Now that verbal working memory has been explored, the third executive function, self-regulation of affect/motivation/arousal will be discussed.

Self regulation of affect/ motivation/arousal.

Self-regulation is defined as a response (or responses) to an event that changes the likelihood of a later response. In changing the likelihood of a later response, the likelihood of a later consequence is changed (Barkley, 1998). As noted earlier, in order for self-control to happen, a mental structure known as working memory, helps the person sense time, look towards the future, and use this information to guide behaviour. **Self-regulation of affect/motivation/arousal** includes the following subfunctions and these subfunctions will be discussed in the following order: 1) self-regulation of affect, 2) objective and social perspective taking ability, 3) self-regulation of drive and motivational states, and 4) self-regulation of arousal (Barkley, 1997, p. 185).

Self-regulation of affect is important to self-control. Given that negative emotional displays often result in negative social consequences, the ability to control negative emotions is helpful. Barkley maintains that both external and internal events (i.e., non-verbal working memory, internalized speech) facilitate emotion reactions. An example of a private, internal event that creates an emotional reaction is the image of a razor blade slicing open one's fingertips. Stopping and delaying a prepotent response slows down the emotional reaction to an event and improves objectivity. Considering another person's perspective, or social perspective taking, arises from the ability to stop and delay emotional expression. Working memory helps the person not only to hold the event in mind, but to also to consider the event from the perspective of another person.

The ability to self-regulate one's drive or emotional states is essential to self-control. Individuals must emote to themselves in order to increase motivation. In the absence of immediate external rewards, self-motivation helps an individual move towards a goal. The ability to self-motivate or self-emote is a critical part of private, self-directed behaviour.

Last, self-regulation of arousal arises from the self-regulation of motivation and emotion. That is, the individual's ability to self-regulate his or her level of motivation and emotion affects his or her arousal state. Together, self-regulation of arousal, motivation and emotion direct the individual towards a goal. Now that this component of the model has been reviewed, the fourth executive function, reconstitution, will be discussed.

Reconstitution.

The fourth executive function, reconstitution, is responsible for analyzing and synthesizing behavioural sequences. Analyzing sequences of behaviour enables an individual to break apart these behavioural sequences. This information can then be used to imitate a sequence of behaviors or else recombine them to create new behavioural sequences. Behavioral inhibition is critical for reconstitution as the response delay allows earlier learned behavioural contingencies and sequences to be analyzed and synthesized in order to create a new, creative, sequence of goal directed behaviour.

Barkley suggests that the reconstitutive function can be divided into a verbal and non-verbal format, similar to the division of verbal and non-verbal working memory. Reconstitution is responsible for arranging the verbal and non-verbal units quickly and fluently. Barkley describes the ability to quickly arrange language units into a variety of comprehensive verbal response as 'verbal fluency'. On the other hand, 'behavioural fluency' involves the ability to quickly arrange behavioural units into a range of different behavioural responses.

> *Fine motor fluency or written motor fluency is a manifestation of this process. Fine or gross motor fluency, written fluency, musical or vocal fluency, and even design fluency ought to be manifestations of this process of reconstitution. Whenever a goal must be accomplished, regardless of the form of behaviour that may be required to attain it, the reconstitutive*

> *function will be available to act upon the archive of previously acquired structures of those forms of behavior to generate a range of novel, complex structures that may be of value in the attainment of that goal. (Barkley, 1997, p. 187-188)*

Thus, the reconstitutive process arranges both verbal and non-verbal behavioural units quickly into the best behavioural forms in order to attain a goal. The reconstitutive function can use previously acquired structures of behaviour, also known as rules, in order to create new structures of behavior or new rules.

A wide variety of rules are created through the reconstitutive function. As Barkley (1997) notes, the rules need not be in a verbal format. Rather, rules can in a non-verbal format and the rules can be made up in any kind of "contingency-specifying stimuli" (Barkley, 1997, p. 188).

> A sheet of music or pictorial diagrams arranged in a sequence are sets of rules as much as is a written recipe or manual for performing some mechanical procedure. Rules specify patterns in event sequences—the contingent "if-then" relations among these events—and such specifications can be represented in many forms. (Barkley, 1997, p. 188)

In summary, the reconstitutive function involves the breaking apart and putting together of complex behavioural sequences. New, creative behavioral sequences that fit with the earlier created rules (held in working memory) are generated. Reconstitution is responsible for creating new and flexible behaviours. The reconstitutive function also generates verbal and non-verbal rules that direct behavior. Now that we have discussed the last executive function, the motor control/fluency/syntax component of Barkley's model will be reviewed.

Motor control/fluency/syntax.

The motor control part of the hybrid model relies on behavioural inhibition and the four executive functions (Barkley, 1997). Behavioural inhibition and the four executive functions interact in order to control the motor system. They take it from control by the immediate, external environment to the control of the internal environment. The internal control of behaviour prevents non-essential information or motor behaviours from interfering with self-control, and prevents the external immediate environment from controlling behavior. As a child becomes older, the internal control of behaviour becomes more and more important, particularly for attaining one's goals.

Together, the four executive functions interact to bring the system under internal control. For example, self-regulation of motivation is critical to initiating and maintaining a behavioural response. Once a behavioural response has been determined and the response is ready for motor execution, then motivation must initiate and maintain the behavioural response. Motivation drives the behavioural response towards a goal. The working memory executive function is also important as it allows feedback from the last response to be kept in mind (also known as the retrospective function), which helps the individual change subsequent responses. Keeping feedback from previous responses in mind increases sensitivity to mistakes and improves behavioural flexibility. If a sequence of behaviours is interrupted, working memory enables the original plan to be kept in mind while the individual responds to the interruption.

In summary, we have now reviewed the components of Barkley's hybrid model. Next, this model will be specifically applied to ADHD.

Barkley's Hybrid Model Applied to ADHD

The reader has been provided with an outline of Barkley's (1997, 1998) model and now it will be applied to ADHD. Then, predicted impairments and some related research evidence will be reviewed.

Barkley (1997) suggests that ADHD involves a deficit in behavioural inhibition. The term 'deficit' is not a lost or destroyed function, nor is expected to catch up to normal individuals. Rather, Barkley likens the term to mental retardation: the term suggests a chronic cognitive delay, which does not change with age or time.

As mentioned earlier, behavioural inhibition helps the four executive functions work successfully, and to generate internally represented information (e.g., rules, motivation, imagery). Barkley (1997) argues that a problem or an inhibitory deficit (i.e., developmental delay) in the behavioural inhibition system characterizes ADHD. The inhibitory deficit impairs the functioning of the four executive functions. Impairment of the four executive functions prevents the four executive functions from generating internal forms of information (e.g., rules, motivation). Reducing internally generated information disrupts the internal control of behaviour and the ability to self-regulate. In turn, the control of goal-directed motor behaviors is reduced. Barkley (1998) summarizes the impairments associated with ADHD:

> Given all this, those with ADHD could be said to have impairments in all of the executive functions and their subfunctions . . . . Consequently, they

> would manifest the difficulties evident in the motor control component of that model as well. Here, then, is a relatively comprehensive theory of ADHD that links up the delay in behavioural inhibition ascribed to the disorder by myself and many others with the executive functions, self-regulation, and time, which means that ADHD is not just a deficit in behavioural inhibition but also a deficit in executive functioning and self-regulation as a consequence of that inhibitory impairment. This deficit results in a renegade motor control system that is not under the same degree of control by internally represented information, time, and the future as would be evident in the normal peer group of that ADHD individual. (Barkley, 1998, p. 249)

ADHD is viewed as a performance disorder or a disorder of not being able to do what one knows one should do. Although individuals with ADHD are *often aware of what they should have done*, this knowledge does not help the individual control his or her actions. ADHD is a disorder in the "where" and "when" rather than the "what" and "how" (Barkley, 1998, p. 249). It is a disorder of applied intelligence and detaches the "crystallized intelligence of prior knowledge from its application in the day-to-day stream of adaptive functioning" (Barkley, 1998, p. 249). Now that Barkley's (1997) hybrid model has been related to ADHD, some of the impairments that are predicted from this model will be explored. Then, research evidence related to these predicted impairments is discussed.

Predictions related to Barkley's model

The following components of Barkley's six part model of ADHD will now be stated in terms of the expected deficits in individuals with ADHD: behavioral inhibition, non-verbal working memory, working memory, self-regulation of affect/motivation/arousal, reconstitution, and motor control.

Behavioural Inhibition.

Barkley (1997) predicts that an individual with ADHD has problems in each of the three components of behavioural inhibition: disrupted prepotent responses, ongoing response perseveration and weak interference control. Impaired behavioural inhibition would impact each of the four executive functions and the motor control system. Impaired behavioural inhibition would result in weakened non-verbal working memory, verbal working memory, self-regulation of affect/motivation/arousal, and reconstitution. Impaired behavioural inhibition would also impact the motor control system. Each of these impairments will be discussed. First, predicted impairments related to non-verbal working memory are discussed.

Impaired non-verbal working memory.

Barkley (1997) predicts that an individual with ADHD would have impaired non-verbal working memory (i.e., visual working memory). Impaired behavioral inhibition would disrupt the working memory system and its contents. Thus, the individual with ADHD would have difficulty holding and manipulating events in mind. They would have difficulty with tasks requiring imitation of complex behavioural sequences. They would have problems with hindsight, foresight, and reduced self-awareness. They would be influenced by immediate, external events rather than by internal events. Their sense of time and organization of behaviours across time would be impaired. They would be less likely to continue with a goal. In addition, they would have problems with non-verbal rule governed behaviour.

Non-verbal working memory problems would translate to poor hindsight and foresight. Thus, the child's ability to use information derived from past behaviours to change later responses (hindsight) is impaired. An individual with ADHD should have impaired planning ability. Planning involves not only non-verbal working memory, but also other executive functions. Planning requires motivation over time, behavioural response inhibition (and control from interference), and reconstitution.

Next, predictions related to poor verbal working memory are reviewed.

Impaired verbal working memory.

Barkley (1997) predicts that an individual with ADHD would have impaired verbal working memory. The delayed internalization of speech would reduce problem solving capacity and rule-governed behaviour. The individual would be less likely to use self-talk before responding to an event. They would have difficulty with self-reflection. Given that self-talk is linked to motor control, they should have more difficulty using self-talk to control motor activity. They would have more problems creating meta-rules or rules and would have difficulty using rules or strategies to guide behaviour across time. To remind the reader, rules are guidelines for directing behaviour and are important for complex problem solving.

The individual would have weaker reading comprehension and poorer moral reasoning. With respect to poorer reading comprehension, Barkley suggests that both non-verbal and verbal working memory interact to help the individual to understand what he or she is reading:

> . . . the internalized speech of silent reading must be also held in mind. The deficits predicted to exist in both of these executive functions due to ADHD would be predicted to create a diminution in the power of reading comprehension in those with the disorder (Barkley, 1997, p. 247).

In summary, Barkley's (1997) model predicts a variety of impairments related specifically to verbal working memory. Next, impairments related to delayed self-regulation of affect/motivation/arousal will be discussed.

Impaired self-regulation of affect/motivation/arousal.

Barkley (1997) predicts that individuals with ADHD would have impaired self-regulation of affect, motivation and arousal particularly related to goal directed behaviors. An individual with ADHD would have impaired social perspective taking. Since individuals with ADHD have more difficulty using internal forms of information (non-verbal and verbal), they would have more difficulty motivating themselves. They should be less able to cope with behavioural contingency delays and delayed reinforcement, and more open to more immediate and external forms of reinforcement.

Now that predicted impairments related to delayed self-regulation of affect/motivation/arousal have been reviewed, impairments related to reconstitution will be discussed.

Impaired reconstitution.

The model predicts that individuals with ADHD would have reduced ability to analyze and synthesize behaviour. They would have reduced verbal and behavioral fluency. They would have more difficulty analyzing previous behavioural unit sequences. This would leave them less capable of synthesizing the behaviour into new behavioural response patterns. "This problem should be evident in those with ADHD not only in their speech, but in non-verbal forms of fine and gross motor behavior as well" (Barkley, 1997, p. 253).

Barkley predicts that verbal fluency should also be impaired in individuals with ADHD. In fact, Barkley predicts that the deficit in verbal fluency should extend to non-verbal fluency.

> . . . I would also argue that those with ADHD should have a diminished ability to perform tasks involving non-verbal fluency, such as design, vocal, musical, fine, and gross motor fluency. In short, whenever a task demands the construction of a novel, complex sequence of non-verbal responses, those with ADHD will be less capable of quickly and accurately assembling such novel responses from their past repertoire of behaviour from others who are unaffected by this disorder. (Barkley, 1997, p. 253)

Individuals with ADHD should show reduced behavioural goal directed creativity. They would also have weaker behavioural syntax and poor reproduction of behavioural simulations. Now that predicted deficits in reconstitution have been discussed, predictions related to the last component of Barkley's model, the motor control/fluency/syntax component, will be discussed.

Poor motor control/fluency/syntax.

Barkley's model predicts that individuals with ADHD should show poor motor control/fluency/syntax. Poor motor control/fluency/syntax results in behavioural inflexibility, reduced sensitivity to response feedback, reduced goal-directed persistence, reduced task re-engagement after disruption, and reduced control of behavior by internally represented information.

Individuals with ADHD should show more task irrelevant responses. They would show reduced complexity and novelty in their motor sequence responses. They would be more controlled by the immediate external environment than the internal environment. They would have reduced ability to engage in goal directed ability, particularly with reduced external forms of reinforcement. They would be more likely to be involved in their immediate external environment (i.e., handling and exploring objects in the external environment). They would have reduced ability to execute goal directed behaviour, as they would be more engaged in the external environment. They would have reduced motor response sensitivity to mistakes or reduced ability to generate new behaviour patterns. This would lead to patterns of perseverative responding on tasks that require flexibility. This would also result in reduced likelihood of benefiting from feedback about performance errors.

In summary, a variety of impairments in the six areas may be predicted from Barkley's (1997) hybrid model. Now that we have reviewed some of the predicted impairments, research evidence related to this model will be discussed.

Impairments in Children with ADHD: Research Evidence

This part of the literature review will focus on some of the research evidence associated with Barkley's (1997) predicted impairments in individuals with ADHD. This by no means a comprehensive review of the predicted impairments. This section focuses only on parts of Barkley's model that are likely related to the WISC-III PS and FD factors: non-verbal working memory, verbal working memory, self-regulation of affect/motivation/arousal, and motor control. Thus, this review of the research literature is limited to only these areas.

Non-verbal working memory deficits.

Overall, there is limited research on the relationship between non-verbal working memory and ADHD (Barkley, 1997). A primary difficulty with research in the area of non-verbal working memory is that measures assessing non-verbal working memory usually are not pure measures of non-verbal working memory (Barkley, 1997).

In general, the research evidence for non-verbal working memory deficits in ADHD children is mixed. Barkley's research indicated reduced non-verbal working memory for spatial location in ADHD children (Mariani & Barkley, 1997). However, Weyandt and Willis's (1994) research using a visual search task of a display for a target item and did not find any differences between ADHD and non-ADHD children.

Barkley (1997) argues that measures of non-verbal working memory might include visual memory tests. However, research examining reproduction and organizational deficits using visual memory tests such as the Rey-Osterrieth Complex Figure Drawing Test has mixed findings. Some studies have found that children with ADHD have difficulty with visual organization and copying tasks (e.g., Rey-Osterrieth Complex Figure Drawing Test) (Cahn & Marcotte, 1995; Douglas & Benezra, 1990; Grodzinsky & Diamond, 1992; Sadeh, Ariel, & Inbar, 1996). The Rey-Osterrieth Complex Figure Test requires the child to reproduce a complicated, non-meaningful visual design, and then re-draw the design after a number of minutes (delayed visual memory). For example, Sadeh et al. found differences between 30 normal-intelligence children with ADHD and 20 normal children on the Rey-Osterrieth Complex Figure Drawing Test and the Taylor Complex Figure Test. Results indicated that the group of normal children scored significantly better than the group of children with ADHD on all task conditions (i.e., copy condition, immediate recall, and delayed recall). Similarly, Douglas and Benezra administered various verbal and non-verbal measures to 30 ADHD, 30 normal, and 24 reading disabled boys. Their findings indicated that across all of the nonverbal tasks, the only task on which differences between the ADHD and control group were found, was on the Rey-Osterrieth Figure Test.

On the other hand, some studies have not found such differences (i.e., lower performance on measures of non-verbal visual working memory such as the Rey-Osterrieth Complex Figure Drawing Test) (Moffit & Silva, 1988; Reader, Harris, Schuerholz, & Denckla, 1994). Other studies have found differences only in children with Attention Deficit Disorder (ADD) and comorbid reading disorders (McGee, Williams, Moffitt, & Anderson, 1989). For example, in a longitudinal study, McGee et al. examined three groups of 13 year old boys: 1) ADD and reading disability, 2) reading disability, and 3) control. The adolescents were examined on various non-verbal neuropsychological measures. McGee et al. found that children with comorbid ADD and reading disabilities showed significantly lower scores on the delayed recall measure of the Rey-Osterrieth Complex Figure Test in comparison to children with only reading disabilities and normal children. However, unfortunately implications from this study are limited as it focused primarily on children with primarily ADD, not ADHD. As Barkley (1997) notes, studies that *did not* find differences on visual memory, organization and copying tasks (i.e., non-verbal working memory measures) involved community-screened children while studies that found differences on these tasks typically involved clinic-referred children. Barkley (1997) attributed the differences in study results to more severe symptoms in the clinic-referred children in comparison to the community-screened children.

In addition to the noted impairments in non-verbal working memory, Barkley (1997) reports that the literature supports impaired hindsight, foresight, and planning ability in children with ADHD. Given that the PS factor has been hypothesized (e.g., Kaufman, 1994) to measure planning ability, this function will now be briefly discussed. Planning ability relies on foresight and to some degree hindsight. As Barkley notes (1997), one of the best measures of planning ability is the Tower of London task. This task requires the child to look at three wooden pegs that have an arrangement of colored balls. Based on certain rules as to how the balls may be moved, the child must copy the arrangement with their own pegs and balls. For this task, the child must visually represent and manipulate in mind, how the balls could be moved, prior to moving them. Research has suggested impaired performance on the Tower of London task (and tasks similar to the Tower of London such as the Tower of Hanoi) in ADHD children (Pennington, Grossier, & Welsch, 1993; Weyandt & Willis, 1994). Barkley (1997) suggests that this finding lends support to his argument that children with ADHD have problems with planning. In summary, the literature generally supports impaired non-verbal working memory in children with ADHD, although this finding is not conclusive. Next, impairments in verbal working memory is addressed.

Verbal working memory deficits.

Barkley's model of ADHD predicts that individuals with ADHD should have impaired verbal working memory. Tasks that involve verbal working memory include digit span tasks (forward and backward) and mental computation tasks, such as mental arithmetic. These tasks require verbal material to be kept in mind, and sometimes manipulated, across time and the literature generally supports problems in these tasks in children with ADHD (Barkley et al., 1990; Douglas & Benezra, 1990; Mariani & Barkley, 1997). The literature has found that children with ADHD tend to have problems on tasks requiring mental computation (Ackerman, Anhalt, & Dykman, 1986; Barkley et al., 1990; Mariani & Barkley, 1997) and on digit span tasks (Barkley et al., 1996; Mariani & Barkley, 1997).

Tasks of verbal working memory include the DS and AR subtests of the WISC-III FD factor and research evidence suggests that children with ADHD tend to perform relatively weakly on mathematical tasks similar to the two subtests that make up the WISC-III FD factor (i.e., Anastopoulos et al., 1994; Lufi, Cohen, & Parish-Plass, 1990; Zentall & Smith, 1993). Zentall and Smith examined 92 boys with ADHD, with and without, coexisting aggression. They categorized three groups of boys: ADHD (n=22), ADHD and aggression (n=13), and non-disordered (57). These three groups of boys were assessed for both timing and accuracy for performing mathematics. Results indicated that the boys with ADHD made more errors, had slower and more variable response times, and tried fewer mathematical problems than the non-disordered boys. Limits of this study included a small group of ADHD boys. However, this research does support weak verbal working memory in ADHD boys.

Barkley notes that tasks requiring storage and recall of simple verbal information that does not require a lot of mental manipulation tend not to show impairment in children with ADHD (Barkley et al., 1990; Cahn & Marcotte, 1995). For example, Cahn and Marcotte examined 57 children with ADHD. They administered a verbal measure (i.e., the Story Memory subtest of the Wide Range Assessment of Memory and Learning Test) to these 57 retrospectively identified ADHD children. Results indicated that on the Story Memory subtest, subjects with ADHD showed no evidence of impaired recall, both immediately following story presentation and after a time delay. Cahn and Marcotte suggest that the straight-forward, simple organizational structure (i.e., sequential and temporal narrative) of this material likely facilitated recall of the verbal information.

However, tasks that require more complex mental manipulation of verbal information generally tend to show impairment in children with ADHD (Seidman et al., 1995; Seidman et al., 1996). As well, when verbal memory tasks require organizational strategies, children with ADHD show more impairment in comparison to non-ADHD children (Frost, Moffitt, & McGee, 1989; Shapiro, Hughes, August, & Bloomquist, 1993). For example, Frost et al. examined 678 members of a birth cohort. This sample was followed since birth and reassessed every two years with a number of psychological, medication and sociological measures. These subjects were assessed at age 13. Subjects who met the criteria for ADD (n=13), Conduct Disorder (n=17), Anxiety (n=14), Depression (n=10), multiple disorders (n=19), and non-disordered (n=605) were compared on various neuropsychological measures including verbal, verbal memory, and visual-motor integration factors. The verbal factor consisted of the following subtests: WISC-R Information, Vocabulary, Similarities, and AR subtests. The verbal memory factor consisted of the following measures: Rey Auditory Verbal Learning delayed recall, last trial and first trial tasks. The visual-motor-integration factor consisted of the following measures: Trail Making Part A & Part B times, WISC-R CD subtest, and Grooved Pegboard total. Results indicated that the ADD group performed significantly worse on the verbal memory and visual-motor-integration factors than the non-disordered children. These results suggest that when verbal memory tasks require more complex manipulation of verbal material, children with ADD tend to show more impairment. However, limits of this study include the use of an ADD group rather than an ADHD group, thus limiting implications for the ADHD group. As well, there was a relatively small number of subjects (n = 13) in the ADD group which limits statistical power. Next, research literature related to self-motivation in ADHD children will be reviewed.

Self-regulation of motivation deficits.

Barkley's (1997, 1998) model predicts, and the research literature generally supports, reduced self-motivation in children with ADHD. He hypothesizes that children with ADHD have problems with tasks that require repetitive responding and little reinforcement (Barkley, 1997). In general, research has supported reduced motivation on low reinforcement tasks for ADHD children (Barber, Milich, & Welsh, 1996; Barkley, 1990). Barber et al. examined the impact of the schedule of reinforcement and task difficulty on a learning task in 45 ADHD and 45 control boys between the ages of 7 and 10. The boys were assigned to one of three reinforcement conditions: continuous (i.e., 100% reinforcement and 100% feedback), partial (i.e., 50% reinforcement with 100% feedback), and none (i.e., 0% reinforcement and 100% feedback). Feedback, in this study, was defined as informing the boys as to whether their answer was correct or incorrect. Each boy was given two verbal memory tasks: a semantically related word pair (i.e., baby-bottle) and a semantically unrelated word pair (dog-glass) memory task. Subjects also completed a questionnaire to determine the memory strategies used for the task. Although results indicated that on the two tasks (verbal and non-verbal) and reinforcement conditions there were no significant differences between the ADHD and control boys, some other relevant findings did emerge from this study. First, there were order effects: boys with ADHD performed worse when they were given the more difficult, semantically unrelated task first. When the ADHD boys were administered the relatively easier, semantically related task first, performance was better. Authors suggest that practical implications include giving ADHD boys easier tasks first and thus improving the chance for overall success. As well, a lack of statistical power could have been responsible for not finding significant differences between the task and reinforcement conditions in this study.

Kaufman (1994) suggested that the WISC-III PS factor may well measure aspects of self-regulation of motivation. He has even encouraged clinicians to view the child's PS factor score as an indicator of motivation. Next, research examining motor control/fluency/syntax impairment in ADHD children will be discussed.

Motor control/fluency/syntax deficits.

The majority of studies of examining motor control problems in children with ADHD support the existence of such deficits (Barkley et al., 1990; Hartsough & Lambert, 1985; Szatmari, Offord, & Boyle, 1985; Wilson & Marcotte, 1990). Fine motor coordination (e.g., tracking, paper/pencil mazes) has often been found impaired in ADHD children (DuPaul & Stoner, 1994; Mariani & Barkley, 1997; Moffitt, 1990; Sadeh et al., 1996). In a longitudinal study, Moffitt followed a cohort of 435 boys from age 3 to age 13. Although Moffitt focused on delinquent behaviour and attention deficit disorder (ADD), he examined performance on a variety of measures, including motor performance as measured by the Bayley Motor Scales at age 3 and the McCarthy Motor Scales at age 5. Moffit examined four groups of boys: a control group of non-disordered boys; a group of attention deficit disordered non-delinquent boys; a group of non-attention deficit disordered but delinquent boys; and a group of attention deficit disordered and delinquent boys. Results indicated that the four groups varied significantly on the tests of motor ability. At age 3, on the Bayley Motor Scales, the ADD and delinquent group scored significantly below the other three groups (i.e., control, only ADD, only delinquent), which did not significantly differ between themselves. Similarly, on the McCarthy Motor Scales at age 5, the ADD and delinquent group scored significantly below the other three groups, which did not significantly differ from each other. Weaknesses with this study include the use of only ADD groups, and not groups including hyperactivity. Thus, we do not know whether findings translate to children with ADHD. As well, the Bayley and McCarthy Motor Scales are generally measures of gross motor behaviour. Also, we do not know how the boys scored at later ages.

More recently, Mariani and Barkley (1997) examined the neuropsychological capacities of 34 preschool boys with ADHD and 30 community 'normal' non-behaviorally disordered boys. Each boy was administered more than 25 different variables. These variables included the following measures of motor sequencing and visual motor ability: the Purdue Pegboard (a measure of manual speed and dexterity), the Hand Movements subtest of the Kaufman Assessment Battery for Children (the child imitates a series of progressively more complex hand movements), and the Beery Developmental Test of Visual Motor Integration (the child copies a series of geometrical forms. The only significant differences between the ADHD and normal boys were on the Kaufman Hand Movements subtest. However, when whole data set was analyzed dimensionally, a four-factor solution indicated that a first factor, Motor Control, measured motor planning, speed, agility and sequencing. Authors concluded that children with ADHD were likely to be significantly impaired on measures of motor control. As the authors note, limitations of this study include a relatively small sample size. As well, subjects were administered a relatively large number of measures which raises the likelihood of false positives.

Children with ADHD tend to show more impaired performance on measures of complex, coordinated sequences of motor movements than on measures of more simple, motor movements, such as finger tapping tests or grooved pegboard tests (Grodzinsky & Diamond, 1992; Mariani & Barkley, 1997). Complex motor sequences, such as handwriting, have often been implicated as weak in children with ADHD (Sleator & Pelham, 1986), as have drawing skills (McGee et al., 1992). Barkley (1990) notes that "Many ADHD children are notorious for having difficulties with handwriting or penmanship" (p. 79). Handwriting requires fine motor control and the integration of many behavioral sequences into written language and the clinical literature has shown that children with ADHD are often delayed in this area in comparison to age peers (Sleator & Pelham, 1986). As well, children with ADHD tend to show delays on complex motor sequences such as drawing (Hoy, Weiss, Minde, & Cohen, 1978; McGee et al., 1992).

Marcotte and Stern (1997) examined graphomotor output in 80 subjects with ADHD using the Repeated Patterns Test (see Waber & Bernstein, 1994). Forty subjects had the ADHD predominantly inattentive type and 40 subjects had the ADHD combined type. The Repeated Patterns Test measures graphomotor output independent of linguistic requirements such as spelling and punctuation. This task requires the child to copy five patterns of escalating difficulty. The purpose of this study was to compare graphomotor output in children with ADHD to normal children. Researchers hypothesized that both the inattentive and combined types of ADHD would have graphomotor problems in comparison to the normal control group. These researchers examined children between the ages of 8 and 13 as the test only has normative data for this age group. Subjects were retrospectively identified from clinic files and subjects were chosen for the study without knowledge of the child's Repeated Patterns Test performance. They were given the test as part of a neuropsychological evaluation battery of tests. Subjects were also given the Beery Developmental Test of Visual Motor Integration to rule out deficits in visual perception and visual motor integration. Results indicated that performance on the Beery Developmental Test of Visual Motor Integration was within the Average range. On the Repeated Patterns Test, however, both groups of ADHD showed significantly weaker graphomotor output than the normative group. As well, the ADHD combined type scored significantly lower than the ADHD predominantly inattentive type on the Repeated Patterns Test. Researchers suggested that the weaker performance of both ADHD groups in comparison to the normative group was not accounted for by poorer visual perception or visual motor integration (i.e., given normal Beery scores). They suggest that ADHD children have deficits in the basic mechanical skills demanded of writing.

A seminal study by Hoy et al. (1978) examined 15 adolescents who were diagnosed with hyperactivity five years earlier. Hoy et al. compared these 15 adolescents to an equivalent social class, intelligence, sex and age control group. They administered 11 cognitive tests, which included measures of visual-motor integration and motor skills.

Hoy et al. administered the following visual motor integration and motor tests: the Bender Visual Motor Gestalt test, the Goodenough-Harris Draw a Person Test, and the Lincoln-Oseretsky Motor Development Scale. Results indicated that the adolescents diagnosed with hyperactivity performed significantly worse on the Bender Visual Motor Gestalt Test and on the Lincoln-Oseretsky Motor Development Scale, suggesting impaired motor skills. A weakness of this research study, however, is the reliance on earlier, pre-DSM-IV diagnostic criteria and thus it is unclear how closely the 15 boys would resemble today's ADHD predominantly hyperactive and combined types. Another weakness in this study is the small sample size.

In general, although the research literature suggests problems in the area of motor control in ADHD children, these results have been infrequently discussed in the literature with respect to their theoretical implications.

In summary, Barkley's model of ADHD, along with predicted impairments and related research evidence have been discussed. Next, age-related differences on some cognitive measures will be reviewed.

Age differences.

Grodzinsky and Diamond (1992) examined the relationship between age and ADHD, and they suggest that an enhanced understanding of this relationship can impact our understanding of the associated deficits in ADHD. Grodzinsky and Diamond examined the relationship between age, frontal lobe functioning, and ADHD. On tasks requiring frontal lobe functioning, there might be greater differences between ADHD and normal children at younger versus older ages. This finding would be consistent with the notion that children with ADHD have delayed maturation in the applicable brain area. Alternatively, the differences between ADHD and normal children might remain stable throughout development. This finding would be consistent with the view that children with ADHD have a stable impairment that does not change throughout development. Overall, Grodzinsky and Diamond's research findings support the second view. They administered a number of measures to 66 boys with ADHD and 64 control boys (ages 6 – 11). These measures included the Rey-Osterrieth Complex Figure Test, Porteus Mazes, and the Stroop Test. The children were broken into two age groups: a 6-8 group and a 9-11 group. Results indicated that there were no interactions by age: both the ADHD and control groups showed improvement on the tasks with age. However, the ADHD group showed significant impairment on these tasks at both age levels. Thus, Grodzinksy & Diamond's research supports the view that children with ADHD have stable impairment on tasks requiring frontal lobe functioning in comparison to control children.

Seidman, Biederman, Faraone, Weber, and Oullette (1997) examined age differences on neuropsychological measures in two age groups (younger and older) of children with ADHD (n=118) and children without ADHD (n=99). The younger age group included children under 15 years and the older age group included children over 15 years. Subjects in this sample were between the ages of 6 and 17, and 68% were taking medication for ADHD (48% taking stimulant medication). Subjects were administered a variety of neuropsychological measures including the Rey-Osterrieth Complex Figure Test, the Wisconsin Card Sorting Test, and the Stroop test. Similar to Grodzinsky and Diamond's (1992) results, findings indicated that regardless whether the subjects had

ADHD or not, the older participants performed better than the younger participants. This finding suggests that regardless of whether a child has ADHD, neuropsychological performance on these three measures tends to improve with age. Second, children with ADHD continue to show impairment on such measures over time in comparison to the control group. Both younger and older children with ADHD show impairments on these three measures in comparison to the control group. However, a limitation of this study was the high percentage of medicated students at the time of testing.

Other studies, however, using continuous performance tests, have found age or developmental differences on tasks of attention in children with ADHD (Mitchell, Chavez, Baker, Guzman, & Azen, 1990; H. Swanson, 1983). For example, H. Swanson found that as learning disordered and attention deficit children become older (i.e., over 10 years), they tend to show greater impairment in comparison to non-learning and attention deficit disordered children in their ability to discriminate between signaled and non-signaled letters. H. Swanson attributed maturational age as influencing attentional performance in learning disordered and attention disordered children. However, this study is limited as H. Swanson studied learning disabled children with attentional problems rather than children with pure ADHD.

Methodological and Statistical Considerations in ADHD

Methodological considerations.

Barkley (1997) discusses some of the methodological issues that plague research of ADHD. Three issues relevant to the present work will be discussed. Firstly, a common difficulty for researchers is the frequent use of small sample sizes. Small sample sizes tend to limit statistical power. However, small sample sizes are dictated by necessity, as large sample sizes are usually not possible. As Barkley observes, small sample sizes are related to the practical dictates of clinical research, funding and timelines. Research using small sample sizes should not be discarded. Rather, small sample sizes should encourage researchers to use caution when interpreting research findings, particularly negative findings.

The "ghost of comorbidity" is a second methodological problem haunting research of ADHD (Barkley, 1997). As noted earlier in the literature review, an individual with ADHD is very likely to be comorbid with other psychiatric and learning disorders. For this reason, it is extremely difficult to find 'pure' samples of children with ADHD. Often, differences between the control group and the ADHD group may be due to the comorbid disorder and not ADHD. Barkley reports that although some recent research has controlled for comorbid disorders, most research has not. However, the research studies that have controlled for comorbidity have implicated problems with behavioral inhibition and the executive functions as related to ADHD. In conclusion, not only is it difficult to obtain samples of children with ADHD for research purposes, it is also difficult to obtain 'pure' samples of ADHD. Given that children with ADHD often present with comorbid diagnoses, the present study focused on examining the WISC-III PS and FD factors in pure samples of children with ADHD.

A third methodological issue requiring consideration involves the measures used to determine cognitive deficits in children with ADHD. In particular, Barkley (1997) urges consideration of the "developmental sensitivity of the measures being used to assess the executive functions at particular ages" (p. 263). The deficits predicted by Barkley's model are viewed as developmental delays. This framework suggests that children with ADHD should lag behind normal children in the development of the executive functions as well as in the development of behavioral inhibition. If a cognitive task is too difficult for normal children, let alone children with ADHD, no differences will be found between the normal and ADHD groups.

> All this suggests that at any given age at which ADHD and normal children are being compared, the tests of inhibition and executive functions must be chosen such that most normal children have only recently mastered this level of difficulty or are well in the midst of doing so. One is then likely to find that ADHD children are lagging behind in their mastery of this level of difficulty of the task. (Barkley, 1997, p. 265)

In summary, it is important that normal children of the same age group have mastered the measure or ability that is being used to measure deficits in ADHD populations. The WISC-III PS and FD factors have been extensively standardized across age groups of children and therefore should be amendable to comparison between different age groups. The PS and FD factors have been standardized and normed across age groups and thus researchers can compare how ADHD children score in comparison to similarly aged normal children.

In summary, several methodological issues plague research of ADHD. The present study has attempted to account for several of these problems. Next, statistical considerations will be addressed.

Statistical considerations.

Not only are there certain methodological considerations researchers must be aware of, but there are also statistical considerations. The primary statistical consideration that will be addressed is the statistical assumption made by many researchers to control IQ as a covariate in studies of children with ADHD. Essentially, Barkley (1997) argues that the assumption to statistically control IQ as a covariate in studies of children with ADHD is flawed. He bases his argument on research that has found negative, low correlations between hyperactive-impulsive behavior and measures of intelligence. For example, when these children are selected without equating for IQ, children with ADHD differ significantly from control or normal groups on measures of verbal intelligence. They also show differences on measures of IQ. "ADHD specifically, has an inherent association with diminished IQ, particularly verbal IQ" (Barkley, 1997, p. 297). Barkley states that this "small but significant relationship implies that up to 10% or more of the variance in measures of crystallized IQ may be explained by symptoms of ADHD" (Barkley, 1997, p. 297). Barkley concludes that the relationship between IQ and ADHD raises serious questions about the wisdom of statistically controlling out IQ as a covariate in studies of children with ADHD.

> Typically, when this has been done, differences between children with hyperactive-impulsive behavior or with ADHD and control groups on various cognitive tests are often reduced or are no longer statistically significant . . . . The repeated findings that ADHD symptoms are significantly related to IQ, in both normal and ADHD samples, challenges

> the wisdom of controlling for IQ. Such study design probably eliminates some of the differences between groups that are the result of the independent variable of interest, ADHD. It also removes some of the differences that are a secondary function of the effects of ADHD on the executive functions. In the future, researchers on cognitive deficits associated with ADHD at the very least should report their findings with and without controlling for IQ so that other investigators can decide for themselves how any group differences should be interpreted in light of the association of ADHD with IQ deficits. Certainly, it should no longer be assumed that controlling for IQ automatically enhances the internal validity and rigor of the research, or that investigators who fail to do so are somehow less than rigorous, their findings about ADHD therefore open to doubt. Nor should it be assumed that initially significant group differences that become non-significant in the process of controlling for IQ therefore do not really reflect the effects of ADHD on these outcomes. (Barkley, 1997, p. 297-298)

In conclusion, Barkley clearly states that controlling for IQ does not necessarily improve the validity of research findings. Even if significant findings become non-significant when controlling for IQ, Barkley (1997) states that this does not mean that the significant findings are any less valid.

In summary, we have reviewed the etiology of ADHD and associated impairments. Barkley's model was reviewed and applied ADHD, and predicted impairments based on his model were discussed. Research literature related to these predicted impairments were noted. This section concluded with a discussion of some methodological and statistical concerns plaguing researchers in this area. Next, the WISC-III PS and FD factors will be addressed.

WISC-III: PS and FD Factors

The last section of the literature review focuses specifically on the WISC-III PS and FD factors. Earlier in the introduction, the controversy regarding the factor structure of the WISC-III was briefly mentioned (i.e., Sattler, 1992b). Given that the purpose of this study is to examine the PS and FD factors in children, it is important to first address some of the research related to the factor structure of the WISC-III.

WISC-III factor structure.

Wechsler (1991) suggests that a four-factor model best fits the WISC-III data. Wechsler's analysis of the standardization data indicates that the PS factor accounts for 4 to 5 percent of the test variance and that the CD and SS subtests load strongly on the PS factor. The subtest loadings range from a high of 0.98 for the CD subtest in the 6 to 7 age group to a low of 0.52 for the SS subtest in the 11 to 13 age group (Wechsler, 1991). The only pattern interruption (which is at the limits of non-significance) is the 0.30 loading of the SS subtest in the group aged 6-6 (Wechsler, 1991).

There is a lot of support in the research literature for the stability of the four-factor model in various populations (e.g., special education, psychiatric) and across age groups (Blaha & Wallbrown, 1996; Hishinuma & Yamakawa, 1993; Kamphaus, Benson, Hutchinson, & Platt, 1994; Keith & Witta, 1997; Konold & Kush, 1997; Roid, Prifiteria

& Weiss, 1993; Roid & Worrall, 1996). For example, using the WISC-III standardization sample, Kamphaus et al. tested the following three WISC-III models: 1) the original two factor model, 2) a three-factor model, and 3) the four-factor model supported by the WISC-III manual. Results indicated that the four-factor model fit the data better than the other two models for all ages. Similarly, Keith and Witta re-examined the WISC-III factor structure using the WISC-III standardization sample data. They questioned whether the WISC-III measures the same constructs across the 6 to 16 year age span. Keith and Witta found that the "WISC-III appears to be *remarkably consistent* in what it measures from ages 6 to 16; indeed, the matrices at different age levels were statistically indistinguishable (cf. Allen & Thorndike, 1995)" (p. 104).

The four-factor model has also been supported in special education populations (Blaha & Wallbrown, 1996; Hishinuma & Yamakawa, 1993; Konold & Kush, 1997; Roid et al., 1993; Roid & Worrall, 1996). For example, Konold and Kush examined the factor structure of the WISC-III in a sample of children requiring special education services. These children were either diagnosed with a mental handicap or a learning disability. Given that many previous researchers used all thirteen subtests in their analyses in order to determine the WISC-III factor structure, despite the fact that 12 subtests are used to obtain scores, this study analyzed the 12 subtests which actually yield the following four-factor scores including VC, PO, FD and PS. Using the twelve subtests, Konold and Kush's results support the four-factor solution in special education samples.

Not only is the four-factor model supported in special education samples, but it is also supported in a sample of psychiatric inpatients (Tupa & Wright, 1997). Tupa and Wright explored the factor structure of the WISC-III and tested one, two, three and four-factor models using confirmatory factor analysis on 177 child psychiatric inpatients (aged 6 to 12). Results indicated that the four-factor model best fit the data. Despite the generally consistent support for the four-factor solution, some research evidence does not support the four-factor model but rather supports a three-factor model including the PS factor. Next, research evidence supporting a three-factor model that includes the PS factor is presented.

There is controversy regarding the proposed four-factor solution (e.g., Little, 1992; Reynolds & Ford, 1994; Sattler, 1992b) and some research suggests that a three-factor model that includes the PS factor best fits the data (e.g., Reynolds & Ford, 1994; Sattler, 1992b). As noted earlier, Sattler's analysis of the WISC-III standardization data indicate that a three-factor model composed of VC, PO, and PS factors best fit the WISC-III data. Sattler found that each of the factor scores account for 25, 16, and 10 percent of the variance, respectively. Sattler's research supports the loading of the CD and SS subtests on the PS factor for the entire sample. He defined the PS factor as measuring eye-hand coordination, attention and concentration for quick processing of visual information.

Although Sattler (1992b) supports the three-factor model consisting of VC, PO, and PS factors, he also found weaknesses with the model. For example, he found that the three-factor model is weak at ages 6 and 15, where only two factors emerged. As well, the AR and DS subtests best represent the third factor at 11 years, while the SS, AR, Picture Arrangement, and CD subtests best represent the third factor at 7 years. Overall, however, Sattler argues that both the CD and SS subtests substantially load on the PS factor. He concludes that a three-factor model consisting of VC, PO, and PS factors best fits the data.

Of note, although Sattler's (1992b) research suggests that a three-factor model that includes the PS factor best fits the data, some research has indicated that a three-factor model that does not include the PS factor as best fitting the data (e.g., Allen & Thorndike, 1995). In summary, although there are some inconsistent findings regarding four-factor model (i.e., whether there is a four or three-factor model), the literature generally supports the inclusion of the PS factor. Now we might question why is performance on the PS factor important?

Why is Performance on the PS factor Important?

Prifitera et al. (1998) state why performance on the PS factor is important:

> ... on the surface, the Coding and Symbol Search subtests are simple visual scanning and tracking tasks. . . . Yet, it could be a mistake to think of the PSI as a measure of simple clerical functions that are not especially related to intelligence. Performance on this index is an indication of the rapidity with which a student can process simple or routine information without making errors. Because learning often involves a combination of routine information-processing (such as reading) and complex processing (such as reasoning), a weakness in the speed of processing routine

> information may make the task of comprehending novel information more time-consuming and difficult. A weakness in simple visual scanning and tracking may leave a child less time and mental energy for the complex task of understanding new material. This is the way in which these lower order processing abilities are related to higher order cognitive functioning. (pp. 30-31)

Although the PS factor measures simple visual processing and scanning, it may also be related to more complex cognitive functioning (Kaufman, 1994). Thus, if a child shows a weakness on tasks requiring routine information processing, then he or she may have less resources left for more tasks requiring more complex cognitive processing.

Prifitera et al. (1998) hypothesize that children with low PS scores experience certain problems. These children are likely to experience the following difficulties.

> ... learn less material in the same amount of time, or take longer to learn the same amount of material as compared to those without processing speed deficits. We think that these children may also mentally tire more easily because of the additional cognitive effort required to perform routine tasks, and that this could lead to more frequent errors and possible expressions of frustration. Conversely, a strength in processing speed may facilitate the acquisition of new information. (p. 31)

Now that we have reviewed why performance on this factor is important, it is relevant to explore performance on the PS factor in different clinical groups, including children with brain-injuries, learning disabilities, and/or ADHD. Then, it is relevant to address some of the research that has focused on the FD factor, followed by the SCAD profile, a profile that incorporates the PS and the FD factors. First, however, research examining the PS factor in brain-injured populations will be discussed.

WISC-III PS Factor in Clinical Populations

PS factor in brain-injured populations.

The PS factor has been found to be lower in some clinical groups, including children with brain-injuries (Donders, 1995; Donders, 1997). In one study, both the WISC-III and the Kaufman Brief Intelligence Test (Kaufman & Kaufman, 1990) were given to brain-injured children. Results indicated that the PS factor correlated more strongly with length of coma than any of the other WISC-III factor or IQ scores, as well as any of the Kaufman Brief Intelligence Test scores. Donders (1997) also found that the PS index (as well as the PO factor) is lower in children with traumatic brain-injuries in comparison to the other WISC-III index scores. As Kaufman (1994) notes, this finding is considered consistent with the observation that children with traumatic brain-injuries tend to perform poorly on speeded tasks (Bawden, Knights & Winogron, 1985; Chadwick, Rutter, Shaffer, & Shrout, 1981). Not only has the WISC-III PS factor been found lower in brain-injured populations, but this factor has also been found lower in children with learning disabilities. Next, the performance on the PS factor in learning disabled populations will be reviewed.

PS factor in learning disabled populations.

Some research suggests that the PS factor, or tests that make up this factor, is lower in children with learning disabilities (e.g., Ackerman & Dykman, 1995; Daley &

Nagle, 1996; Wechsler, 1991; Williams et al., 1993). As well, some research has indicated lower scores in learning disabled children on tasks that are similar to the subtests that make up the PS factor (e.g., Kerns & Decker, 1985; Waber & Bernstein, 1994). Wechsler (1991) examined the WISC-III PS factor and subtest scores in children with unspecified learning disabilities (n = 65) and reading disorders (n = 34). In this sample, 38% were female and 62% were male. Children in the unspecified learning disabilities group consisted of the following subcategories: 66% unspecified learning disabilities, 26% had both reading and writing disabilities, 5% had arithmetic disabilities, and 3% had writing disabilities. Results indicated that children with learning disabilities had lower than normal PS scores; they had a mean score of 89.1 (SD=15.2) on the PS factor. As well, the learning disabled children had their lowest subtest scores on the CD (mean=7.5), AR (mean=7.6), SS (mean=8.0), and DS (mean=7.5) subtests. The small sample size and lack of operational definitions, however, limit this research.

Ackerman and Dykman (1995) examined two groups of learning disabled children: 1) a group of comorbid reading and arithmetic disabled children, and 2) a group of reading disabled children. They examined these two groups of learning disabled children at two age groups, 8-12 years (n=65), and 12-17 years (n=40). Ackerman and Dykman examined performance on the WISC (the younger subjects received the WISC) or the WISC-III (the older subjects received the WISC-III). Results indicated that both the younger and older comorbid reading and arithmetic disabled subjects showed significantly lower scores on the CD (and AR) subtests of the WISC, in comparison to the group with only a reading disability. As well, the older group of comorbid reading and arithmetic disabled children scored significantly lower on the CD and SS subtests in comparison to the younger group of comorbid reading and arithmetic disabled children.

Daley and Nagle (1996) examined the WISC-III PS factor in 308 learning disabled children. In this study, subjects qualified as learning disabled if they had a severe achievement and intellectual ability discrepancy in one or more of the following areas: "oral expression, listening expression, written expression, basic reading skill, reading comprehension, mathematical calculation, or mathematics reasoning" (Daley & Nagle, 1996, p. 324). Although Daley and Nagle found that the PS factor score was lower in the group of children with learning disabilities, the other factor scores were also low. The mean PS index score was 93.79 (SD = 14.24), the mean FD index score was 86.03 (SD = 8.88), the mean VC index score was 91.14 (SD = 13.41), and the mean PO index score was 93.61 (SD = 12.86). A main problem with Daley and Nagle's study was the lack of differentiation between the different types of learning disabilities. Secondly, this study was limited as most of the children were described as 'low-functioning.' For example, about 60% of the sample had FSIQ scores of 89 or lower. A third problem with this study was that few children were administered the WISC-III PS factor. For example, only 66 of the over 300 children were administered the PS factor.

Williams et al. (1993) examined the WISC-III CD subtest, one of the two subtests that make up the PS factor, in children with learning disabilities. They examined whether non-verbal tasks, including the WISC-III CD subtest, the Beery Developmental Test of Visual Motor Integration, and the Grooved Pegboard would predict performance on the Woodcock Johnson Tests of Achievement—Revised, Writing Fluency subtest. The

Writing Fluency subtest requires the child to write basic sentences about a picture and three target words in a 7 minute time-frame. Subjects were scored on misspellings of target words and correct grammar. Williams et al. examined 146 male and female clinic and school referred children with a variety of learning impairments. All of the children had been diagnosed with a learning disability according to a significant ability-achievement discrepancy. Researchers found that performance on the CD subtest, to a certain degree, predicted writing dysfluency (e.g., handwriting difficulties or difficulty writing quickly and easily). Results indicated that combined low scores on the WISC-III CD subtest, Beery visual motor test, and the Grooved Pegboard test, were good screening devices for written dysfluency problems. A limitation of this study, however, in relation to the present research, was that it did not examine differences on the PS factor, but only looked at performance on the CD subtest.

Kerns and Decker (1985) examined best predictors of reading disabilities in 105 reading disabled and 120 normal children between the ages of 7 and 14 years. Unfortunately, this study did not examine the WISC-III PS factor but involved a task that resembled the WISC-III SS subtest. Kerns and Decker (1985) administered the WISC-R and two speeded matching tests (the Colorado Perceptual Speed Test and the Identical Picture Test). The Colorado Perceptual Speed Test is similar to the SS subtest. The Colorado Perceptual Speed Test presents a stimulus array of four letters followed by a set of four possible response choices (i.e., dbbx: xbbd bdxd pbbs dbbx) and children are told to circle the exact copy of the stimulus. The Identical Picture Test is the same as the Perceptual Speed Test, except that it contains simple geometrical shapes rather than letters. Results suggested that the WISC-R DS (and Information) subtest, and the Colorado Perceptual Speed test were significant predictors of reading disabilities. The single best predictor was the Colorado Speed Test. This finding is important, as this test is very similar to the WISC-III SS subtest. However, this test is not identical to the SS subtest and thus conclusions drawn from this research are limited with respect to the WISC-III PS factor.

Although Waber and Bernstein (1994) did not specifically examine the WISC-III PS factor, these researchers examined learning disabled children's graphomotor output on another test, the Repeated Patterns Test. Waber and Bernstein compared learning disabled (n = 174) and non-learning disabled children's (n = 229) graphomotor output on the Repeated Patterns Test. Children were between the ages of 8 and 16 years. Results indicated that 67 percent of the learning disabled children scored below normative expectations for their gender and age. Waber and Bernstein concluded that graphomotor output is a significant difficulty for learning disabled children, even when there are minimal language-processing demands. This study was good in that it controlled for the linguistic demands of writing and focused on the motor control aspects. Problems with this study, however, included the lack of specific operational criteria for determining learning disability. For example, criteria for learning disabilities included the Vocabulary and Block Design WISC-R subtest scores of 85, and there was "no attempt made to select for specific complaints or diagnostic criteria" (p. 52). No information was provided as to the type of learning disability the child experienced. As well, this test focused on the Repeated Patterns Test rather than on the WISC-III PS factor.

Tiholov et al. (1996) examined whether the WISC-III PS factor distinguished between groups of clinically referred children. In this study children aged 6 to 16 were grouped according to the following categories: ADHD, visual-motor integration problems, behavioral problems, low academic achievement, and physical health problems. There were two main results. First, children diagnosed with visual motor integration difficulties showed significantly lower PS index scores. Second, children diagnosed with two clinical problems (i.e., ADHD, low academic achievement, behavioral or emotional problems), showed significantly lower mean scores on the PS index when compared to those not diagnosed with those particular problems in the two areas. Significant difficulties with this study included the lack of a control group made up of 'normal' children, as well as the prevalence of comorbid diagnostic categories.

In conclusion, some research (e.g., Ackerman & Dykman, 1995; Daley & Nagle, 1996; Wechsler, 1991; Williams et al., 1993) has suggested that learning disabled children score lower on the WISC-III PS factor as well as tests that are similar to the subtests that makeup the PS factor (e.g., Kerns & Decker, 1985; Waber & Bernstein, 1994). Much of the research in this area, however, is inconclusive. Next, research related to the PS factor in ADHD populations will be reviewed.

PS factor in ADHD populations.

Some evidence suggests that the PS factor, or the subtests that make up the PS factor, is lower in children with ADHD (Ehler et al., 1997; Lufi et al., 1990; Saklofske et al., 1994; Swanson, 1997; Wechsler, 1991). As well, research indicates that performance on tasks that are similar to the PS factor tasks is lower in ADHD children (e.g., Sergeant

& Scholten, 1983, 1985). Wechsler (1991) examined 69 children ages 7 to 16 years diagnosed with ADHD. Wechsler notes, "As expected, because of the diagnostic characteristics of ADHD, the sample has low mean scores on the Processing Speed and Freedom from Distractibility scales" (p. 215). He found that children with ADHD exhibited lower than normal PS index scores and they had a mean PS score of 92.0 (SD=14.8). The lowest mean subtest score for the ADHD sample was on the CD subtest (mean=7.7) and on the DS subtest (mean=8.2). The finding that the lowest mean subtest score in ADHD children was on the CD subtest is similar to Ehlers et al.'s (1997) findings and Lufi et al.'s (1990) findings. As mentioned earlier, a limitation of Wechsler's research is the small sample size and lack of specificity regarding the operational definition for ADHD. Another problem is the lack of clarity as to which subtypes of ADHD were used in the research.

A research study by Saklofske et al. (1994) involved the administration of the WISC-III to 45 children with ADHD. These researchers compared ADHD children's scores on two tests of cognitive functioning: the WISC-III and the Stanford-Binet—Fourth Edition. All of the children in this study scored in the clinical range of the Conner's Parent or Teacher Rating Scales on the Hyperactivity Index and they met the DSM-III-R diagnostic criteria for ADHD. WISC-III results indicated that the PS factor was the lowest factor score for these children (mean = 92.60 and standard deviation = 14.25). (FD scores were the second lowest factor score with a mean of 93.00 and a standard deviation of 12.96). Although this research evidence is far from conclusive, it certainly supports the general finding that the PS factor (and FD factor score) tends to be at least relatively lower in children with ADHD. Both factor scores were about one-half a standard deviation below the mean.

Swanson (1997) found that children with ADHD scored significantly lower on the PS factor in comparison to the rest of the sample composed of a clinical population of children with varying difficulties (e.g., behavioural or emotional problems). However, there were several difficulties with this research. First, a child diagnosed with ADHD was very likely to have a comorbid disorder. Thus, it was difficult to determine whether the low PS factor score was related to the diagnosis of ADHD or to another learning, behavioural or emotional condition. Another difficulty with this study was the combined grouping of the three different types of ADHD (i.e., predominantly inattentive, predominantly hyperactive-impulsive, and combined types). This is problematic, given that Barkley (1997, 1998) suggests that the predominantly inattentive type may be a completely different disorder from the other two types of ADHD.

Sergeant and Scholten (1983) used the Sternberg test, which is very similar to the WISC-III SS subtest to examine performance in children with hyperactivity and children without hyperactivity. The Sternberg test measures aspects such as visual search, reaction time, and memory encoding. In this task, the child sees a set of letters, sees another set of letters, and then must indicate whether ('yes' or 'no') the stimulus was part of the original stimulus display. Sergeant and Scholten (1983) found that children with hyperactivity generally had slower reaction times (i.e., responding 'yes' or 'no' to the stimulus) and they were less accurate than children without hyperactivity. A difficulty with this study, however, is the reliance upon a pre-DSM-IV definition of hyperactivity. Another limitation in this study, given the need for quick letter recognition, is the limited usefulness of the Sternberg task for children under age 8. In a later study (Sergeant & Scholten, 1985), even when the researchers stressed the importance of responding quickly, in contrast to the control group, the children with hyperactivity did not increase their speed of response. The control group, on the other hand, increased their speed of response, although they had more errors.

In summary, although far from conclusive, limited research has identified low PS scores in ADHD children. Some research has also identified slower performance on tasks similar to the PS subtests in children with hyperactivity (Sergeant & Scholten, 1983, 1985). Next, gender differences on the PS factor subtests will be reviewed.

PS factor and gender differences.

Some research indicates gender differences favoring females on the WISC-III PS factor (e.g., Kaufman, 1994), on the CD subtest (e.g., Ackerman & Dykman, 1995; Born & Lynn, 1994; Jensen & Reynolds, 1983; Kelly & Britton, 1996; Lynn & Mulhern, 1992; Slate, 1998; Spafford, 1989), and on the SS subtest (Ackerman & Dykman, 1995). However, these differences are minimal as they involve only 1 standard score. Some research, however, has not found gender differences on the PS factor (Mitchell et al., 1994; Quereshi & Seitz, 1994).

In general, the literature suggests that there are gender differences favoring females on the CD subtest in North American (Ackerman & Dykman, 1995; Jensen & Reynolds, 1983; Kelly & Britton, 1996; Slate, 1998; Spafford, 1989), Scottish (Lynn & Mulhern, 1991), and Holland samples (Born & Lynn, 1994). In each of these studies, researchers found that females scored at least one scaled point higher on the CD subtest. For example, Kelly and Britton examined sex differences on the CD subtest in 150 males and 150 females (mean age = 12.2 yr). Subjects were excluded only if they had learning difficulties. Testers consisted of 75 undergraduate students taking an Abnormal Psychology course. Each student was asked to test two boys and two girls. Subjects were given three tests: 1) the CD subtest; 2) an incidental learning task (i.e., subjects were given the key to the CD subtest and were asked to recall which symbols were associated with the numbers 1 to 9); and a motor speed task where subjects were simply asked to copy symbols in spaces below the symbols (i.e., the key was removed). Results indicated that the girls had significantly higher CD scaled scores than the boys. There were no significant gender differences between the incidental and learning tasks. Authors suggested that since the sex differences on the CD task were not accounted for by the incidental and learning tasks, gender differences could perhaps be attributed to gender differences in motivation, attention, or cognitive flexibility. Kelly and Britton suggest that a key research implication from this study is the need to consider gender differences when interpreting the CD subtest. One problem with this study is the lack of defining criteria for 'learning difficulties'. As well, this study relied on 75 undergraduate students to administer the WISC-III CD subtest to subjects (each undergraduate student administered the test to four children). Using so many different testers could impact test administration and scoring.

In summary, research indicates minor gender differences on the CD subtest, favoring females. Next, the FD factor will be reviewed. First, we will begin by addressing why it might be important to note performance on this factor when assessing children's cognitive capacities.

Why is Performance on the FD Factor Important?

Performance on the FD factor is important because it is a good indicator of attention and concentration (Kaufman, 1994; Sattler, 1992b). Distractibility and anxiety typically impair performance on this factor. As noted earlier, this factor is made up of the AR and DS subtests. This factor tends to assess working memory for auditory material. The FD factor requires good auditory working memory, and the ability to focus and attend on information presented in an auditory format. FD factor scores in clinical populations will be reviewed.

FD Factor in Clinical Populations

The FD factor has been found to be lower in some clinical groups, including psychiatric (Greenblatt, Mattis, & Trad, 1991), learning disabled, and ADHD populations.

FD factor in psychiatric populations.

Greenblatt et al. (1991) examined the records of 526 children in a psychiatric hospital setting. Subjects included inpatient (n=151), outpatient (n=307), and day hospital (n=68) groups with a mean age of 10.6. These children were diagnosed with a variety of psychiatric disorders including affective disorder, dysthmic disorder, adjustment disorder, conduct disorder, oppositional defiant disorder, and attention deficit disorder. FD factor performance was defined by relatively lower scores on the AR, DS, and CD subtests relative to the mean of child's other subtest scores. Researchers classified a child as 'deficient' on the FD factor if the following criteria were met: 1) the AR or DS subtests were 3 scaled points below the child's mean for all six Verbal subscale scores, or the CD subtest was 3 points below the mean for the five Performance subscale scores; and 2) the other two subtests were at least one point below the mean. Results indicated that about 11.3% of the sample showed a deficient score on the FD factor. However, this study does not specify the number of males and females. Mean subtest scores for each of the diagnostic groups were not reported. As well, criteria used to diagnose a subject as 'attention deficit' for example, were not specified. Next, the FD factor in learning disabled populations will be reviewed.

FD factor in learning disabled populations.

Some research has indicated weak performance in learning disabled children on the subtests that make up the FD factor (e.g., Ackerman & Dykman, 1995; Spafford, 1989; Vargo et al., 1995). For example, Ackerman and Dykman found that in comparison to the single diagnosis--reading disabled group--the group with comorbid reading and arithmetic disabilities scored significantly lower on the AR subtest of the FD factor.

Vargo et al. (1995) examined performance on the DS subtest in 44 children aged 7 to 16 years with reading disabilities. Vargo et al. compared the group of 44 reading disabled children's performance on the WISC-R to the WISC-R standardization group data. Results indicated that the children with reading disabilities scored significantly lower on the DS (mean=7.59) and AR (mean=8.23) subtests in comparison to the standardization sample's performance on these subtests.

Research has indicated reduced DS performance in individuals with reading disabilities (Spafford, 1989). Spafford examined the diagnostic usefulness of the WISC-R DS subtest in individuals with learning disabilities. Spafford limited the learning disabled group to a homogenous group of 57 reading disabled children (dyslexic). Spafford found that the DS subtest was a strong differential measure between reading disabled children and normal children. Spafford concluded that DS scores can be useful in screening for dyslexia and argued that the WISC-R DS subtest be used with other evidence in determining whether a child is learning disabled. Next, the FD factor in ADHD populations will be reviewed.

FD factor in ADHD populations.

Research suggests that children with ADHD tend to perform relatively weakly on the WISC-III FD factor (i.e., Anastopoulos et al., 1994; Ehlers et al., 1997; Kaufman, 1994; Lufi et al., 1990; Reinecke et al., 1999; Rispens et al., 1997), and on tests that are similar to the subtests that make up the FD factor (Zentall & Smith, 1993). Some research, however, has not found these differences (i.e., Riccio et al., 1997). In a Dutch study, Rispens et al. examined the WISC-R profiles of 465 children aged 6 to 16 years with psychiatric diagnoses, including children with ADD. There were 349 boys and 116 girls with a mean age of 11.6 years. Children with IQ scores lower than 70 were excluded from this study. Specific psychiatric diagnoses included ADD, Conduct Disorder, Mood Disorder, Anxiety Disorder, and other disorders. Results indicated that of the five psychiatric groups, the ADD group achieved the lowest mean score (89.2) on the FD factor. As well, relative to the other factor and IQ scores, the ADD group achieved its lowest mean score on the FD factor. Unfortunately, however, this study was limited to children with ADD, not ADHD, and thus conclusions that may be extended to ADHD population are limited.

Reinecke et al. (1999) also examined the FD factor in a group of 200 children with ADHD. They found that ADHD children's mean score on the FD factor was significantly lower than the other WISC-III factors. However, Reinecke et al. caution users not to base a diagnosis of ADHD on FD performance. These researchers do suggest, however, that FD factor performance may be useful for determining cognitive weaknesses and strengths in an individual with ADHD.

Lufi et al. (1990) examined the WISC-R subtests in 70 boys ranging from 9.4 to 16.0 years in age (mean age was 12.8). There were 29 boys in the ADHD group, 21 boys in the Emotionally Disturbed group, and 20 control boys. None of the subjects were medicated during testing. Results indicated that the AR subtest had the greatest weight in differentiating between the 1) Emotionally Disturbed group and the ADHD group, and 2) the ADHD and Control groups. As well, boys in the ADHD group scored significantly lower on the AR subtest than the Emotionally Disturbed group. This finding is similar to Eheler et al.'s (1997) finding that the AR subtest is low in children with ADHD.

Some research, however, has not found significant differences on the FD factor in ADHD children. Riccio et al. (1997) examined the diagnostic utility of the PS and FD factors in a clinical sample of ADHD children. These children were diagnosed with one of the two following disorders: 1) a single diagnosis of a learning disability, or 2) a single diagnosis of ADHD (predominantly inattentive type or combined type). Subjects were referred for neuropsychological assessment as they were showing behavioral or school related problems. The children ranged in age from 6 to 16.5 years. Approximately 74% of the children were boys and 26% were girls. Results indicated that there were no significant differences on the PS factor and on the FD factor between each of the three clinical groups (learning disability, ADHD predominantly inattentive, and ADHD combined type). Authors suggest that this finding of non-significant differences between these three clinical groups suggests that these two factors do not help with differential diagnosis within a clinical sample. However, there were some significant problems in this study: 1) subjects were obtained from a neuropsychological clinic suggesting that the children had more serious disorders; 2) there was no sample of normal children; and 3) the operational definitions for each of the three clinical groups were not clear. Next, a limited review of gender differences on the FD factor subtests will be reviewed.

FD factor and gender differences.

A brief review of gender differences on the subtests that make up the FD factor is provided. While Quereshi and Seitz (1994) not find gender differences on DS or AR subtests of the FD factor, other research has found that girls obtain significantly higher scores on the DS subtest than boys (Born & Lynn, 1994; Jensen & Reynolds, 1983; Lynn & Mulhern, 1991). Thus, presently, it is unclear whether there are gender differences on the subtests that make up the FD factor.

Next, the PS and FD factors will be examined within the context of the SCAD profile. The SCAD profile consists of the two subtests, CD and SS, which make up the PS factor, and the two subtests, DS and AR, that make up the FD factor.

WISC-III SCAD Profile: Learning Disabled and ADHD Populations

Research related to the SS, CD, AR, and DS subtests (SCAD profile) suggests that children with learning disabilities and/or ADHD have lower scores on the PS and FD factors (i.e., Kaufman, 1994; Prifitera & Dersh, 1993; Schwean & Saklofske, 1998; Ward et al., 1995; Wechsler, 1991). However, some research has not found such differences (Riccio et al., 1997; Watkins, Kush, & Glutting, 1997). The SCAD profile involves adding together the four subtests that make up the PS and FD factors. Then, the sum of the four scaled scores for the SCAD subtests are subtracted from the sum of the four subtests that make up PO factor. Kaufman (1994) suggests that large differences between the child's PO and SCAD score are more likely to occur in exceptional samples, such as learning disabled and/or ADHD, than in normal samples.

The WISC-III manual indicates relatively low scores on one or both of the FD and PS factors in learning disabled and in ADHD children. Wechsler (1991) notes that children with learning disabilities tend to show relatively low scores on the FD and PS factors: "Characteristically, the Freedom from Distractibility Index and Processing Speed Index are depressed for both samples" (p. 212). As noted earlier, Wechsler's (1991) study of 65 learning disabled children aged 6-14 indicated that their lowest subtest scores were on the CD, AR, SS, and DS subtests. Similarly, children with ADHD show at least a 10-point discrepancy from 'normal' children on the PS and FD factors. Children with ADHD tend to show their lowest score on the CD subtest, followed by the DS subtest. The samples of children with learning disabilities or ADHD had FD and PS scores within 2 points of one another, suggesting reduced abilities in both areas. As noted earlier, limitations of this research include relatively small sample sizes.

Prifitera and Dersh (1993) compared the sum of the scaled scores on the VC and PO Indexes with the sum of the scaled scores on the PS and FD Indexes (i.e., SCAD profile). This study consisted of three different groups of children: 1) mentally average (2158 children from the WISC-III standardization sample), 2) learning disabled (n = 99), and 3) ADHD (n = 65). Results indicated that nearly 85% of the learning disabled and ADHD children had higher PO Indexes than SCAD sums in comparison to 48% of the normal children. Learning disabled subjects had their lowest scores on SCAD subtests. The authors noted that less than 5% of normal children have discrepancies of at least 15 points compared to about 1 out of 4 of the learning disabled and ADHD children. Prifitera and Dersh concluded their results "provide evidence for specific patterns of cognitive deficits in learning disabled and ADHD children" and that they show "relatively poor performance ... (on) the third and fourth factors on the WISC-III" (p. 51). However, sample comorbidity is a limitation of this study, as children with ADHD were often diagnosed with a learning disability (Ward et al., 1995) and therefore it is not clear whether results can be attributed to the effects of ADHD or the learning disability. As well, there is a lack of clarity regarding 'mentally average' children. It is not clear whether the 'mentally average' children had any comorbid diagnoses in behavioural, learning, or emotional areas.

Schwean and Saklofske (1998) examined the results from three major studies (e.g., Anastopoulos et al., 1994; Prifitera & Dersh, 1993; Schwean et al., 1993) that previously examined the PS and the FD factors. Their analysis shows that in each of the three studies, the PS factor (when it was administered) and the FD factor, tended to be the lowest factor scores for children with ADHD. (However, Anastopoulos et al. 1994 did not give the SS subtest and thus the PS factor score could not be determined.) Respective mean PS scores were 93.2 and 92.6 in the Prifitera and Dersh (1998) and Schwean et al. (1993) studies and respective mean FD scores were 94.6 and 93.0. Schwean and Saklofske (1998) conclude "in examining the subtest scores across the three studies, it is apparent that subtests with the lowest mean scores are generally those that compose the FD and PS factors" (p. 101). Limits of this work, however, include the specific limitations in each of the three relevant research studies. For example, in the Prifitera and Dersh's (1993) study, subjects tended to have comorbid diagnoses. As well, Anastopoulos et al. (1994) did not administer the SS subtest and therefore they could not determine the PS factor score.

Ward et al. (1995) completed a study focusing on the SCAD profile. Ward et al. examined 719 students in order to determine the incidence of the SCAD profile in a clinically referred population, and the diagnostic utility of the SCAD profile. In this study, 53.3% of the children had learning disabilities (unspecified), 12.2% had emotional disturbances, 6.0% had mental retardation, 4.6% had other disabilities (including speech and language impairments, autism) and 24% were ineligible for services. Ward et al. found a 19.6% incidence rate of the SCAD profile in the learning disabled sample; this finding was not as high as the level found by Prifitera and Dersh (1993). However, some of the limitations of Ward et al. included a very diverse sample and the lack of specificity regarding the learning disabled and 'emotional disturbances' group. As well, this study did not include a 'normal' sample. Although this study included a sample of children who were 'ineligible for services', this term implies that the children had some type of learning or behavioural difficulty but did not meet the specific criteria for requiring special services. Thus, it is likely that these children showed subthreshold disorders in learning or behaviour. For this reason, it would be difficult to determine whether or not there were differences between each of the clinical groups.

Watkins, Kush and Glutting (1997) examined the diagnostic utility of the SCAD profile in a group of 363 children, enrolled in kindergarten through grade 11. These 363 children were previously diagnosed with learning or emotional disabilities. The learning disabilities group consisted of three groups: reading, math, or written expression disabilities. The emotional disabilities group consisted of children who had "one of five emotional characteristics adversely impacting educational progress" (p. 238). In this study, 70% percent of the subjects were male and 30% were female. Children were selected on the basis of two criteria: 1) a WISC-III assessment, and 2) participation in a learning or emotional disability program. A third group of students without disabilities was taken from the WISC-III standardization sample. A SCAD-PO index was calculated (i.e., by adding scaled scores on the SCAD subtests and subsequently subtracting this from the sum of the Picture Completion, Picture Arrangement, Block Design and Object Assembly subtests) for each child. Results indicated that the scores did not differ significantly between children with learning or emotional disabilities. Consistent with previous studies, students with emotional or learning disabilities had higher SCAD scores than students without such disabilities. However, when the SCAD profile was used to classify students into disabled and non-disabled groups, the SCAD scores operated "at near chance levels" (Watkins et al., 1997, p. 243). A key study limitation, however, included the lack of clear defining criteria for learning disabilities. An additional limitation was the lack of clear defining criteria for '*emotional disabilities*'. Given that research supports differences between types of learning disabilities (e.g., Rourke, 1989; Sattler, 1992; Ward et al., 1999), using multiple types of learning disabilities in this study could influence results. As well, in this study, children's cognitive scores were lower than average and this could limit generalizability of study results (e.g., WISC-III FSIQ was 90.9, SD = 11.7; WISC-III VIQ was 90.4, SD = 12.0; WISC-III PIQ was 93.4, SD = 13.6).

In summary, the literature suggests that the SCAD profile will not conclusively diagnose a learning disability or ADHD. However, when a SCAD profile is interpreted in context, low scores on the FD and PS factor can help in diagnosing a learning disability or ADHD or remedial planning.

In summary, this section reviewed the literature related to the WISC-III PS factor, FD factor and the SCAD profile. This literature review ends with a review of the study aims and research questions.

Study Research Questions

This present research extends past work examining the WISC-III PS and FD factors in clinical populations (Swanson, 1996; Tiholov et al. 1996). *The main purpose of the research is to examine the utility of the PS and FD factors in distinguishing between* *groups of children with a pure learning disability (in reading or writing/spelling), pure ADHD, combined learning disability and ADHD, and no formal psycho-educational diagnoses. The research questions related to the PS and FD factors follow.*

Question 1): On the three PS, CD, and SS tests, are there significant differences in the mean scores for group, age, or the interaction of group and age?

Question 2): On the three PS, CD, and SS tests, are there significant differences in the mean scores for group, gender, or the interaction of group and gender?

Question 3) On the three FD, DS, and AR tests, are there significant differences in the mean scores for group, age, or the interaction of group and age?

Question 4): On the three FD, DS, and AR tests, are there significant differences in the mean scores for group, gender, or the interaction of group and gender?

Question 5): On the two SCAD and PO/SCAD measures, are there significant differences in the mean scores for group, age, or the interaction of group and age?

Question 6): On the two SCAD and PO/SCAD measures, are there significant differences in the mean scores for group, gender, or the interaction of group and gender?

Question 7): Is the percentage of children in the 1) learning disabled, 2) ADHD, and 3) learning disabled and ADHD groups who scored high on the PO/SCAD index significantly higher than the percentage of children in the no diagnosis group?

Chapter Three

Research Design and Methodology

Participants

Subjects consisted of a clinical, non-random sample of 224 male and female children aged 6 to 16 years who were referred to the Education Clinic at the University of Alberta, in Edmonton, Alberta, for psycho-educational assessment during the years 1995 to 2001. Given that the purpose of this study was to examine differences on the WISC-III PS and FD factors across four groups of children, it was clinically relevant to include the entire 6 to 16 year age range of subjects assessed by the WISC-III. Subjects were referred to the Education Clinic for psycho-educational assessments by various community sources, including teachers, family practitioners, pediatricians, school-counsellors, parents and various health professionals for purposes such as determining strengths and weaknesses and evaluating learning, behavioural or emotional difficulties.

Subjects consisted of 126 males (56%) and 98 females (44%). This study strived to obtain relatively equal numbers of male and female subjects. However, given the limited clinical data, an exact male/female split was not possible. Subjects were only included in this study if all of the study variables were available. Specifically, information on each of the PS, FD, and PO subtests and indexes had to be available for analysis, as well as gender, age, and diagnostic information.

The total sample mean age was 10.83 years (SD = 2.81) and the mode was 8 years. Subjects ranged in grade from Kindergarten to grade 10. The greatest number of children was enrolled in grade 3 (16.1 %), and the lowest number of children was enrolled in Kindergarten (0.4 %). There were 42 subjects in the learning disabled group, 50 subjects in the ADHD group, 24 subjects in the learning disabled and ADHD combined group, and 108 subjects in the no diagnosis group. Gender and age demographic information for each of the four groups and the total sample is outlined in Table 3.

TABLE 3

GENDER AND AGE DEMOGRAPHIC DATA FOR GROUPS AND TOTAL SAMPLE

	Group Description				
	Learning disability	ADHD	Learning disability & ADHD	No diagnosis	Total Sample
Gender					
Males	27	34	13	52	126
Females	15	16	11	56	98
Age					
Younger (6-11 years)	25	24	11	73	133
Older (12-16 years)	17	26	13	35	91

Procedure

Master's and doctoral level graduate students enrolled in psycho-educational/psychological/neuropsychological assessment courses in the Department of Educational Psychology at the University of Alberta assessed subjects. Prior to testing, the child's guardians or parents signed a permission form allowing their data and file information to be used for experimental purposes. After the assessment was completed, doctoral level supervisors examined the protocols and reports to ensure the accuracy of test administration, scoring, interpretation, and report write-up. Permission to complete the present study was obtained from the ethics committee. Clinical files were reviewed in backward order from the years 2001 through 1995, until a sample consisting of at least 20 participants was included in each of the four groups (learning disabled, ADHD, learning disabled/ADHD combined, and no diagnosis). Relatively equal numbers of subjects were taken from each year. Protocols, test results, and final reports were examined individually and data was collected from clients' files. In order to maintain confidentiality, subjects' names were replaced with codes. Only subjects with valid data sets for all the variables were included in this study and this reduced the original sample size from 260 to 224. Next, the clinical decision-making process will be reviewed.

Clinical Decision-Making Process

This study involved subjects aged 6 to 16 who met the criteria for one of four groups: 1) a learning disability in reading or writing/spelling (n=42); 2) ADHD (predominantly hyperactive and combined types) (n=50); 3) a learning disability in reading or written expression/spelling and ADHD (predominantly hyperactive and combined types) (n=24); and 4) no diagnosis subjects (n=108). A clinical decision making process was employed to determine whether the subject fit one of the four clinical groups. Throughout the clinical decision-making process, the author was blind as to how the subject scored on each of the four WISC-III indexes.

Operational definitions of the four different group categories--1) a learning disability, 2) ADHD, 3) a learning disability and ADHD, and 4) no diagnosis--were based on specific research criteria. The research criteria assisted the researcher in determining whether a subject belonged to one of the four groups. The research criteria for each of the four group categories and subcategories are outlined in the following section. Rather than relying on one diagnostic method or information source, multiple diagnostic methods and information sources were used to determine whether the subject fit into one of the four diagnostic categories. Each subject's results were carefully reviewed by means of a detailed diagnostic process. Based on specific research criteria (see Table 4), the subject was either included in one of the four group categories, or else the subject was not included.

TABLE 4

RESEARCH CRITERIA FOR GROUPS

Learning Disability Group	**Reading disability:** -Achievement score in reading at least one standard deviation (SS = 15 points) below the norm (SS ≤ 85) on one of the following reading subtests: WIAT basic reading subtest or reading comprehension subtest; WJPETA reading subtest; WRMT word identification, word attack or passage comprehension subtest. -Regression equation indicated that child's Z score > −1.65. **Written expression/spelling disability:** -Achievement score in written expression or spelling at least one standard deviation (SS = 15) below the norm (SS ≤ 85) on one of the following subtests: WIAT written expression or spelling subtest; WJPETA spelling subtest. -Regression equation indicated that child's Z score > −1.65. **For each of the two kinds of learning disabilities the following was required:** -The subject was experiencing difficulty in the relevant academic area as reported by the teacher, parent or subject. -No other conditions impaired cognitive functioning as reported by a) the General Information and History Questionnaire, b) the clinical interview, and c) WISC-III FSIQ score > 70. -English was the primary language (reported in General Information and History Questionnaire). -Subject was attending full-time school at the time of testing. -Information from the clinical interview and General Information and History Questionnaire did not point to a major psychological disorder; if information did suggest a psychological disorder, then the child received further behavioural/emotional testing (i.e., the BASC). -If the BASC was administered, no Clinically Significant scale elevation (i.e., T-score ≥ 70) on both the following TRS and/or PRS clinical scales: Aggression, Anxiety, Attention Problems, Atypicality, Conduct Problems, Depression, Hyperactivity, Somatization or Withdrawal scales.

TABLE 4 CONTINUED

RESEARCH CRITERIA FOR GROUPS

ADHD Group	**ADHD combined type:** -Two different raters on the BASC Parent Rating Scale (PRS) and/or the Teacher Rating Scale (TRS) (e.g., two PRS; one PRS and one TRS) score the subject on the Attention Problems and Hyperactivity Problems scales T-score ≥ 60. -Clinician observed indications of inattention and/or hyperactivity/impulsivity (indicated in the behavioural observations section of the final assessment report). **ADHD predominantly hyperactive-impulsive type:** -Agreement between two different raters on the BASC Parent Rating Scale (PRS) and/or the Teacher Rating Scale (TRS) (e.g., two PRSs; one PRS and one TRS) on the Hyperactivity Problems clinical scales T-score ≥ 60 -Clinician observed indications of hyperactivity and/or impulsivity (indicated in the behavioural observations section of the final assessment report). **For both types of ADHD the following was required:** -Absence of a major psychological disorder as indicated by a) the clinical interview, b) the General Information and History Questionnaire, and c) no Clinically Significant scale elevations (T-score ≥ 70) on both rater's following BASC TRS and PRS clinical scales: Aggression, Anxiety, Atypicality, Conduct Problems, Depression, Somatization or Withdrawal clinical scales. -No other conditions impairing cognitive functioning as indicated by a) the Information and History Questionnaire, b) the clinical interview, and c) a WISC-III FSIQ score > 70. -English was the primary language (reported in General Information and History Questionnaire). -The subject was attending full-time school at the time of testing. -The subject was not taking stimulant medication.
Learning Disability & ADHD Group	-Meets the criteria for a learning disability. -Meets the criteria for ADHD.
No Diagnosis Group	-Not meet the criteria for 1) learning disability or 2) ADHD. -No other conditions impairing cognitive functioning as reported by a) the General Information and History Questionnaire, b) the clinical interview, and c) the WISC-III FSIQ score > 70. -English was the primary language (reported in General Information and History Questionnaire). -The subject was attending school full-time at the time of testing. -The clinical interview and General Information and History Questionnaire did not point to a major psycho-educational disorder; if there were indications, then the child was administered the BASC. -If the BASC was administered, there were no Clinically Significant scores (i.e., T-score ≥ 70) on both rater's following TRS and/or PRS clinical scales: Aggression, Anxiety, Attention Problems, Atypicality, Conduct Problems, Depression, Hyperactivity, Somatization or Withdrawal scales.

An example of a clinical decision making process is presented in Figure 1. This example shows the clinical decision-making process followed in classifying a child as learning disabled in reading or written expression/spelling. A similar process was used for the classification each of the four diagnostic groups.

Does the teacher, parent or child indicate problems in this academic area (reading or written expression/spelling)?

The child is experiencing significant difficulty in the relevant academic area as reported by the teacher, parent, or self as found in the General Information and History Questionnaire or clinical interview; the child is underachieving in the relevant (reading, written expression or spelling) school subject (achievement $SS \leq 85$).

Does this child have current evidence of a learning disability in reading or written expression/spelling?

An initial screening indicates that a significant difference (at least one standard deviation) between the WISC-III FSIQ score and the achievement test score on one of the following achievement tests. These tests include the WIAT (basic reading, spelling reading comprehension, written expression subtests), WJPTA (reading, spelling), or WRMT (word identification, word attack, word comprehension, passage comprehension). A regression equation indicates that the Z score > -1.65.

Do any other conditions or disorders account for the learning disability?

No other conditions are impairing cognitive functioning as reported by the a) General Information and History Questionnaire, b) clinical interview, and c) WISC-III FSIQ score > 70. English is the primary language and the subject is attending school full-time at the time of testing (reported in the General Information and History Questionnaire or clinical interview). If the BASC was administered there are no Clinically Significant scores (i.e., T-score ≥ 70) on both the following TRS and/or PRS clinical scales: Aggression, Anxiety, Attention Problems, Atypicality, Conduct Problems, Depression, Hyperactivity, Somatization or Withdrawal.

FIGURE 1. EXAMPLE OF DIAGNOSTIC PROCESS FOR A SUBJECT WITH A LEARNING DISABILITY

Test Administration

Master's and doctoral level students administered all psychometric instruments (e.g., cognitive, achievement, behavioral, and visual-motor integration) according to standardized procedures. Doctoral level psychologists specializing in educational, psychological, or neuropsychological assessment, appointed by the Department of Educational Psychology at the University of Alberta, supervised students' test administration, protocol scoring, test interpretation and report writing. The psychological assessment instruments were chosen for diagnostic use based on the child's presenting issue and the guiding supervisor's clinical experience.

Instrumentation

In this section of the paper, test instruments, test administration, and the reliability and validity of the intelligence, achievement, behavior rating scales, self-concept scale, and visual motor integration tests will be reviewed.

Intelligence test: the WISC-III.

The WISC-III assesses the cognitive abilities of children between the ages of 6 to 16 years. All subjects in this study were administered the WISC-III (n=224). Research indicates that the reliability and validity of the WISC-III is strong (Sattler, 1992b). The WISC-III reliability and validity will now be discussed.

The reliability of the WISC-III is high: the three scales (Verbal, Performance and Full Scale) have internal consistency reliability coefficients greater than 0.89 over the entire age groups (i.e., 6 to 16 years). According to the Wechsler manual (1991), for all age groups, the average internal consistency reliability coefficients are as follows: 0.96

for the Full Scale score, 0.95 for the Verbal Scale score and 0.91 for the Performance Scale score.

Not surprisingly, although still high, subtest reliability correlation coefficients are lower than those for the Verbal, Performance and Full Scale scores. On the Verbal Scale, across the entire age range, the lowest reliability coefficient is 0.77 for the Comprehension subtest and 0.87 for the Vocabulary subtest; on the Performance scale, the lowest reliability coefficient is 0.69 for the Object Assembly subtest to a high of 0.79 for the CD subtest.

Test-retest reliability is also strong: the Wechsler (1991) manual indicates that after twelve to sixty-three days (median = 23 days), with 353 children from six age groups (6,7, 10,11, 14, 15), the Performance Scale score was somewhat less stable than the Full Scale and Verbal Scale scores (Wechsler, 1991). For purposes of statistical analysis, when the six age groups were combined to form three age groups, the stability coefficients were 0.92, 0.95 and 0.94 for the FSIQ score, 0.90, 0.94 and 0.94 for the Verbal IQ, and 0.86, 0.88 and 0.87 for the Performance IQ. Next, the validity of the WISC-III will be reviewed.

It is argued that given that over 73% of the WISC-III test items are the same as the WISC-R, much of the research on the validity of the WISC-R may be applied to the WISC-III (Sattler, 1992; Wechsler, 1991). In general, the instrument shows adequate concurrent, criterion and construct validity (Wechsler, 1991).

The WISC-III demonstrates good concurrent validity with the WISC-R (e.g., Doll & Boren, 1993; Gunter, Sapp & Green, 1995; Sabatino, Spangler, & Vance, 1995; Slate

& Saarnio 1995). Sabatino et al. (1995) examined the concurrent validity between the WISC-III and the WISC-R with 51 gifted children. Results indicated that the two tests show similar Verbal, Performance and Full Scale scores, as well as similar subtest scores. While Verbal and Performance Scale scores were within two points of each other across the two test administrations, only a one-point difference existed across FSIQ scores.

Two studies examine the concurrent validity of the WISC-III with the WISC-R in the WISC-III manual (Wechsler, 1991). First, the WISC-III and the WISC-R were administered to 206 children between the ages of 6 and 16 years in a counterbalanced order, after a period of 12 to 70 days. Results indicated that the two tests correlated by 0.90 for the Verbal Scale, 0.81 for the Performance Scale, and 0.89 for the Full Scale. Consistent with other studies, FSIQ scores were 5.3 points lower on average on the WISC-III than the WISC-R. The second study examined 104 children with learning difficulties, reading difficulties or ADHD. These children were administered the WISC-III and the WISC-R in counterbalanced order. Correlations between the two tests were 0.86 for the Verbal Scale, 0.73 for the Performance Scale, and 0.86 for the Full Scale. Again, FSIQ scores were 5.9 points lower on the WISC-III than the WISC-R.

The WISC-III FSIQ scores appear to be approximately five to nine points lower than scores obtained with the WISC-R (Ackerman, Weir, Holloway, & Dykman, 1995; Bolen, Aichinger, Hall, & Webster, 1995; Lyon, 1995; Post & Mitchell, 1993; Sabatino et al. 1995; Slate, 1995; Slate & Jones, 1995; Wechsler, 1991). However, Sattler (1992) believes that this result is congruent with studies demonstrating that people usually score lower on newer tests of cognitive abilities in comparison to older ones.

Consistent with other research examining IQ and achievement test correlations (e.g., Vance & Fuller, 1995), correlations between WISC-III FSIQ score and group administered achievement tests are in the high 0.50's and 0.60's (Wechsler, 1991). WISC-III FSIQ and WRAT-R subtest score correlations range from a low of 0.28 for Spelling and 0.53 for Reading, to a high of 0.58 for the AR subtest (Wechsler, 1991). Smith, Smith and Smithson (1995) found that correlations between the WISC-III and WRAT-3 ranged from 0.42 to 0.66.

Overall, there is support for the construct validity of the WISC-III: the test appears to provide a good measure of intelligence. Such validity usually relies on relating a presumed measure of a hypothetical quality (or construct) with a behavior or trait that is supposed to underlie it. The factor analyses cited in the WISC-III manual (Wechsler, 1991) indicate that the test adequately measures the two factors linked to the Verbal and Performance Scales. Next, the achievement tests used in this study will be discussed.

Achievement tests.

Achievement tests measure academic achievement in various schoo! subjects such as reading, written expression, spelling and arithmetic. The following four achievement tests were used in this study: the Wechsler Individual Achievement Test (WIAT) (n=134); the Woodcock-Johnson Psycho-Educational Battery (WJPEB) (n=21); the Wide Range Achievement Test – Revised (WRAT-R) or the Wide Range Achievement Test – 3rd Edition (WRAT-3) (n=24); and the Woodcock Reading Mastery Test - Revised (WRMT-R) (n=45). Overall, these tests demonstrate adequate reliability and validity (Sattler, 1992). Each of tests these will now be reviewed.

The WIAT was the most commonly used test of achievement in the present study and the reliability and validity of this test will be briefly reviewed (Psychological Corporation, 1992). The WIAT is a comprehensive test of achievement. It consists of eight subtests designed to measure a variety of achievement skills including the following skills: spelling, basic reading, mathematics, reading comprehension, numerical operations, oral expression and written expression. This achievement test is designed for children ages 5 to 19 years. This test is particularly important to the present study, as it is the only achievement battery presently connected to the WISC-III. The mean standard score is 100 and the standard deviation is 15. Age based reliability coefficients for the composite WIAT test score range from 0.94 for the five-year-old age group, to 0.98 for the ten-year-old age group. With respect to test-retest reliability, WIAT score differences between first and second tests are quite small (e.g., within 1 and 3 standard score points). With respect to inter-scorer agreement (the consistency of scores from one scorer to another), correlations averaged about 0.98 for the reading and listening comprehension subtests. The content, construct and criterion validity of the WIAT are also quite high and suggest that the WIAT measures what is meant to measure. The WIAT correlates strongly with other achievement tests (i.e., 0.88 correlation between the Woodcock Johnson-Revised subtest dictation and the WIAT spelling subtest). Overall, the WIAT has good reliability and validity. Next, the Woodcock-Johnson Psycho-educational Battery will be reviewed.

The Woodcock-Johnson Psycho-Educational Battery consists of a cognitive battery (Part 1) and an achievement battery (Part II). For the present study, only the achievement battery, the Tests of Achievement, was used. The Tests of Achievement, Part II, measure the following academic skills: reading, spelling, punctuation, capitalization, science knowledge, mathematical calculation, applied mathematical problems, social studies and humanities. This battery is meant for children aged 3 to late adulthood. However, not all the tests are used at every age. The mean standard score is 100 and the standard deviation is 15. This battery was well standardized on the United States census data. With respect to reliability, reliabilities range from 0.80's to 0.90's and the validity of the achievement tests is adequate; for example, there are significant correlations (from 0.55 to 0.82) between the measures of spelling, reading and arithmetic and the broad cognitive ability cluster. The WRAT-3 will now be discussed.

The WRAT- R and the WRAT - 3 are individually administered tests of achievement that are often used as 'screeners' for potential learning problems. The WRAT – 3 is an updated revision of the WRAT- R and it will be reviewed. Similar to the WRAT-R, this achievement test is for children aged 5 to adults aged 74 years. It samples performance in three areas: spelling, reading, and arithmetic. The spelling subtest measures the ability to write words from dictation; the reading subtest measures the ability to read single words; and the arithmetic subtest measures written and oral mathematical computations and problem solving. The test takes about 20 minutes to administer to a child. The standard score mean is 100 and the standard deviation is 15. With respect to reliability, the test-retest reliabilities ranged from 0.94 to 0.96 for the 7 to 10 year old age group, and from 0.79 to 0.90 to the 13 to 16 year old age group. With respect to the validity of the test, research generally suggests that the validity is adequate

(Sattler, 1992). Sattler (1992) cautions, however, that the WRAT should only be used for screening purposes, given that the test was not stratified on socioeconomic status, and that reliability data are minimal.

The Woodcock Reading Mastery Test-Revised (WRMT-R) assesses reading skills for children aged 5 years to adults aged 75 years. There are six individually administered subtests. Four of the subtests measure reading achievement: word identification, word attack, word comprehension, and passage comprehension. Two of the subtests measure reading readiness: visual auditory learning and letter identification. On this test the standard score mean is 100 and a standard deviation of 15. Split-half reliabilities range from about 0.34 to 0.98.

Behaviour rating tests.

The main behaviour-rating test used in this study was the Behaviour Assessment System for Children (BASC) (Reynolds & Kamphaus, 1992) (n=176). The BASC has three different forms: the Teacher Rating Scale (TRS), the Parent Rating Scale (PRS), and the Self-Report of Personality Rating (SRP) form. The TRS was created for teachers and includes items that are specifically relevant to the classroom and school environment. The PRS was specifically designed for parents and includes items that are specifically relevant to home. Lastly, the SRP was specifically created for children and adolescents and is made up of items that indicate the child's own experiences, feelings, and beliefs.

Reynolds and Kamphaus (1998) suggest that the TRS, PRS and SRP's internal consistency and test-retest reliability are quite high. For example, the TRS internal consistency values for all three levels (preschool, child and adolescent) are above 0.80

and the reliability scores tend to increase with age (i.e., median scale reliabilities for the four to five year old age group are 0.82 and for the fifteen to eighteen year old age group are 0.89). As well, the manual suggests that the validity of the TRS, PRS and SRP is good. The TRS correlates strongly with other instruments (i.e., Achenbach's Teacher's Report Form, Revised Problem Behaviour Checklist) and this suggests that the validity is good. For example, the Revised Problem Behaviour Checklist's 'Attention Problems-Immaturity Scale' correlates 0.78 with the TRS 'Attention Problems Scale'.

Self-concept scale.

The Piers-Harris Children's Self-Concept Scale (n=48) is an 80-item scale that requires yes/no answers. This scale is written for children at a third grade reading level. Six subscales are hypothesized to measure the following attributes of self-concept: behaviour, intellectual and school status, physical appearance and attributes, anxiety, popularity, happiness and satisfaction. This scale is designed for children in grades 3 to 12. It is viewed as a brief screening instrument for the way the child feels about himself/herself and determining whether a child requires further psychological evaluation. It should be noted, however, that this scale is not designed to diagnose an emotional or behavioral disorder. The scale was standardized on 1,183 children. The manual notes that test-retest reliability for the scale ranged from 0.96 (over a 3-4 week time interval) to 0.42 (over an 8 month interval) and the median test-retest reliability is 0.73 (Piers, 1996). Overall, the content, criterion-related and construct validity of the Piers-Harris are adequate.

As noted earlier, the scale measures six clusters: behaviour, intellectual and school status, physical appearance, anxiety, popularity, and happiness and satisfaction. This test uses T-scores that have a mean of 50 and a standard deviation of 10. A score that is at least one standard deviation below the mean is considered a low score and signals potential concern. For example, a low score on the behaviour scale signifies potential behaviour problems; a low score on the intellectual and school status scale signifies potential areas of learning or school related problems; and a low score on the anxiety scale suggests problems worrying, fear, sadness, and nervousness.

<u>Visual motor integration tests.</u>

Each subject was given one of two tests of visual motor integration—the Bender Visual Motor Gestalt Test (n=179) or the Beery Developmental Test of Visual Motor Integration (n=45). The Bender Visual Motor Gestalt Test will be reviewed, followed by the Beery Developmental Test of Visual Motor Integration.

The Bender Visual Motor Gestalt Test (Bender, 1938) is a popular test of visual motor integration. Beery (1997) notes: "Visual-motor integration is the degree to which visual perception and finger-hand movements are well coordinated" (p. 19). This test is a paper and pencil test that requires the child to copy out nine figures, one at a time, on a piece of paper. The most popular method of scoring results is likely the Koppitz Developmental Bender Scoring System and four categories are used to classify mistakes: perseveration, rotation, distortion, and integration problems. With respect to the reliability of this instrument, scores range from 0.50 to 0.90 with a median reliability of 0.77 (Sattler, 1992). With respect to validity, when testing perceptual motor development, it appears to have good validity (Sattler, 1992). On this test, the standard score has a mean of 100 and a standard deviation of 15.

The Beery-Buktenica Developmental test of Visual Motor Integration (1989, 1997) requires the child to copy a developmental sequence of shapes. The purpose of the test is to identify children who may have visual-motor integration problems. Although the test has been revised a number of times, the test has essentially remained the same in content, form, and characteristics. The 1997 edition of the test differs from the older revisions mainly in the addition of two extra subtests. It should be noted that these two supplemental subtests were not used in this study. The test has high internal, test-retest and inter-rater reliability, and good validity (e.g., the test correlates well with other measures of visual-motor integration). The mean standard score is 100 and the standard deviation is 15.

Group Classification Methods

Next, classification methods will be reviewed for each of the four diagnostic groups.

Learning disability classification method.

Each of the subjects in the learning disabled category were given the following battery of tests. The WISC-III, one of the three following tests of achievement (the WIAT, WJPEB, or WRMT-R), one of two tests of visual-motor integration (the Bender Visual Motor Gestalt Test or the Beery Developmental Test of Visual Motor Integration), a General Information and History Questionnaire, and a clinical interview. As noted earlier, when examining the file data, the author was blind as to how the subject scored on each of the four WISC-III indexes.

The following criteria were used to determine if a subject qualified for the learning disabilities group (Barkley, 1998; Kronenberger & Meyer, 1996; Sattler, 1992). The General Information and History Questionnaire and clinical interview indicated that the purpose of the psycho-educational assessment was to evaluate learning problems. The parent, teacher, or child indicated that the child was experiencing learning problems in the relevant area (reading or written expression/spelling). Each subject's WISC-III and achievement test protocols was initially screened to determine whether there was a difference of at least one standard deviation (e.g., 15 points) between the WISC-III FSIQ score and achievement test subtest score. The achievement tests used included the Wechsler Individual Achievement Test (WIAT), Woodcock-Johnson Psycho-Educational Battery (WJPEB), or the Woodcock Reading Mastery Test - Revised (WRMT-R). (Each of the three achievement tests (WIAT, WJPEB, WRMT-R) are on the same standard score distribution as the WISC-III (mean = 100; SD = 15).) An extra criterion was added in order to ensure that the child's achievement test score was a standard deviation below the mean (e.g., 15 points). If these criteria were met, then a regression equation was used to determine whether the child's Z score > −1.65.

No other conditions could account for the poor achievement results. The Background Information and History Questionnaire or clinical interview could not point to other conditions that could impair cognitive functioning (i.e., head trauma). The WISC-III FSIQ score was greater than 70. According to the Background Information and

History Questionnaire, English was the subject's primary language and he or she was attending school full-time.

All of the subjects were screened for major behavioral, emotional or psychological problems through the clinical interview and Background Information and History Questionnaire. There could be no previously diagnosed psychological disorders (other than a previously diagnosed learning disability). Most subjects in this group were administered the BASC as part of the psycho-educational assessment battery. However, if there was an indication of a potential disorder through the clinical interview, questionnaire, or test results, subjects had to be administered the BASC. There could be no Clinically Significant scores on both of the following BASC TRS and/or PRS clinical scales: Aggression, Anxiety, Attention Problems, Atypicality, Conduct Problems, Depression, Hyperactivity, Somatization or Withdrawal scales. Thirty-six of the 42 subjects in the learning disabled group were administered the BASC. Six subjects were administered a self-esteem screening inventory (Piers-Harris Children's Self-Concept Scale) in order to rule out low self-concept. On this inventory, the subject had to score within the normal range on the scales measuring pathology, such as the anxiety and behaviour scales.

Of the 42 subjects who were diagnosed with a learning disability, seven subjects had been previously diagnosed with a learning disability. The 42 subjects were subcategorized as follows: reading disabled (n=30) and written expression/spelling disabled (n=12). Next, the ADHD classification methods will be reviewed.

ADHD classification method.

When diagnosing ADHD, it is critical to use and integrate a variety of data sources and methods (Gordon & Barkley, 1998; Morgan et al., 1996).

> Despite advances in our knowledge about the role of psychological testing and the allure of numbers over perception, the search for accurate and reliable measures of ADHD symptoms has not yielded a litmus test. The absence of a gold standard for the diagnosis as well as the heterogeneity of the disorder itself precludes any one test (and, for that matter, rating scale or interview format) from claiming pinpoint accuracy. (Gordon & Barkley, 1998, p. 294)

In the present study, a diagnosis of ADHD was based the following data: assessment results, clinical observations, the General Information and History Questionnaire, parental, teacher and/or subject clinical interviews, and parent and teacher BASC results.

Each of the children in ADHD group were given the WISC-III, an achievement test, a visual-motor integration test (the Bender Visual Motor Gestalt Test or the Beery Developmental Test of Visual Motor Integration), a Background Information and History questionnaire, a clinical interview, two BASC rating scales, and a clinical debriefing.

The 'Attention Problems' scale on the BASC was designed to assist in the diagnosis of ADHD (Reynolds & Kamphaus, 1998). This scale measures attention difficulties, distractibility and concentration difficulties. Reynolds and Kamphaus (1998) suggest that the 'Attention Problems' scale on the BASC is "essential to the diagnosis of ADHD" (p. 49). Examples of questions on this scale include the following items:

completes homework from start to finish without taking a break; completes work on time; does not pay attention to lectures; forgets things; gives up easily; gives up easily when learning something new; has a short attention span; has trouble concentrating; is easily distracted; listens attentively; and listens to directions.

The 'Hyperactivity' scale on the BASC was designed to measure symptoms of impulsivity and hyperactivity. This scale looks at behaviours such as over-activity and behaving without thinking. Examples of questions on the 'Hyperactivity' scale include the following: acts silly; acts without thinking; climbs on things; touches everything when shopping; needs too much supervision; interrupts others when they are speaking; disrupts the schoolwork of other children; and taps foot or pencil.

With respect to utilizing the BASC in diagnosing ADHD, consistent with other researchers (e.g., Douglas & Benezra, 1990) the following steps were taken when determining whether to include a subject in the ADHD group. To be included in the ADHD group, two different raters (i.e., parent and teacher) had to concur regarding symptoms of inattention and/or hyperactivity-impulsivity in the child. First, each behaviour-rating protocol was examined to determine whether it was a valid profile. If the profile was valid, then the BASC 'Attention Problems' and the 'Hyperactivity' scales were examined for elevation.

For the ADHD combined type, both raters scored the child in the At-Risk to Clinically Significant range on the BASC 'Hyperactivity' scale and the 'Attention Problems' scale (i.e., T-score $\geq$ than 60). For the ADHD hyperactive-impulsive type, both raters scored the subject in the At-Risk to Clinically Significant range on the

'Hyperactivity' scale (i.e., T-score $\geq$ 60). The clinician must have observed hyperactive-impulsive symptoms and/or attention problems during the assessment. Of the 50 children diagnosed with ADHD, 45 subjects were included in the combined subgroup and 5 subjects were included in the predominantly hyperactive-impulsive subgroup.

Both subgroups of ADHD (i.e., combined and hyperactive-impulsive types) required satisfaction of the following exclusionary criteria. There were no major psycho-educational disorders (other than a previous diagnosis of ADHD) as determined by the General Information and History Questionnaire, clinical interview, and test results. Both BASC raters could not rate the subject in the Clinically Significant range (i.e., T-score $\geq$ 70) on the following BASC PRS or TRS Clinical scales: Aggression, Anxiety, Atypicality, Conduct Problems, Depression, Somatization, or Withdrawal. No other conditions could impair cognitive functioning as indicated by the General Information and History Questionnaire, clinical interview, or a WISC-III FSIQ score $\leq$ 70. Subjects could not be taking stimulant medication.

Each youth was screened for learning disabilities and was administered a test of achievement. As determined by the General Information and History Questionnaire and clinical interview, the subject's primary language was English and the subject was attending school at the time of testing. Of the 50 subjects diagnosed with ADHD, 6 subjects had been previously diagnosed with ADHD. None of the subjects were taking stimulant medication. Subjects taking stimulant medication were purposefully excluded from this study.

Learning disability and ADHD comorbid group classification method.

In order to be included in this group, subjects fulfilled the criteria previously set out in each of the learning disability and ADHD group membership categories. Each of the children in this group were administered the WISC-III, an achievement test (WIAT, WJPETA, WRMT), a visual-motor integration test, a Background Information and History questionnaire, a clinical interview, two BASCs, and a clinical debriefing with the clinician.

With respect to a diagnosis of a learning disability, 17 subjects were classified as reading disabled and 7 were classified as written expression/spelling disabled. The previously outlined procedures determined whether a child was learning disabled.

Of the 24 subjects diagnosed with a learning disability and ADHD, 21 subjects were included in the predominantly hyperactive-impulsive group and 3 subjects were included in the combined group. Three of the subjects had been previously diagnosed with ADHD.

No diagnosis group classification method.

This group consisted of 108 subjects who were screened for intellectual impairment, learning disabilities, ADHD, and any other significant psycho-educational problems. This study aimed to have a group of subjects without a significant intellectual, emotional or behavioural (i.e., psycho-educational) diagnosis. Children in this group were typically referred for psycho-educational evaluation by their parents who were interested in learning about their child's strengths and weaknesses. It is important to remember that the no diagnosis group was a group of clinically referred children and thus is not the same as a group of 'normal' or the same as the WISC-III standardization sample.

All subjects in this group were administered the WISC-III, the PS and FD factor subtests, the four PO subtests, a test of achievement (WIAT, WJPEB, WRAT-R or WRAT-3), and a test of visual motor integration (the Bender Visual Motor Gestalt Test or the Beery Developmental Test of Visual Motor Integration). The test of achievement, at the minimum, screened the child for potential problems in reading, spelling, written expression, and/or mathematics.

All subjects in this group were screened for significant emotional, behavioural, intellectual problems via the General Information and History Questionnaire and the clinical interview. Of the children in this group, 24 children were administered the BASC. Both rater's BASC PRS and/or TRS Clinical subscales (i.e., Aggression, Anxiety, Attention Problems, Atypicality, Conduct Problems, Depression, Hyperactivity, Learning Problems, Somatization, or Withdrawal scales) could not be in the Clinically Significant range (T-score $\geq$ 70).

No other conditions could impair cognitive functioning as determined by the a) General Information and History Questionnaire, b) the clinical interview, and c) the WISC-III FSIQ score was above 70. English was the primary language and the subject was attending school full-time, as determined by the General Information and History Questionnaire and clinical interview. The subject could not be taking stimulant medication.

Next, Chapter Four presents both descriptive and inferential statistics for the present study.

Chapter Four

Results

First, general descriptive statistics for the sample will be provided, followed by inferential statistics.

Sample Characteristics

Table 7 illustrates the means and standard deviations for FSIQ, VIQ, and PIQ scores for each of the four groups and the total sample. The total sample mean FSIQ score is 97.20 (SD = 14.35), the mean VIQ is 97.57 (SD = 15.42), and the mean PIQ is 98.51 (SD = 14.44). All the means were within normal range. Next, the mean factor index scores and subtest scores are reviewed.

TABLE 7

WISC-III MEAN VERBAL IQ, PEFORMANCE IQ, AND FULL SCALE IQ SCORES BY GROUP AND TOTAL SAMPLE

	Mean	SD
Learning Disability (n=42)		
Verbal IQ	96.29	11.62
Performance IQ	99.10	12.62
Full Scale IQ	96.83	9.84
ADHD (n=50)		
Verbal IQ	95.44	15.65
Performance IQ	92.88	12.52
Full Scale IQ	93.40	13.95
Learning Disability & ADHD (n=24)		
Verbal IQ	93.96	10.94
Performance IQ	98.63	11.19
Full Scale IQ	95.08	8.03
No Diagnosis (n=108)		
Verbal IQ	99.86	17.17
Performance IQ	100.86	15.95
Full Scale IQ	99.57	16.60
Total Sample (n=224)		
Verbal IQ	97.57	15.42
Performance IQ	98.51	14.44
Full Scale IQ	97.20	14.35

Factor index scores.

Table 8 shows the means and standard deviations for the four-factor index scores for the total sample and by group. As can be seen from Table 8 all the mean scores were within normal range.

TABLE 8

WISC-III MEAN FACTOR INDEX SCORES BY GROUP AND SAMPLE

	Mean	SD
Learning Disability (n=42)		
Verbal Comprehension	97.95	11.30
Perceptual Organization	101.33	11.99
Freedom from Distractibility	92.02	14.41
Processing Speed	93.33	12.22
ADHD (n=50)		
Verbal Comprehension	96.32	15.26
Perceptual Organization	95.76	13.69
Freedom from Distractibility	92.04	14.62
Processing Speed	90.86	13.46
Learning Disability & ADHD (n=24)		
Verbal Comprehension	94.17	11.35
Perceptual Organization	102.79	10.05
Freedom from Distractibility	92.42	13.66
Processing Speed	89.29	14.30
No Diagnosis (n=108)		
Verbal Comprehension	99.98	16.98
Perceptual Organization	101.63	16.26
Freedom from Distractibility	98.56	17.18
Processing Speed	102.46	15.89
Total Sample (n=224)		
Verbal Comprehension	98.01	15.16
Perceptual Organization	100.39	14.53
Freedom from Distractibility	95.22	16.01
Processing Speed	96.75	15.54

Subtest scores.

Table 9 shows the total sample means and standard deviations for the PS, FD, and PO subtests. The means and standard deviations were in the normal range.

TABLE 9

WISC-III MEAN SUBTEST SCORES FOR SAMPLE

	Mean	SD
Arithmetic	9.07	3.67
Digit Span	9.34	2.87
Coding	8.70	3.28
Symbol Search	10.06	3.47
Picture Completion	10.31	2.84
Picture Arrangement	10.29	3.22
Block Design	9.87	3.56
Object Assembly	9.67	3.22

Research Questions

The main purpose of the research is to examine the utility of the PS and FD factors in distinguishing between groups of children with a pure learning disability (in reading or writing/spelling), pure ADHD, combined learning disability and ADHD, and no formal psycho-educational diagnoses. The research questions related to the PS and FD factors follow.

Question 1): On the three PS, CD, and SS tests, are there significant differences in the mean scores for group, age, or the interaction of group and age?

Question 2): On the three PS, CD, and SS tests, are there significant differences in the mean scores for group, gender, or the interaction of group and gender?

Question 3) On the three FD, DS, and AR tests, are there significant differences in the mean scores for group, age, or the interaction of group and age?

Question 4): On the three FD, DS, and AR tests, are there significant differences in the mean scores for group, gender, or the interaction of group and gender?

Question 5): On the two SCAD and PO/SCAD measures, are there significant differences in the mean scores for group, age, or the interaction of group and age?

Question 6): On the two SCAD and PO/SCAD measures, are there significant differences in the mean scores for group, gender, or the interaction of group and gender?

Question 7): Is the percentage of children in the 1) learning disabled, 2) ADHD, and 3) learning disabled and ADHD groups who scored high on the PO/SCAD index significantly higher than the percentage of children in the no diagnosis group?

Next, the statistical analyses of the data will be reviewed.

Data Analysis

The Statistical Package for the Social Sciences (SPSS) was used to analyze the data. We considered using a three-way ANOVA, but using a three-way ANOVA design would result in very different sample sizes. The sample sizes would range from a minimum of 3 subjects for the following groups: younger males with learning disabilities and ADHD, older females with learning disabilities, and younger males with ADHD. In contrast, there were 39 younger females in the no diagnosis group. Therefore, two 2-way

ANOVAs were used (group by age, group by gender) to analyze the data, permitting more equal and adequate sample sizes.

A two-way ANOVA procedure was used to investigate whether there were significant differences on each of the variables across groups. The Tukey Honestly Significant Difference (HSD) post hoc test was used to compare group mean differences. The purpose for using the Tukey (HSD) post-hoc comparison method was that it tends to be quite conservative when comparing group means and it is appropriate with unequal sample sizes across groups (Glass & Hopkins, 1984).

The dependent variables may be grouped conceptually as follows: PS and its subscales of CD and SS; FD and its subscales of DS and AR; and the SCAD and PO/SCAD indices. For the first two groupings, there are three dependent variables. A more conservative alpha level of 0.017 (0.05/3) was used for the ANOVA and post-hoc analyses. For the last grouping, the alpha level was reduced to 0.025 (0.05/2) for the ANOVA and post-hoc analyses. The alpha level was reduced in order to control for spurious Type I errors.

Results indicated that the power effects for group, age, and gender were usually over 0.80; however, for the interactions, the power dropped down and ranged from a high of 0.79 to a low of 0.07. However, this reduction in power for the interactions is viewed as an artifact of the Type III sum of squares analyses.

Results are presented in four major sets. The PS and its subscales of CD and SS; FD and its subscales of DS and AR are a second subset; the SCAD indice is a third subset; and the PO/SCAD indice is a fourth subset. Each presentation will provide the means and standard deviations and the corresponding ANOVA tables. Tables 19-24 in Appendix A shows the Summary ANOVAs.

First, results will be reviewed for the two-way ANOVA procedure on PS, FD, SCAD, and PO/SCAD.

PS Factor, CD and SS Subtest Variables

Results from group by age ANOVA.

A two-way ANOVA procedure was used to investigate whether there were differences for group, age, or the interaction of group and age on the PS, CD and SS variables. The main effect for group was significant on the PS factor ($F (3, 223) = 7.22$, $p < 0.001$), CD subtest ($F (3, 223) = 4.19$, $p < 0.001$), and SS subtest ($F (3, 223) = 6.38$, $p < 0.001$). On each of these three variables, the learning disability, ADHD, and learning disability and ADHD groups scored significantly lower than the no diagnosis group. Results indicated a significant main effect for age on PS ($F (1, 223) = 20.12$, $p < 0.001$), CD ($F (1, 223) = 15.23$, $p < 0.001$), and SS ($F (1, 223) = 11.46$, $p \leq 0.001$). The younger age group scored significantly higher than the older age group on each of the three variables. Results indicated no significant group by age interactions on PS, CD, or SS. Table 10 shows a summary of the PS factor and subtest means by group and Table 11 shows a summary of PS factor and subtest means by age. See Table 19 in Appendix A for summary ANOVAs.

TABLE 10

SUMMARY OF PS FACTOR AND SUBTEST MEANS BY GROUP

Measures	Group				F (3, 223)
	No Diagnosis	LD and ADHD	LD	ADHD	
PS	102.46[a] (15.89)	89.29[b] (14.30)	93.33[b] (12.22)	90.86[b] (13.46)	7.22*
CD	9.63[a] (3.13)	7.29[b] (3.11)	8.38[b] (3.65)	7.62[b] (2.77)	4.19*
SS	11.29[a] (3.39)	8.54[b] (3.41)	8.88[b] (3.12)	9.12[b] (3.06)	6.38*

Note: * $p < 0.017$

TABLE 11

SUMMARY OF PS FACTOR AND SUBTEST MEANS BY AGE

Measures	Age group		F (1,223)
	Younger	Older	
PS	101.71 (14.45)	89.49 (14.22)	20.12*
CD	9.64 (3.19)	7.32 (2.90)	15.23*
SS	10.94 (3.35)	8.77 (3.23)	11.46*

Note: * $p < 0.017$

<u>Results from group by gender ANOVA.</u>

A two-way ANOVA procedure was used to investigate whether there were differences for group, gender, or the interaction of group and gender, on the PS, CD and SS variables. Consistent with the previous two-way ANOVA, the effect of group was statistically significant for PS ($F(3, 223) = 9.57$, $p < 0.001$), CD ($F(3, 223) = 5.73$, $p \leq 0.001$), and SS ($F(3, 223) = 9.52$, $p < 0.001$). On each of the three variables, the learning disability, ADHD, and learning disability and ADHD groups scored significantly lower than the no diagnosis group. Results indicated no significant main effect of gender, and no significant group by gender interactions on the PS, CD, or SS variables. Table 12 shows a summary of the PS factor and subtest means by gender. See Table 22 in Appendix A for summary ANOVAs.

TABLE 12

SUMMARY OF PS VARIABLE MEANS BY GENDER

	Gender		
Measures	Female	Male	F (1, 223)
PS	99.59 (15.38)	94.54 (15.35)	3.09
CD	9.38 (3.41)	8.17 (3.08)	4.31
SS	10.48 (3.53)	9.73 (3.40)	1.03

<u>Note:</u> * $p < 0.017$

FD factor, DS and AR Subtest Variables

Results from group by age ANOVA.

A two-way ANOVA procedure investigated whether there were differences for group, age, or the interaction of group and age on the FD, DS and AR variables. The main effect for group was not significant on FD, DS, or AR. The main effect for age was significant on FD ($F (1, 223) = 9.96, p < 0.01$), DS ($F (1, 223) = 10.32, p < 0.01$) and AR ($F (1, 223) = 6.03, p \leq 0.017$). There was no significant group by age interactions on FD, DS, or AR. Next, differences for group, gender or the interaction of group and gender were investigated on FD, DS and AR. Table 13 shows summary means on the FD factor and subtests by group, and Table 14 shows summary means by age. See Table 20 in Appendix A for summary ANOVAs.

TABLE 13

SUMMARY OF FD FACTOR AND SUBTEST MEANS BY GROUP

	Group				
Measures	No Diagnosis	LD and ADHD	LD	ADHD	F (3, 223)
FD	98.56 (17.17)	92.42 (13.66)	92.02 (14.41)	92.04 (14.62)	1.25
AR	9.61 (3.51)	8.83 (3.17)	8.29 (2.93)	8.66 (3.37)	0.64
DS	9.92 (3.03)	8.54 (2.69)	8.93 (2.89)	8.84 (2.37)	1.49

Note: * $p < 0.017$

TABLE 14
SUMMARY OF FD FACTOR AND SUBTEST MEANS BY AGE

	Age group		
Measures	Younger	Older	F (1,223)
FD	99.40 (15.75)	89.11 (14.41)	9.96*
AR	9.80 (3.38)	8.00 (3.06)	6.03*
DS	10.08 (2.90)	8.27 (2.48)	10.32*

Note: * $p < 0.017$

Results from group by gender ANOVA.

There was no significant main effect for group or gender, and no significant group by gender interaction on FD, DS, or AR. See Table 23 in Appendix A for summary ANOVAs.

TABLE 15

SUMMARY OF FD VARIABLE MEANS BY GENDER

	Gender		
Measures	Female	Male	F (1, 223)
FD	97.57 (16.34)	93.39 (15.57)	1.35
AR	9.23 (3.34)	8.94 (3.39)	0.07
DS	9.98 (3.01)	8.85 (2.67)	3.41

Note: * $p < 0.017$

SCAD

Results from group by age ANOVA.

A two-way ANOVA procedure determined whether there were differences for group, age, or the interaction of group and age on SCAD. In order to create SCAD, the sum of the four subtests that make up the PS and FD factors was added.

A two-way ANOVA was used to investigate whether there were differences for group, age, or the interaction of group and age on SCAD. The group by age interaction for SCAD was statistically significant ($F(3, 223) = 3.63$ $p \leq 0.017$). The younger group scored higher than the older group for each of the diagnostic and control groups, but a greater difference was observed for the no diagnosis group. A main effect for group on SCAD was found ($F(3, 223) = 5.47$, $p < 0.001$). Each of the three clinical groups (i.e., learning disabled, ADHD, learning disabled and ADHD) scored significantly lower than the no diagnosis group on SCAD. The main effect for age was significant for SCAD ($F(1, 223) = 22.74$, $p < 0.01$), with the younger group scoring significantly higher than the older group on SCAD. See Table 21 in Appendix A for summary ANOVAs.

Results from group by gender ANOVA.

A two-way ANOVA procedure was used to investigate whether there were differences for group, gender, or the interaction of group and gender on SCAD. Results indicated a significant main effect for group on SCAD ($F(3, 223) = 8.43$ $p < 0.001$), with the no diagnosis group scoring significantly higher than the other three groups.

There was no significant main effect for gender and no significant group by gender interaction. See Table 24 in Appendix A for summary ANOVAs.

PO/SCAD

PO/SCAD was computed in the way recommended by Kaufman (1994). The performance on SCAD was compared to performance on the four subtests that make up the PO index (Picture Completion, Picture Arrangement, Block Design, and Object Assembly). In order to determine the difference between performance on the SCAD subtests and the PO index, the sum of the four SCAD subtests is subtracted from the sum of the four PO index subtests. Therefore, negative values on the PO/SCAD measure indicate higher scores on the SCAD subtests than on the PO subtests. Positive PO/SCAD values indicate higher PO index subtests than SCAD subtests.

Results from group by age ANOVA.

The main effect for group on PO/SCAD was significant ($F(3, 223) = 6.82$, $p < 0.001$). The learning disabled group, and the learning disabled and ADHD group scored significantly higher on PO/SCAD than the no diagnosis group. As well, there was a significant main effect for age on PO/SCAD ($F (1, 223) = 8.55$, $p \leq 0.01$), with the older group scoring higher than the younger group. There was no significant group by age interaction on PO/SCAD. Table 16 shows summary means for the SCAD and PO/SCAD indices by group and Table 17 shows summary means by age.

TABLE 16

SUMMARY OF SCAD AND PO/SCAD MEANS BY GROUP

	Group				
Measures	No Diagnosis	LD and ADHD	LD	ADHD	F (3, 223)
SCAD	40.44[a] (10.09)	33.21[b] (8.08)	34.48[b] (7.48)	34.24[b] (7.91)	5.47*
PO/SCAD	0.38[a] (8.58)	8.54[b] (10.42)	6.71[b] (9.73)	2.74 (9.18)	6.82*

Note: * $p < 0.025$

TABLE 17

SUMMARY OF SCAD AND PO/SCAD MEANS BY AGE

	Age group		
Measures	Younger	Older	F (1,223)
SCAD	40.45 (8.63)	32.36 (8.60)	22.74*
PO/SCAD	1.15 (8.56)	5.62 (10.38)	6.82*

Note: * $p < 0.025$

Results from group by gender ANOVA.

A two-way ANOVA procedure was used to investigate whether there were differences for group, gender, or the interaction of group and gender on PO/SCAD. On

PO/SCAD, there was a significant main effect for group ($F(3, 223) = 7.37$, $p < 0.001$), and the no diagnosis group scored significantly lower than the learning disabled group and the learning disabled and ADHD group. There was a main effect for gender on PO/SCAD ($F(1,223) = 7.56$, $p \leq 0.01$), with boys scoring higher than girls. There was no significant group by gender interaction on PO/SCAD.

TABLE 18

SUMMARY OF SCAD AND PO/SCAD MEANS BY GENDER

	Gender		
Measures	Female	Male	F (1, 223)
SCAD	39.07 (9.54)	35.68 (9.19)	3.13
PO/SCAD	0.39 (8.87)	4.98 (9.66)	7.56*

Note: * $p < 0.025$

Chi-square.

As explained in the PO/SCAD section, in order to obtain PO/SCAD, the sum of the SCAD subtests was subtracted from the sum of the PO subtest scaled scores. If the PO sum exceeded the SCAD sum, by 9 points or more, the difference between these two sums was considered significant ($p < 0.05$).

A Chi-Square procedure was used to determine whether the frequency of children in a) the three clinical groups--learning disabled, ADHD, and learning disabled and ADHD--who scored significantly higher on PO/SCAD is significantly higher than b) the frequency of children in the no diagnosis group?

Results indicated that students in the three combined clinical were significantly more likely to score significantly higher on the PO/SCAD index than the students in the no diagnosis group (χ^2 (1, n = 224) = 22.36, $p < .001$).

Summary

In summary, Chapter Four presented both descriptive and inferential statistics for the present study. Next, present study findings will be reviewed within the context of theoretical implications and future research directions.

Chapter Five

Discussion

Overview

Within the discussion chapter, the following areas are addressed. Firstly, an overview of the research questions will be provided. Then, results for children with learning disabilities are conceptualized within an information-processing framework using two models: 1) Baddeley's working memory model, and 2) Borkowski et al.'s (1989) metacognitive model of academic achievement. Secondly, results for children with ADHD are contextualized within Barkley's model of ADHD. Recommendations for future research are presented in the context of theory. Developmental, diagnostic and educational implications are reviewed, followed by remedial and treatment implications arising from the present study results and theory. This chapter concludes with study limitations, delimitations, and conclusions.

Research Questions

The main purpose of the research was to examine the utility of the PS and FD factors in distinguishing between groups of children with a pure learning disability (in reading or writing/spelling), pure ADHD, combined learning disability and ADHD, and no formal psycho-educational diagnoses.

Question 1): On the three PS, CD, and SS tests, are there significant differences in the mean scores for group, age, or the interaction of group and age?

Question 2): On the three PS, CD, and SS tests, are there significant differences in the mean scores for group, gender, or the interaction of group and gender?

Question 3) On the three FD, DS, and AR tests, are there significant differences in the mean scores for group, age, or the interaction of group and age?

Question 4): On the three FD, DS, and AR tests, are there significant differences in the mean scores for group, gender, or the interaction of group and gender?

Question 5): On the two SCAD and PO/SCAD measures, are there significant differences in the mean scores for group, age, or the interaction of group and age?

Question 6): On the two SCAD and PO/SCAD measures, are there significant differences in the mean scores for group, gender, or the interaction of group and gender?

Question 7): Is the percentage of children in the 1) learning disabled, 2) ADHD, and 3) learning disabled and ADHD groups who scored high on the PO/SCAD index significantly higher than the percentage of children in the no diagnosis group?

Learning Disabilities

We need to compare present study test findings on the PS and FD factors for learning disabled children with similar research. This is particularly difficult, given varying operational definitions and research criteria for learning disabilities. As well, present study findings for the learning-disabled group need to be framed within a context or theory to help explain study findings, and to help determine future research. The context used to help us understand findings for the learning disabilities group is the information-processing framework. Within this framework, the two models used to explain present study findings are 1) Baddeley's working memory model, and 2) Borkowski et al.'s (1989) metacognitive model.

Present results for the children with learning disabilities are discussed within the information-processing framework. As mentioned earlier, this is a stage-approach to cognition, with mental operations performed on the information as it goes through stages (Hunt, 1999). Within the information-processing paradigm, Baddeley's working memory model and Borkowski et al.'s (1989) model of academic skill development are particularly relevant to understanding the cognitive deficits in or challenges for children with learning disabilities. Without belaboring the details of each model, as they were discussed in the literature review, only a general review of each model is provided.

Baddeley's Model of Working Memory

Firstly, Baddeley's (1986, 1994) model of working memory maintains that a limited amount of information can be held in working memory (Baddeley & Hitch, 1994; Baddeley, 1986, 1992, 1994). Working memory is a stage between short and long-term memory, and is limited in size. Working memory is made up of 1) a central executive that regulates information between the visuospatial sketchpad and phonological loop, 2) a visuospatial sketchpad responsible for visual-spatial processing, and 3) a phonological loop responsible for verbal processing. When information is brought into working memory, it must be kept there long enough in order to determine both the problem and how to solve it.

Working memory is critical to understanding learning disabilities, particularly verbal learning disabilities such as reading disabilities, because working memory is believed to be an important component of reading skills and reading comprehension (Dixon et al., 1988; Turner & Engle, 1989). For example, during reading, it is believed that the central executive retrieves linguistic information (i.e., phonological rules, word meanings, syntax information), while the subsidiary system(s) holds onto the words or sentences while they are processed so that longer text units can be comprehended.

It has been suggested that the PS factor may, to a certain extent, measure non-verbal or visual working memory (Kaufman, 1994; Riccio et al., 1997; Sattler, 1992b), while the FD factor measures verbal or auditory memory (Kaufman, 1994; Sattler, 1992b). Thus, the correlates for the PS and FD factors in Baddeley's model of working memory would be the visuospatial sketchpad and the phonological loop, respectively. However, as will be later noted, the PS and FD factors are not pure measures of nonverbal and verbal working memory.

PS factor findings.

Firstly, results for the low PS scores in learning disabled children are discussed. The present study found that children with a diagnosis of 1) reading or written expression/spelling learning disabilities and 2) learning disabilities and ADHD scored significantly lower on the PS variable in comparison to the children without a diagnosis. This finding is consistent with research suggesting that a low PS score characterizes children with learning disabilities (e.g., Ackerman & Dykman, 1995; Daley & Nagle, 1996; Wechsler, 1991; Williams et al., 1993). This finding is also consistent with research implicating lower scores in learning disabled children on tasks that are similar to the subtests that make up the PS factor (e.g., Kerns & Decker, 1985; Waber & Bernstein, 1994). Present study findings can be viewed as supporting non-verbal or visual working memory deficits in children with reading and written expression/spelling disabilities.

Thus, given that the PS factor and factor subtests, particularly the SS subtest, are largely visual in nature, according to Baddeley's model of working memory, these children may be showing deficits or impairment in the visuo-spatial sketch pad.

SCAD and PO/SCAD findings.

Secondly, results for SCAD and PO/SCAD for the learning disabled children are addressed. The present study found that children with a diagnosis of 1) learning disabilities and 2) learning disabilities and ADHD scored significantly lower on SCAD in comparison to the children without a diagnosis, and significantly higher on PO/SCAD than the children without a diagnosis. This finding is generally consistent with the research literature implicating lower scores on the SS, CD, AR, and DS subtests (SCAD profile) in learning disabled children (Kaufman, 1994; Prifitera & Dersh, 1993; Ward et al., 1995; Wechsler, 1991). This finding should be taken as supporting non-verbal working memory problems in children with learning disabilities. Next, we might question how a deficit in working memory might impact a child with learning disabilities?

Impact of weak working memory.

Prifitera et al. (1998) point out how impaired working memory affects children:

> Children with serious deficits in working memory are academically challenged, but not necessarily because of lower intelligence. A weakness in working memory may make the processing of complex information more time consuming and drain the student's mental energies more quickly as compared to other children of the same age, perhaps contributing to more frequent errors on a variety of learning tasks. (p. 28)

Thus, children with impaired working memory spend more time and energy on tasks that would require fewer resources from a child without impaired working memory. This could well explain why children with learning disabilities, despite normal intelligence, exhibit more difficulty in learning academic tasks such as reading or writing.

We have discussed the present study findings for the learning disabled group in the context of Baddeley's model of working memory, as well as discussed how poor working memory can impact a child. Next, results for the learning disabled group will be further explored within Borkowski et al.'s (1989) model of academic skill development.

Borkowski et al.'s (1989) Model of Academic Skill Development

Present findings for the group with learning disabilities are discussed within the context of Borkowski et al.'s (1989) model of academic skill development. This model is viewed as an adjunct to Baddeley's model of working memory for describing problems in learning disabled children. Although Borkowski et al.'s model is not explicitly linked to examining the cognitive structures of learning disabled children, it is a useful tool for examining the difficulties that learning disabilities children may experience. Since this model was reviewed earlier in the literature, it will only be briefly reviewed.

Borkowski et al.'s (1989) model focuses on the role of metacognition or awareness of one's cognitive processes and the ability to self-regulate these cognitive processes. This model argues that academic skill attainment requires both spontaneous and formally taught cognitive strategies. These strategies include *conditional strategy knowledge* (*how, when and where* to use a certain strategy) and *general strategy knowledge* (understanding that a strategic approach to learning improves learning, the need to expend effort in order to learn, and realizing that they are the agents of their own learning). As children recognize that their efforts and use of strategies result in successful learning, recurring self-attributions improve their sense of *self-efficacy* (their belief in their ability to reach a goal). Together, self-attributions and self-efficacy guide their decision-making to help choose the best learning strategies.

According to this model, we can implicitly assume that learning disabled children have problems allocating cognitive resources (Swanson, 1993b, c). Specifically, they can be described as having problems using and assigning cognitive resources especially in tasks requiring effort. It has been suggested that good PS performance requires strategy knowledge and use (Kaufman, 1994). Kaufman (1994) summarizes how strategy knowledge or performance on the CD subtest is important for good performance:

> As such, a child's *strategy* is most likely a valuable determinant of performance. Sometimes poor strategies are quite evident. The examiner may notice, for example, that a left-handed child is blocking the key with his/her hand and thus not taking advantage of the second Coding Response Sheet that is provided. The test-taking approaches . . . . may actually be more indicative of the ability to plan and strategize than to remember visual stimuli. (p. 244)

Thus, children's strategies likely affects PS factor performance. Borkowski et al.'s (1989) model implies that children who have difficulty learning academic skills (i.e., children with learning disabilities) are likely deficient in strategy knowledge and/or use.

In summary, results for the group with learning disabilities were contextualized within Baddeley's theory of working memory and Borkowski et al.'s model of academic skill development. Next, results for the group with ADHD will be reviewed within the context of Barkley's theory of ADHD.

ADHD

Present findings on the PS and FD factors for the ADHD group need to be reviewed within the context of theory, and with others who have conducted similar research. This is particularly difficult, given varying operational definitions and research criteria of ADHD. As Reader et al. (1994) note "because populations differ due to varying operational definitions of ADHD and because studies employ different tests and/or versions of the same test differing in terms of administration and scoring" (p. 507). Present findings for the ADHD group will be addressed within the context of Barkley's model of ADHD, which will not only help explain results, but also help determine future research.

Barkley's Model of ADHD

Barkley's (1997, 1998) model of ADHD will be reviewed in relation to study findings. Firstly, since this model was thoroughly discussed in the literature section, only a brief review of his six-part model of ADHD is provided. The first part of his model involves three kinds of behavioral inhibition: 1) stopping the prepotent response, 2) interrupting an ineffective response and 3) interference control). The four executive functions include: 1) non-verbal working memory, 2) verbal working memory, 3) self-regulation of affect/motivation/arousal (i.e., controlling emotions), and 4) reconstitution (breaking down observed behaviors and putting them together into new behaviors). The last part of Barkley's model involves the motor control and execution component.

The present discussion is limited to parts of Barkley's model that are likely related to the WISC-III PS and FD factors. These parts include non-verbal working memory, verbal working memory, self-regulation of affect/motivation/arousal, and motor control.

Non-verbal working memory difficulties.

Barkley's (1997) theory suggests that children with ADHD have working memory difficulties, including both nonverbal and verbal working memory problems. Barkley (1997, 1998) argues that measures of nonverbal working memory can include measures of visual short-term memory. This implies that, to a certain extent, the PS factor may indicate nonverbal working memory abilities. Similarly, verbal working memory tasks might include auditory or verbal short-term working memory measures such as the FD factor subtests (Barkley, 1997, 1998). Firstly, present study findings for the PS factor in the group of children with ADHD are addressed.

Present findings indicated that children with ADHD score significantly lower score on the PS factor than children without a diagnosis. These findings are consistent with Barkley's prediction that children with ADHD show impaired performance on non-verbal or visual working memory tasks. Findings are consistent with research suggesting that a suppressed PS factor is characteristic of ADHD groups (Ehler et al., 1997; Lufi et al., 1990; Saklofske et al., 1994; Swanson, 1997; Wechsler, 1991). Present study results are also consistent with research indicating poorer scores in children with ADHD on tasks that are similar to the PS factor subtests (Sergeant & Scholten, 1983, 1985).

There is limited research on the relationship between non-verbal or visual working memory and ADHD (Barkley, 1997). A particular difficulty with research in this area is that measures of non-verbal working memory are usually not pure measures of nonverbal working memory (Barkley, 1997) and this limitation can be extended to the PS factor. The PS factor, although it measures aspects of visual working memory, also requires significant visual-motor coordination and speed. Thus, the PS factor cannot be viewed as a measure of pure nonverbal working memory or visual working memory.

Research examining visual working memory in clinic-referred children with ADHD has indicated impairment on visual organization and copying tasks (Douglas & Benezra, 1990; Grodzinsky & Diamond, 1992; Sadeh et al., 1996) and spatial location tasks (Mariani & Barkley, 1997). On the other hand, studies using community-screening samples have not found impaired performance on visual organization (Moffit & Silva, 1988; Reader et al., 1994) or spatial location tasks (Weyandt & Willis, 1994). The differences in study findings are attributed to using clinical versus community-screened samples of individuals with ADHD.

As noted in the literature review, Barkley's model of ADHD relates nonverbal working memory to planning ability. Working memory helps children keep the present situation, past consequences of behaviours (hindsight), and future implications (foresight) in mind. An implication of impaired nonverbal working memory is that children with ADHD should show impaired planning ability. The literature supports impaired planning ability in children with ADHD (Barkley, 1997, 1998; Naglieri & Das, 1990; Naglieri et al., 1990; Pennington et al., 1993; Reardon & Naglieri, 1992; Weyandt & Willis, 1994). Kaufman (1994) argued that the PS factor may be measuring planning ability, to a certain extent, and that this "seems warranted from the apparent similarity of the component subtests to the kinds of tasks used by Das and Naglieri to validate the Planning portion of the PASS model" (p. 246). Thus, present study findings support Barkley's assertion that children with ADHD show impairment on tasks requiring planning skills. Next, Barkley's prediction that children with ADHD have impaired verbal working memory is reviewed.

Verbal working memory difficulties.

Barkley's theory suggests that children with ADHD should show impaired verbal working memory. However, the present study did not find significant differences on the FD factor between the ADHD and no diagnosis children. Tasks requiring storage and recall of simple verbal information are less likely to show impairment in children with ADHD (Barkley et al., 1990; Cahn & Marcotte, 1995) than tasks requiring more complex mental manipulation (Seidman et al., 1995; Seidman et al., 1996) or organizational strategies (Frost et al., 1989; Shapiro et al., 1993). This might explain why the present study did not find significant differences on the FD factor between the ADHD and no diagnosis groups. Although the DS and AR subtests measure aspects of verbal working memory, they are not pure measures of verbal working memory, as both involve numbers or numerical ability.

However, significant differences were found on the SCAD subtests and children with ADHD scored significantly lower on the SCAD subtests than children without a diagnosis. Findings on the SCAD profile are generally consistent with research implicating lower SS, CD, AR, and DS subtests scores (SCAD profile) in children with ADHD (Kaufman, 1994; Prifitera & Dersh, 1993; Schwean & Saklofske, 1998; Wechsler, 1991).

Future research might be directed at exploring performance in children with ADHD on tasks measuring complex verbal working memory. For example, one could compare performance on the DS backwards and forwards aspects of the subtest. Unfortunately, this was not available for the present study. We might expect relatively greater impairment on the DS backward subtest in comparison to the DS forward, as the backward subtest requires more complex mental manipulation than the DS forward subtest. Alternatively, a better measure of verbal working memory might be the memory for sentences subtest on the Stanford-Binet Intelligence Scale-Fourth Edition. Next, we will review Barkley's prediction that children with ADHD have difficulty with self-regulation of motivation.

Self-regulation of motivation.

Barkley's model predicts that children with ADHD have difficulty with tasks providing little reinforcement (Barkley, 1997). Thus, children with ADHD should show impairment on tasks that are rote and boring, similar to the PS factor, and to a certain extent the FD factor, subtests. Kaufman (1994) notes that the PS factor subtests are particularly boring and he refers to them as the 'validity' factors. For example, the SS subtest requires quick visual scanning of low-interest symbols. The CD subtest requires the child to copy rather boring symbols quickly. Kaufman (1994) suggests that the PS factor, in particular, may well be measuring motivation and has even encouraged clinicians to view the child's PS factor score as an indicator of motivation.

Present study findings indicating low PS scores children with ADHD when compared to the no diagnosis children support Barkley's prediction that children with ADHD perform weakly on tasks that provide little reinforcement. As well, findings that the children with ADHD score significantly poorly on the SCAD subtests in comparison to the children without a diagnosis, support Barkley's prediction that children with ADHD should show impairment on low reinforcement tests. In general, the research has supported reduced motivation on low reinforcement tasks in ADHD children (Barber et al., 1996; Barkley, 1990). Next motor control deficits will be discussed.

Motor control deficits.

Barkley's model predicts that children with ADHD have problems with motor control and he notes that although the literature has implicated such problems in ADHD children, they have been infrequently discussed with respect to their theoretical implications. The PS factor subtests, particularly the CD subtest, are dependent on motor control or graphomotor output. Although the SS subtest only requires a slash in the yes or no box, it too requires fast motor response, although to a lessor degree than the CD subtest. Present study findings that children with ADHD scored significantly lower on the PS index in comparison to the no diagnosis children are consistent with Barkley's prediction that children with ADHD should show problems with motor control. In particular, the finding that the 1) ADHD and 2) learning disabilities and ADHD groups scored significantly lower on the CD subtest than the children without a diagnosis is particularly supportive of motor control deficits as related to ADHD.

The present study finding is consistent with research supporting motor control problems in children with ADHD (Barkley et al., 1990; Hartsough & Lambert, 1985; Szatmari et al., 1985; Wilson & Marcotte, 1990). ADHD children tend to have impaired fine motor coordination (DuPaul & Stoner, 1994; Mariani & Barkley, 1997; Moffitt, 1990). Impairment is greater on measures of complex motor sequences such as handwriting or drawing (i.e., Sleator & Pelham, 1986; Hoy, et al., 1978; McGee et al., 1992; Sadeh et al., 1996) than on simple, motor movement measures (Grodzinsky & Diamond, 1992; Mariani & Barkley, 1997). As well, graphomotor output independent of linguistic demands has also been found to be lower in children with ADHD (Marcotte and Stern, 1997).

Now that we have contextualized results for the learning disabled and ADHD groups with their respective models, we will examine developmental, diagnostic, educational, and remedial implications of the study findings.

Implications

Possible developmental implications.

The finding that the older age group tended to score more poorly than the younger age group on PS, FD, SCAD and PO/SCAD. It is possible that maturational age may influence performance on these factors in children with learning disabilities or ADHD. The finding of age differences on these variables may be considered consistent with

Ackerman and Dykman's (1995) research. They found that although both the younger (age 8-12) and older (age 12-16) group of comorbid learning disabled subjects scored significantly lower scores on the CD and AR WISC subtests, the older group scored significantly lower on the CD and SS subtests than the younger group. As well, studies using continuous performance tests have found age differences on tasks of attention in children with ADHD (Mitchell et al., 1990; H. Swanson, 1983). H. Swanson found that as children with learning disorder and ADHD become older, they show increased impairment on continuous performance tasks (i.e., discriminating between non-signaled and signaled letters). However, some studies have not found age differences (Grodzinsky & Diamond, 1992, Seidman et al., 1997). Next, diagnostic implications of study results are discussed.

Diagnostic implications.

Present study findings suggest that the three diagnostic groups tended not to differ from one another suggesting that performance on the PS and FD factor does not discriminate between different diagnostic categories (ADHD group, learning disability group, and ADHD and learning disability combined group). These results are consistent with Watkins et al.'s (1997) findings that although children with learning disabilities or emotional disabilities showed lower than normal PS factor score (as well as FD factor score), these factors did not differentiate between children with learning disabilities and emotional disabilities.

The general lack of significant differences between learning disabled, ADHD, and learning disabled and ADHD groups on PS and SCAD underscores the importance of interpreting the PS and SCAD scores not in isolation, but within the context of the whole child's academic, intellectual, emotional/behavioral performance. While low PS and SCAD scores will not diagnose the presence of a learning disability or ADHD, when interpreted in context, performance on these two factors can become significant data (Kaufman, 1994). Prifitera et al. (1998) point out the importance of using the WISC-III subtest scores or any test scores as *part* of a child's total evaluation. Prifitera et al. (1998) recommend that clinicians:

> ... need to view test results as tools used by a clinician in the evaluation process whether for diagnosis, intervention, planning, classification, description, etc. Test results need to be viewed in the context of other information and knowledge about that person. Then, based on the knowledge of the patient that includes a wide variety of sources (only one of which is test information), the clinician looks at the information to confirm or disconfirm hypotheses of either an apriori or a posteriori nature. (p. 5)

For example, just as a physician may find a high blood pressure reading, he or she will likely not be able to diagnose hypertension immediately from that high blood pressure reading. Rather, first the physician needs to determine whether the reading is reliable. Then, he or she needs to consider which of the many problems or disorders could be responsible for the elevated reading. In the same way, Prifitera et al. (1998) suggest that: "... a relationship between low scores on WISC-III PS ... and attentional disorder is not in and of itself diagnostic of ADHD, but the knowledge of this relationship should be included when trying to understand the person who is the object of the assessment" (p. 6). This leads to a discussion of educational implications of present study findings.

Educational implications.

Present study findings have implications for understanding the difficulties children with learning disabilities and/or ADHD have in a school setting. For example, with respect to educational implications for students with low PS performance, Prifitera et al. (1998) hypothesize that children with poor PS scores may have the following difficulties:

> … learn less material in the same amount of time, or take longer to learn the same amount of material as compared to those without processing speed deficits. We think that these children may also mentally tire more easily because of the additional cognitive effort required to perform routine tasks, and that this could lead to more frequent errors and possible expressions of frustration. (p. 31)

In a classroom, poor PS scores may leave students with fewer resources to process information quickly. These students likely have problems with quick verbal and/or written output. They may also have difficulty with nonverbal (i.e., visual) working memory or inadequate knowledge of or use of appropriate learning strategies. Thus, once the nature of the deficits has been determined, intervention can be directed towards the student's area of weakness. For example, providing the child with compensatory strategies for poor visual working memory or teaching the child appropriate strategies.

Remedial implications for children with learning disabilities will now be reviewed, followed by treatment implications for children with ADHD.

Remedial implications: learning disabilities.

Firstly, remedial implications for children with learning disabilities are reviewed. Remedial implications for children with learning disabilities are provided within the context of Baddeley's model of working memory and Borkowski's model of academic skill development. Within the context of Baddeley's model of working memory, a learning disabled child with a low PS, SCAD, and higher PO/SCAD score may have problems with visual working memory. Thus, it can be useful to ensure instructions are posted and always in view of the child, so that posters, diagrams, or even simple instructions are written out to help the child remember. Using external cues or physical props can help to compensate for the ineffective internal structures. Such methods will be more fully explained later in the section on remedial implications for children with ADHD. Next, remedial implications are reviewed within the context of Borkowski et al.'s (1989) model.

Borkowski et al.'s (1989) model focuses on the role of metacognition. Academic skill attainment requires spontaneous and formally taught cognitive strategies. Interventions could be directed at helping a learning disabled child attain *conditional strategy knowledge such as how, when and where* to use a certain strategy. Examining the strategies a child is using when learning and helping him or her learn new strategies or use the ones he or she knows can be helpful. As well, interventions can be directed at helping a child obtain *general strategy knowledge* or understanding that learning is improved by using a strategic approach. By attaining conditional and general strategy knowledge, the child will begin to attribute successful learning to their own efforts and this improves their sense of self-efficacy. Together, self-attributions and self-efficacy guide will their decision-making to help choose the best learning strategies. Next, treatment implications for children with ADHD are reviewed

Treatment implications: ADHD.

With respect to children with ADHD, we will first review treatment implications related to poor working memory and poor motivation. With respect to poor working memory, Barkley (1997) suggests methods of compensating for poor working memory:

> Moving to the specifics, parents or educators of children with ADHD may need to rely on external prompts, cues, reminders, or even physical props that serve to supplement the internal forms of information that are proving so ineffective. If the rules that are understood to be operative during classroom individual desk work, for instance, do not seem to be controlling the ADHD child's behaviour, then externalize them. This could be achieved by posting signs about the classroom that are related to these rules, creating a poster displayed at the front of the class, or typing in the rules on a card that will be taped to the child's desk. Having the child verbally self-state these rules out loud before and during individual work performances may also be helpful. Tape recording these reminders onto a cassette tape which the child listens to through an earphone while working

> would be another means of externalizing the rules and putting them at the points of performance. (pp. 341-342)

As noted by Barkley (1997), methods of externalizing information can be varied. In general, it is believed that methods for compensating for poor internal working memory information are most effective when the information that needs to be remembered is directed outward in the form of external reminders, such as posters, notes, and even audio tapes. Next, we will review treatment implications for poor motivation in children with ADHD.

External forms of motivation are critical for improving poor motivation in children with ADHD. As Barkley notes, no matter how much internalized forms of information are externalized, it will only be somewhat successful unless internal forms of motivation are externalized.

> It is not simply the internally represented information that is weak in those with ADHD, but also the internally generated sources of motivation associated with it. These are critical to driving goal directed behavior toward tasks, the future, and the intended outcome in the absence of external motivation to do so in the immediate context. . . . Instead, artificial means of creating external sources of motivation must be arranged in the context where the work or behavior is desired *at the point of performance* where it is to occur. . . . Rewards, in most cases artificial or socially arranged ones, must be instituted more immediately and more often throughout a performance context for those with ADHD and must be

> tied to more salient reinforcers that are available within relatively short periods of time if the behavior is to be improved.... The methods of behavior modification are particularly well-suited to achieving these ends, and many techniques exist within this form of treatment that can be applied to those with ADHD... (Barkley, 1997, pp. 344-345)

Thus, to improve motivation, rewards must be initiated at the 'point of performance' and must be tied to the behaviour at the time it occurs. Behaviour modification methods are very well suited to the treatment of ADHD. It is beyond the scope of the present paper to address the many varied methods of behavioural reinforcement. However, creating external sources of motivation are key to improving motivation in a child with ADHD. Next, study limitations will be reviewed, followed by study delimitations and conclusions.

Study Limitations

As with any research project, there are limitations in this study. Some of these limitations will now be addressed. Firstly, using a clinic-referred population reduces the ability to generalize study results to a 'normal', non-clinic referred population. Secondly, given the limited practicality of obtaining large numbers of learning disabled and/or ADHD children, this research relied on archival data. Thus, this research relied on other clinicians to accurately administer, score, and interpret psychometric measures. Use of archival data required retroactive group classification that lends itself to errors of misclassification. As well, the research criteria used to diagnose a subject with ADHD were somewhat artificial in nature. Children diagnosed with ADHD in this present study may not have met the specific DSM-IV diagnostic criteria for the disorder. Thus, this study is limited to the subjects identified by the research criteria utilized in this study.

Another limitation of the present research is the reliance on quasi-experimental research methods. That is, the independent variable was not manipulated and subjects were pre-assigned to the variable. For this reason, we tried to reduce differences unrelated to the IV by selecting a control group or comparison group (i.e., the no diagnosis group). However, the quasi-experimental design limits our ability to draw conclusions about causal differences. That is, even though children with learning disabilities, ADHD, or both learning disabilities and ADHD, differ from the children without a diagnosis on the PS factor, it cannot be concluded that these diagnoses are causally related the poor PS factor score. Instead, the difference could result from a third correlated factor.

Although the researcher tried to obtain equal numbers of boys and girls in each of the four diagnostic categories, unfortunately, it was not possible to obtain exactly equivalent numbers of males and females. However, the ANOVAs indicated few gender differences on the variables under examination.

Another limitation of the present study includes the inability to generalize present study findings from a group level to the level of the individual. Finding statistical differences between groups of children is not always useful as we are left to diagnose and plan for remediation with the *individual*. As Grodzinsky and Barkley (1999) note:

> Finding differences between *groups* of children having a diagnosis of ADHD relative to those not so diagnosed does not mean such tests will be

> helpful in the classification (diagnosis) of *individuals* in clinical evaluations (Elwood, 1993). Only a minority of the subjects in one group need to be deficient or impaired on the tests to create significant differences among group means to lead to statistical significance. (p. 13)

However, although we have difficulty generalizing group results to the individual level, there are good reasons for looking at statistical differences between groups as this might help us better understand the cognitive processes that are occurring in certain diagnostic groups of children. This can help us better build models of childhood clinical disorders and test these models, ultimately with the hope of planing for remediation and treatment. Next, study delimitations are reviewed.

Delimitations

This particular study was limited to a clinical population of students who were retroactively classified by the researcher into the appropriate clinical classifications (e.g., learning disability, ADHD, learning disability/ADHD, and no diagnosis children). As well, this study was limited to students who had been given the required battery of psychometric tests and who met the specific research criteria outlined in the methods chapter of this work. Thus, generalizations of study findings are limited to groups of students who meet the particular research criteria used in this study. Next, a review of study conclusions is provided.

Conclusions

The purpose of this research was to explore the WISC-III PS and FD factors within three clinical groups of children. The chapter began with reviewing the general research question: *Do children with learning disabilities, ADHD, combined learning disability and ADHD, and those not experiencing any significant behavioral, emotional, or intellectual diagnoses, show significantly different mean scores on the WISC-III PS and FD indexes?*

Current findings suggest that although there are generally differences on the PS factor and SCAD subtests between the children with learning disabilities, ADHD, and learning disabilities and ADHD, in comparison to the children without a diagnosis, we cannot distinguish between clinical groups based on the PS and SCAD scores. However, consistent with the literature, results support lower scores on the PS factor, as well as the four SCAD subtests that make up the PS and FD factors, in children with learning disabilities, ADHD, or both diagnoses, in comparison to children without a diagnosis.

Caution should be used when using the PS and SCAD scores as a basis for a diagnostic hypothesis. Low PS or SCAD scores will not diagnose the presence or absence of a disability and they do not differentially diagnose learning disabled children from ADHD children. However, a low PS or SCAD subtest scores may increase the diagnostician's confidence in an ADHD or learning disability diagnosis. For example, if the assessment data indicates the presence of a learning disability and the student demonstrates low PS or SCAD scores, then we can be more confident in the diagnosis. Ultimately, the most useful aspect of examining the PS and SCAD subtest scores is for understanding a child's strengths and weakness, as well as for remedial planning.

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Appendix A

Summary ANOVAS

TABLE 19

SUMMARY OF ANOVAS GROUP BY AGE FOR PS, CD, AND SS

Source	df	MS	F	Power
PS				
Group	3	1345.32	7.22*	.98
Age	1	3748.20	20.12*	.99
Group X Age	3	220.58	1.18	.32
Error	216	186.27		
CD				
Group	3	37.26	4.19*	.85
Age	1	135.57	15.23*	.97
Group X Age	3	16.56	1.86	.48
Error	216	8.90		
SS				
Group	3	63.16	6.38*	.97
Age	1	113.49	11.46*	.92
Group X Age	3	14.12	1.43	.38
Error	216	9.90		

Note: * $p < 0.017$

TABLE 20

SUMMARY OF ANOVAS GROUP BY AGE FOR FD, DS, AND AR

Source	df	MS	F	Power
FD				
Group	3	277.18	1.25	.33
Age	1	2217.24	9.96*	.88
Group X Age	3	657.33	2.95	.70
Error	216	222.69		
DS				
Group	3	10.73	1.49	.39
Age	1	74.46	10.32*	.89
Group X Age	3	21.66	3.00	.70
Error	216	7.22		
AR				
Group	3	6.53	.64	.18
Age	1	61.69	6.03*	.69
Group X Age	3	32.19	3.15	.73
Error	216	10.23		

Note: * $p < 0.017$

TABLE 21

SUMMARY OF ANOVAS GROUP BY AGE FOR SCAD AND PO/SCAD

Source	df	MS	F	Power
SCAD				
Group	3	361.78	5.47*	.94
Age	1	1503.85	22.74*	.99
Group X Age	3	239.96	3.63*	.79
Error	216	66.14		
PO/SCAD				
Group	3	547.46	6.82*	.98
Age	1	686.37	8.55*	.83
Group X Age	3	87.56	1.09	.29
Error	216	80.30		

Note: * $p < 0.025$

TABLE 22

SUMMARY OF ANOVAS GROUP BY GENDER FOR PS, CD, AND SS

Source	df	MS	F	Power
PS				
Group	3	2039.10	9.57*	.99
Gender	1	657.25	3.09	.42
Group X Gender	3	22.27	.11	.07
Error	216	213.04		
CD				
Group	3	56.32	5.73	.95
Gender	1	42.34	4.31	.54
Group X Gender	3	5.71	.58	.17
Error	216	9.83		
SS				
Group	3	102.01	9.52*	.99
Gender	1	11.05	1.03	.17
Group X Gender	3	11.27	1.05	.28
Error	216	10.72		

Note: * $p < 0.017$

TABLE 23

SUMMARY OF ANOVAS GROUP BY GENDER FOR FD, DS, AND AR

Source	df	MS	F	Power
FD				
Group	3	732.66	2.99	.70
Gender	1	330.15	1.35	.21
Group X Gender	3	443.53	1.81	.47
Error	216	245.16		
DS				
Group	3	19.93	2.58	.63
Gender	1	26.32	3.41	.45
Group X Gender	3	15.76	2.04	.52
Error	216	11.08		
AR				
Group	3	24.91	2.25	.56
Gender	1	.73	.07	.06
Group X Gender	3	21.29	1.92	.49
Error	216	11.08		

Note: * $p < 0.017$

TABLE 24

SUMMARY OF ANOVAS GROUP BY GENDER FOR SCAD AND PO/SCAD

Source	df	MS	F	Power
SCAD				
Group	3	674.18	8.43*	.99
Gender	1	250.10	3.13	.42
Group X Gender	3	47.05	.59	.17
Error	216	79.98		
PO/SCAD				
Group	3	595.93	7.37*	.98
Gender	1	610.96	7.56*	.78
Group X Gender	3	3.29	.04	.06
Error	216	80.84		

Note: * $p < 0.025$