

University of Montana

ScholarWorks at University of Montana

Graduate Student Theses, Dissertations, &
Professional Papers

Graduate School

2002

Inattentive and impulsive profiles of the CPT -II and their relationship with DSM -IV ADHD subtypes

Kristin A. Kirlin

The University of Montana

Follow this and additional works at: <https://scholarworks.umt.edu/etd>

Let us know how access to this document benefits you.

Recommended Citation

Kirlin, Kristin A., "Inattentive and impulsive profiles of the CPT -II and their relationship with DSM -IV ADHD subtypes" (2002). *Graduate Student Theses, Dissertations, & Professional Papers*. 9439.
<https://scholarworks.umt.edu/etd/9439>

This Dissertation is brought to you for free and open access by the Graduate School at ScholarWorks at University of Montana. It has been accepted for inclusion in Graduate Student Theses, Dissertations, & Professional Papers by an authorized administrator of ScholarWorks at University of Montana. For more information, please contact scholarworks@mso.umt.edu.

INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps.

ProQuest Information and Learning
300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA
800-521-0600

UMI[®]



**Maureen and Mike
MANSFIELD LIBRARY**

The University of

Montana

Permission is granted by the author to reproduce this material in its entirety,
provided that this material is used for scholarly purposes and is properly cited in
published works and reports.

****Please check "Yes" or "No" and provide signature****

Yes, I grant permission

No, I do not grant permission

Author's Signature: Cristina C. [Signature]

Date: 8/21/02

Any copying for commercial purposes or financial gain may be undertaken only with
the author's explicit consent.

**Inattentive and Impulsive Profiles of the CPT-II and their Relationship
with DSM-IV ADHD Subtypes**

by

Kristin A. Kirlin

B.A., Psychology, Reed College, 1995

M.A., Clinical Psychology, University of Montana 2000

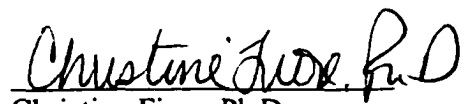
Presented in Partial Fulfillment of the Requirements for the Degree of

Doctorate of Philosophy

The University of Montana

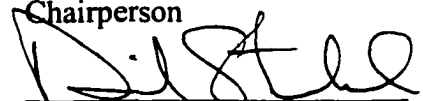
August 2002

Approved by:



Christine Fiore, Ph.D.

Chairperson



David Strobel, Ph.D.

Dean of Graduate Studies

8-28-02

Date

UMI Number: 3062632

UMI[®]

UMI Microform 3062632

Copyright 2002 by ProQuest Information and Learning Company.
All rights reserved. This microform edition is protected against
unauthorized copying under Title 17, United States Code.

ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

Inattentive and Impulsive Profiles of the CPT-II and their Relationship with DSM-IV ADHD Subtypes pp. 1-105.

Chairperson: Christine Fiore, Ph.D. 

The DSM-IV recognizes three subtypes of ADHD based on the results of field trials and factor analytic studies that identified two dimensions of symptoms in the disorder: inattention and hyperactivity/impulsivity. The three DSM-IV subtypes are predominantly inattentive (ADHD/I), predominantly hyperactive-impulsive (ADHD/HI), and combined type (ADHD/C).

Study of these three ADHD subtypes has suggested differences in demographics, prevalence, course, rates of comorbid conditions, possible etiology, and treatment response. Given the potential clinical meaningfulness of identifying these subtypes, ADHD assessment instruments that discriminate between subtypes are needed.

The CPT-II is a version of the continuous performance task designed to measure symptoms of inattention and impulsivity. Conners' (2000) suggests that the pattern of elevated scores on the CPT-II can be used to determine whether a child's problem is primarily one of inattention or impulsivity. The present study examines whether the profiles generated by the CPT-II are clinically meaningful by comparing the performance of a clinical sample of children (N = 40) with different profile types on measures of attention, impulsivity, depression, anxiety, learning problems, and executive function.

It was hypothesized that 1) the children with clinical CPT-II profiles would exhibit greater impairment on the other measures than the children with nonclinical profiles, 2) the inattentive and impulsive CPT-II groups would differ in ways consistent with the literature on the differences between the ADHD subtypes, and 3) that omission and commission scores on the CPT-II would be useful for identifying groups of children who would differ in ways consistent with the differences reported between the ADHD subtypes.

The results did not support Hypothesis 1; the children with clinical and nonclinical CPT-II profiles did not differ significantly on the dependent measures. For Hypothesis 2, the children with inattentive, impulsive, and indeterminate CPT-II profiles differed significantly only in their use of semantic clustering during a list-learning task. There was also a nonsignificant trend for differences in self-reported anxiety between the three CPT-II profile groups. The results failed to support Hypothesis 3 and did not identify differences between children with differing levels of omission and commission scores.

The clinical implications and suggestions for future research are discussed.

Table of Contents

List of Tables	iv
List of Figures	v
Introduction	1
Diagnostic Criteria & Clinical Features of ADHD	3
Etiology of ADHD	23
Assessment of ADHD	33
Treatment of ADHD	43
The Present Research	51
Method	54
Participants	54
Procedures	55
Measures	55
Results	71
Sample Descriptive Statistics	71
Comparisons Between CPT-II Groups	74
Multiple Discriminant Analysis	78
Discussion	84
References	94

List of Tables

Table 1:	Means, Standard Deviations, Ranges, & Percent beyond Clinical Cut-off of Dependent Measures for Sample	73
Table 2:	Correlations between Clinical Measures	74
Table 3:	Demographics of CPT-II Groups	75
Table 4:	Means of Clinical Measures for Inattentive, Impulsive, & Indeterminate CPT-II Groups	77
Table 5:	Means of Clinical Measures for Omission & Commission CPT-II Groups	78
Table 6:	Standardized Canonical Discriminant Function Coefficients & Functions at Group Centroids	80
Table 7:	Results of Three-Group Discriminant Analysis	81
Table 8:	Classification Matrices for Three-Group Discriminant Analysis for Original Analysis & Cross-Validation Samples	82

List of Figures

Figure 1: Scatterplot of three groups' values on discriminant functions 1 & 2 83

Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the leading reasons for referral to family physicians, pediatricians, pediatric neurologists, and child psychiatrists and is the most commonly diagnosed learning and behavioral disorder in children (Biederman, Newcorn, & Sprich, 1991). The symptoms of inattention, impulsivity, and hyperactivity that characterize ADHD disrupt classrooms and families' homes, pose a great financial cost to society, and are associated with later psychiatric disorders and antisocial behavior in adulthood (see Biederman et al, 1991; Chan, Zhan, & Homer, 2002).

Despite the importance of accurately assessing and identifying ADHD, it can be difficult to diagnose reliably. The criteria for the disorder have been continuously redefined and there are a wide range of possible symptoms and subtypes. High rates of comorbidity and complex etiology further complicate the accurate diagnosis of ADHD. Many question whether the diagnosis of ADHD is being misapplied to children who are difficult to control, but have developmentally normal levels of attention and activity (see Garber, Garber, & Spizman, 1996).

A variety of assessment techniques have been developed to aid in the diagnosis of ADHD. Computerized Continuous Performance Tests (CPTs) have been designed to evaluate symptoms of ADHD such as inattentiveness and impulsivity and have gained

popularity in the assessment of ADHD. Conners' CPT-II is a version of the CPT paradigm that has recently been released (Conners, 2000). The Conners' CPT-II differs from many other versions of the CPT task in that the individual responds to every item *except* the target stimulus rather than only to a rarely occurring target. The CPT-II claims that this unique feature contributes to it being a better measure of impulsivity than many other versions of the CPT (Conners, 2000).

The Conners' CPT-II produces a variety of measures and Conners (2000) suggests that the clinician may use the pattern of elevated scores to help identify whether the respondent's impairment is primarily one of inattention or impulsivity. This distinction between the inattentive and impulsive symptoms of ADHD corresponds to the ADHD subtypes identified in the current version of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association [APA], 1994). The ADHD subtypes recognized in DSM-IV (1994) are the result of field trials and factor analytic studies that identified two dimensions of symptoms in the disorder: inattention and hyperactivity/impulsivity (see Lahey et al., 1994). Since the DSM-IV's (1994) publication, researchers have continued to examine the differences between the individuals belonging to each ADHD subtype and debate the value of this new classification system.

The present research examined whether groups of children identified by the CPT-II as predominantly inattentive and predominantly impulsive differ in expected ways based on the literature on ADHD subtypes. Specifically, their demographics and

performance on measures of learning, behavior, and executive function were compared. To illustrate the factors complicating the assessment and diagnosis of ADHD, this introduction will first address the diagnostic criteria and clinical features of the disorder. Next, current conceptualization regarding the etiology of ADHD will be discussed, followed by a review of the literature on the assessment and treatment of ADHD. Throughout this introduction, our understanding of the differences between the ADHD subtypes will be outlined. Finally, the present research will be addressed.

Diagnostic Criteria & Clinical Features of ADHD

Although identified by a variety of names, ADHD has been recognized for the past century (Kaplan, Sadock, & Grebb, 1994). In the early 1900's, the term "hyperactive syndrome" was used to describe impulsive, disinhibited, hyperactive children, including many who had suffered neurological damage as the result of encephalitis. Despite no evidence of overt brain damage in most children with ADHD symptoms, this association with encephalitis led ADHD children with poor coordination, learning disabilities, and emotional lability to be labeled as having "minimal brain damage" throughout the 1960's.

In more recent decades, our conceptualization of the symptoms associated with ADHD has continued to change. With each successive revision of the DSM our terminology for what is now known as ADHD has been redefined: hyperkinetic reaction (DSM-II, 1968), attention deficit disorder with and without hyperactivity (DSM-III,

1980), and ADHD (DSM-III-R, 1987; & DSM-IV, 1994). Despite these revisions, the core symptoms of inattention, hyperactivity, and impulsivity have remained constant (Marks, Himelstein, Newcorn, & Halperin, 1999). For the purposes of the present research, the DSM-IV (1994) concept of ADHD will be used. In reviewing the literature, reference will be made to earlier terms for the disorder as used in past research.

DSM-IV Diagnostic Criteria.

The APA classifies ADHD among the attention-deficit and disruptive behavior disorders in the disorders usually first diagnosed in infancy, childhood, or adolescence (DSM-IV, 1994). To meet the diagnostic criteria, a child must experience at least six developmentally inappropriate symptoms of either inattention or hyperactivity-impulsivity in at least two settings (e.g., school and home). Symptoms of inattention include: lack of attention to detail, difficulty sustaining attention, failure to listen when spoken to, failure to finish projects, organizational difficulties, avoidance of tasks requiring mental effort, losing things, distractibility, and forgetfulness of daily activities. Symptoms of hyperactivity-impulsivity include: fidgeting, failure to remain seated, feelings of restlessness or excessive running and climbing, difficulty engaging in activities quietly, being often “on the go,” excessive talking, blurting out answers, difficulty awaiting turn, and frequently interrupting or intruding on others.

To meet diagnostic criteria for ADHD: 1) the initial impairing symptoms of inattention and/or hyperactivity-impulsivity must be present before the age of seven, and 2) the current symptoms must be at least six months in duration and cause clinically

significant impairment in functioning. Furthermore, these symptoms cannot only be present in the context of a pervasive developmental disorder, psychotic disorder, or another mental disorder.

Subtypes of ADHD.

Given the long list of possible symptoms of ADHD, the clinical presentation of children meeting the diagnostic criteria is quite heterogeneous. Over time, the DSM has conceptualized this diversity in a variety of ways (see Cantwell & Baker, 1992; Faraone, Biederman, Weber, & Russell, 1998; Morgan, Hynd, Riccio, & Hall, 1996). The second edition of the DSM (DSM-II, 1968) recognized only hyperkinetic reaction, characterized by motoric disinhibition. The third edition (DSM-III, 1980) divided attention deficit disorder into two subtypes: with and without hyperactivity (ADD+H and ADD-H, respectively). The revised third edition (DSM-III-R, 1987) combined the symptoms of inattention, impulsivity, and hyperactivity into one unitary disorder, ADHD, and included undifferentiated attention deficit disorder not otherwise specified (ADD, NOS) as a residual diagnostic category for children with symptoms of inattention only. The fourth edition (DSM-IV, 1994) continues to use the term ADHD, but also describes subtypes based on the results of field trials and factor-analytic studies that identified two dimensions of symptoms: inattention and hyperactivity/impulsivity (see Lahey et al., 1994; Faraone, Biederman, Weber, et al., 1998).

Most individuals with ADHD manifest symptoms of both the inattention and hyperactivity-impulsivity dimensions, but some experience predominantly one or the

other. To differentiate between these different possible patterns of symptoms, the DSM-IV (1994) recognizes three subtypes of ADHD: predominantly inattentive type (ADHD/I), predominately hyperactive-impulsive type (ADHD/HI), and combined type (ADHD/C).

To meet the criteria for ADHD/C, the individual must exhibit six or more symptoms of inattention *and* six or more symptoms of hyperactivity-impulsivity for at least six months. ADHD/I is defined as six or more symptoms of inattention, but fewer than six symptoms of hyperactivity-impulsivity for at least six months. The ADHD/HI subtype includes individuals with six or more symptoms of hyperactivity-impulsivity and less than six symptoms of inattention for at least six months. The DSM-IV-TR (2000) acknowledges that these are not distinct groups. Some individuals with ADHD/I will still exhibit prominent clinical features of hyperactivity and impulsivity, and some with ADHD/HI will exhibit significant symptoms of inattention.

The changes in ADHD diagnostic criteria and the inclusion of subtypes in DSM-IV (1994) have raised concern regarding the generalizability of research conducted with DSM-III (1980) or DSM-III-R (1987) criteria to individuals diagnosed under the new system. Biederman et al. (1997) examined the correspondence between DSM-III-R (1987) and DSM-IV (1994) definitions of ADHD among a clinical sample of children. They developed approximated DSM-IV-type subtypes from the ADHD symptoms listed in DSM-III-R (which considered ADHD to be a unitary disorder). Their results revealed a κ coefficient of .71 between these two ADHD subtype criteria.

Willcutt, Pennington, Chhabildas, Friedman, and Alexander (1999) also examined the correspondence between different versions of DSM ADHD criteria. They suggest that the ADHD/C subtype of DSM-IV (1994) is essentially analogous to DSM-III (1980) ADD+H and DSM-III-R (1987) ADHD, and the ADHD/I subtype is similar to DSM-III (1980) ADD-H and DSM-III-R (1987) undifferentiated ADD, NOS. They conclude that the ADHD/II subtype is the only truly new addition.

Since the inclusion of ADHD subtypes in DSM-IV (1994), researchers have examined the validity of distinguishing between groups based on symptoms of inattention and hyperactivity-impulsivity. Dane, Schachar, and Tannock (2000) compared the activity levels of children with ADHD/I, ADHD/C, and a control group of non-ADHD children during a full-day evaluation using solid-state actigraph (a device that records the number of movements per unit of time). During afternoon testing, the ADHD groups exhibited significantly more activity than the non-ADHD group, but the two subtypes did not significantly differ. These results do not provide support for the DSM-IV distinction between subtypes based on levels of hyperactivity. However as Dane et al. (2000) note, a laboratory setting is not the children's normal daily environment and the lack of familiarity and one-on-one interaction with the examiner may have influenced their activity level.

Lahey et al. (1998) investigated the validity of DSM-IV (1994) ADHD and its subtypes in younger children (4 to 6 years old). Children diagnosed with all three subtypes of ADHD by structured diagnostic protocol exhibited lower mean scores on

independent measures of adaptive functioning relative to controls. Hudziak et al. (1998) attempted to validate the DSM-IV criteria for ADHD and its subtypes with latent class and factor analysis of parent-reported symptoms. Their results were consistent with separate continuous domains of inattention, hyperactivity-impulsivity, and combined type problems. Neuman et al. (1999) also utilized a latent class approach to identify ADHD subtypes and found two categories of symptoms, inattentive and combined inattentive and hyperactive-impulsive, each of which appeared to be part of a separate continuum of severity.

Cross-cultural studies have also supported the distinction between the ADHD symptoms of inattention and hyperactivity-impulsivity. Beiser, Dion, and Gotowiec (2000) explored the factor structure underlying measures of parent, teacher, and self-reported ADHD symptoms among American Indian and non-Native children. Their results revealed symptoms of inattention and hyperactivity co-aggregate in unique patterns that support DSM-IV (1994) diagnostic categories. This 2-factor solution was culturally invariant suggesting that the two dimensions of ADHD symptoms are not culture-bound.

As discussed in more detail below, research has also examined the clinical meaningfulness of distinguishing between ADHD subtypes. The results have suggested that the three subtypes differ in prevalence and demographic factors, rates of comorbid conditions, course, possible etiology, and treatment response (see Cantwell & Baker, 1992; Carlson, Shin, & Booth, 1999; Faraone et al., 1998).

Prevalence & Gender Ratio.

It is estimated that 3-7% of prepubertal school-age children meet the diagnostic criteria for ADHD (DSM-IV-TR, 2000). ADHD is more common in boys than girls (2:1 in community samples, 9:1 in clinic-referred samples; DSM-IV-TR, 2000; Nolan, Volpe, Gadow, & Sprafkin, 1999), and is most common in first-born boys (Kaplan et al., 1994). The gender ratio is significantly less skewed toward males in the ADHD/I subtype than other subtypes (Baumgaertel, Wolraich, & Dietrich, 1995; Lahey et al., 1994; Nolan et al., 1999). Nolan et al. (1999) observed that ADHD/C girls in their clinical sample of children and adolescents exhibited a greater severity of symptoms than boys, suggesting that girls may be underreferred, underdiagnosed, and undertreated for ADHD.

The prevalence rates of ADHD have been affected by the revisions of the DSM criteria. Baumgaertel et al. (1995) compared the prevalence rate of DSM-III (1980), DSM-III-R (1987), and DSM-IV (1994) ADHD diagnoses based on teacher behavior ratings in a nonreferred German elementary school sample. Use of the DSM-IV (1994) ADHD criteria increased the prevalence rate by 64% over the rate diagnosed by DSM-III-R (1987) criteria (17.8% vs. 9.6% respectively). This change was largely due to the inclusion of a greater number of children with predominantly inattentive symptoms with the DSM-IV (1994) criteria. Application of DSM-IV (1994) ADHD criteria encompassed the majority of children with reported academic and behavior problems.

Lahey et al. (1994) also examined the relationship between DSM-IV (1994), DSM-III (1980), and DSM-II-R (1987) definitions of ADHD. Their results revealed a

net increase in ADHD diagnoses of 7.1% from DSM-III (1980) to DSM-III-R (1987) among their clinical sample of 4 to 17 year old youth. Application of DSM-IV (1994) criteria increased ADHD prevalence 23.2% above DSM-III (1980) rates, and 15% above the rate of cases identified with DSM-III-R (1987) criteria. The new ADHD cases identified by DSM-IV (1994) criteria were largely girls with ADHD/I and preschool children with ADHD/HI.

The prevalence of ADHD also differs by subtype. The ADHD/HI subtype is less prevalent than the other two subtypes (9%-15% of clinical referred cases of ADHD, and 21-27% of community cases of ADHD) (Biederman et al., 1997; Faraone et al., 1998; Lahonde et al., 1998; Nolan et al., 1999). ADHD/I has been the most prevalent subtype in epidemiological studies and ADHD/C has been the most common among clinical samples (see Carlson et al., 1999; Nolan, Gadow, & Sprafkin, 2001). Lahey et al. (1994) report no differences between the ADHD subtypes in terms of ethnicity among the DSM-IV (1994) field trial sample.

Clinical Features, Course, & Long-term Outcome.

Two patterns of ADHD symptoms have been recognized in infancy (Kaplan et al., 1994). In the first pattern, the infant cries easily, is very active, needs little sleep, and is highly sensitive to stimuli and easily upset by changes in the environment (e.g., noise, light, temperature). The second and more rare pattern of symptoms of ADHD in infancy includes being placid and limp, sleeping a great deal, and having the appearance of being developmentally slow.

The DSM-IV (1994) criterion that ADHD symptoms must cause impairment before the age of seven has raised concern regarding the early clinical features of ADHD and the usefulness of this age cut-off. Applegate et al. (1997) examined the validity of the age-of-onset criterion for ADHD and each of its subtypes. Their results revealed differences between the three subtypes in the age of onset of first symptoms of the disorder, as well as in the age at which they first experience impairment as a result of their ADHD symptoms.

The children in the ADHD/I subtype experienced their first ADHD symptoms at a significantly later age than the other two subtypes. Children with ADHD/I symptoms also experienced a significantly later age of impairment than those with ADHD/C (mean age of 6.13 and 4.88 years respectively), and both these two subtypes experienced a later age of impairment than those with ADHD/HI symptoms (mean age of 4.21 years). Almost all of the children in their sample with ADHD/HI met the age of impairment criterion (98%), but many children who met current symptom criteria for the ADHD/I and ADHD/C subtypes of ADHD did not experience impairing symptoms before the age of seven (43% and 12% respectively). The authors conclude that requiring evidence of impairment before the age of seven may reduce the accuracy of identifying older children who are currently experiencing impairing symptoms of the ADHD/C and ADHD/I forms of ADHD.

Although symptoms are often evident earlier, ADHD is usually not diagnosed until elementary school when children with the disorder experience difficulty with the

attention, concentration, and structured behavior required to succeed in a formal learning situation (DSM-IV-TR, 2000; Applegate et al., 1998; Kaplan et al., 1994). In school, children with ADHD may experience difficulty sitting still, completing assignments and tests, and waiting to be called on (Kaplan et al., 1994). It is estimated that over 90% of children with ADHD do not perform at their known level of potential in school (Barkley, 1989).

Symptoms of ADHD can have significant long-term effects on children's academic performance. Children with ADHD experience poorer grades, more frequently repeat grades and are placed in special classrooms, end their education earlier, receive more tutoring, and have poorer performance on academic tests than their peers (see Biederman et al., 1991; Klein & Mannuzza, 1991). Without treatment, children with ADHD are two to three times more likely to drop out of school before graduating than other children (Barkley, 1989).

Symptoms of inattention appear to play a larger role in ADHD children's academic difficulties than symptoms of hyperactivity-impulsivity. Academic deficits and school problems are more common in the children in the ADHD/I and ADHD/C subtypes (DSM-IV-TR, 2000; Baumgaertel et al., 1995; Faraone, Biederman, Weber, et al., 1998; Graetz, Sawyer, Hazell, Arney, & Baghurst, 2001; Lahey et al., 1994; Lahey et al., 1998; Lamminmäki, Ahonen, Närhi, Lyytinen, & de Barra, 1995). In their sample of adolescent girls with ADHD, Hudziak et al. (1998) reported a positive association

between the severity of girls' ADHD/I symptoms and their academic problems and school failures independent of ADHD/HI symptoms.

In addition to academic difficulties, children with ADHD often experience low frustration tolerance, emotional lability, accident-proneness, poor self-esteem and strained relationships with peers and family members (DSM-IV-TR, 2000; Kaplan et al., 1994). Research suggests that the social difficulties associated with ADHD differ by subtype (Lahey et al., 1994). Individuals with ADHD/HI experience high rates of rejection by their peers than the other subtypes (DSM-IV-TR, 2000). In contrast, those with ADHD/I are typically more passive socially, display deficits in social knowledge, have higher rates of social phobia, and have increased rates of social neglect from peers (DSM-IV-TR, 2000; Maedgen & Carlson, 2000; Nolan et al., 2001). Compared to controls and children with ADHD/I, children with ADHD/C also display more aggressive behavior and emotional dysregulation (Maedgen & Carlson, 2000). In Hudziak et al.'s (1998) sample of female adolescents with ADHD the severity of ADHD/C symptoms was positively related to their parents' reports of peer relationship problems, and the severity of ADHD/I symptoms was associated with higher rates of family problems. Biederman et al. (2002) suggest that boys with ADHD experience higher rates of social dysfunction than ADHD girls.

The social impairments associated with ADHD appear to emerge as early as preschool. Lahey et al. (1998) examined the social and functional impairment of four to six year old children with ADHD while controlling for their number of symptoms of

disruptive behavior disorders and internalizing disorders. Teachers rated young children with all three ADHD subtypes as less popular with classmates, less prosocial, less cooperative, and less assertive than comparison children. Children in the ADHD/C subtype were rated by teachers as more actively disliked by classmates than controls. The behavior of children with ADHD/HI symptoms reportedly caused significantly more unintentional injuries. Children who met criteria for each ADHD subtype also self-reported greater social difficulties than controls, and received more special education services for learning and behavior problems.

Children with ADHD also experience higher rates of associated cognitive impairments such as difficulties with language, motor coordination problems, poor handwriting, and neurological “soft signs” such as poor right-left discrimination and sequencing difficulties (Barkley, 1989; Carte, Nigg, & Hinshaw, 1996; Kaplan et al., 1994). Pick, Pitcher, and Hay (1999) examined fine and gross motor performance and kinesthetic sensitivity in a community sample of boys with ADHD/I and ADHD/C. Their results indicated boys with ADHD/I had significantly poorer manual-dexterity than controls, and children with ADHD/C had more difficulty with balance.

The long-term course of ADHD varies widely and efforts to identify childhood characteristics that predict the outcome of cases of ADHD have had little success (Klein & Mannuzza, 1991). ADHD symptoms may remit at the time of puberty, or some or all of an individual’s symptoms may persist (DSM-IV-TR, 2000; Kaplan et al., 1994). Most individuals with ADHD go into partial remission between the ages of 12 and 20 but

continue to experience some significant symptoms into adolescence and adulthood (DSM-IV-TR, 2000; Kaplan et al., 1994). Overt symptoms of hyperactivity are often the first to emerge and remit, but symptoms such as poor concentration and subjective feelings of restlessness continue (Nolan et al., 2001).

There is some evidence that the stability of ADHD differs by subtype. Children with the ADHD/HI subtype are more likely to have a stable diagnosis over time than those with ADHD/I (see Faraone, Biederman, Mennin, Russell, & Tsuang, 1998; Goodyear & Hynd, 1992; Halperin et al., 1990; Kaplan et al., 1994). Teegarden and Burns (1999) examined the 12-month stability of ADHD subtypes and disruptive behavior disorders in a school-based sample of children based on teacher reports. Their results revealed a greater level of stability in the teacher-rated hyperactive-impulsive dimension and in behavioral symptoms than in the inattentive dimension.

As adolescents, 25-35% of youth with ADHD engage in delinquent activity, and they are at an increased risk of drug abuse, depression, low self-esteem, and automobile accidents (Barkley, 1989; Hechtman, Weiss, & Perlman, 1984). Biederman et al. (2002) report that girls with ADHD may be at particularly high risk of substance abuse as adolescents. Many adolescents with ADHD also continue to experience academic and learning problems (see Biederman et al., 1991; Fischer, Barkley, Edelbrock, & Smallish, 1990). In their review of the adolescent outcome of children with ADHD, Klein and Mannuzza (1991) report that at the age of fifteen roughly 70% of adolescents continue to experience symptoms of ADHD (e.g., restlessness, poor concentration, low grades, and

poor performance on cognitive tasks) and 40% are diagnosed with conduct disorder. Hechtman (1985) reports that adolescents who have received stimulant treatment for ADHD in childhood also appear to experience difficulties. Many continue to experience antisocial behavior problems (20-30%), residual symptoms, poor peer relationships, low self-esteem, and be an average of two grades behind in core academic subject areas.

For some individuals with ADHD, the symptoms span into adulthood. An estimated 30-70% of children diagnosed with ADHD continue to experience significant symptoms as adults including impulsivity, slow processing speed, inattention, lower educational attainment, and accident-proneness (Bellak & Black, 1992; Biederman, Faraone, Spencer et al., 1993; Jackson & Farrugia, 1997; Jenkins et al., 1998; Kaplan et al., 1994; Wender, Wolfe, & Wasserstein, 2001). The estimated prevalence of full ADHD among adults is 1% or 2% (Bellak & Black, 1992).

Follow-up studies suggest that adults with a history of childhood ADHD move more frequently, have more car accidents, and have failed more grades. They report more gambling disorders and marital discord, higher rates of incarceration and substance abuse, and more inconsistent work records. They also have more impulsive and immature personality traits, rate their childhoods more negatively, and have poorer self-esteem and social skills (see Hechtman, 1985; Jackson & Farrugia, 1997; Jenkins et al., 1998). For those who do not experience significant symptoms as adults, the sequelae of a history of ADHD may still continue to negatively affect their psychological, educational, social, and vocational functioning (see Bellak & Black, 1992).

Murphy, Barkley, and Bush (2002) examined the differences between ADHD/I, ADHD/C, and controls in young adults. Their results suggest that both ADHD subtypes differed significantly from controls; they completed fewer years of education, received more special education in high school, had received higher rates of mental health services, reported greater psychological distress, and experienced higher rates of dysthymia, alcohol and substance abuse and dependence, and learning disorders. The two subtype groups also differed significantly from each other. The young adults with ADHD/C were more likely than those with ADHD/I to have been diagnosed with oppositional defiant disorder, to have interpersonal problems, to be paranoid, to have a criminal record, and to have attempted suicide.

Comorbid Disorders.

Research suggests that ADHD is characterized by frequent comorbidity cross-culturally, including concurrent mood, anxiety, learning, communication disorders, Tourette's Disorder, and behavioral disorders (DSM-IV-TR, 2000; Biederman et al., 1991). The presence of such comorbid diagnoses complicates the assessment, diagnosis, prognosis, and treatment of ADHD (see Biederman et al., 1991). Children with ADHD and comorbid disorders may experience greater social, emotional, and psychological difficulties than those with ADHD alone (see Biederman et al., 1991). Furthermore, children with different comorbid conditions may have different risk factors, clinical courses, neurobiology, and pharmacological responses (see Biederman et al., 1991). Each of the more frequent comorbid disorders of ADHD will be discussed in turn.

In their review of the literature, Biederman et al. (1991) report that ADHD and mood disorders co-occur in 15-75% of epidemiological and clinical samples. Barkley (1998) reports an average rate of comorbidity of 25% for ADHD and major depression, and 6-10% for ADHD and bipolar disorder. Children with ADHD and a mood disorder may be at increased risk of suicide than children with ADHD alone (see Biederman et al., 1991). ADHD and mood disorders appear to share a common familial vulnerability; first-degree relatives of children with ADHD experience higher rates of mood disorders than relatives of normal control children (see Biederman et al., 1991).

Children with ADHD also experience higher rates of anxiety disorders than community samples. Studies of epidemiological and clinical samples of children have found a comorbid association between ADHD and anxiety disorders of roughly 25% (see Barkley, 1998; Biederman et al., 1991). Research suggests that relatives of children with ADHD are at an increased risk of anxiety disorders compared to the relatives of normal children, but that ADHD and anxiety disorders are transmitted independently in families (see Biederman et al., 1991).

Why ADHD and mood and anxiety disorders commonly co-occur remains unclear. Jensen, Shervette, Xenakis, and Richters (1993) and Biederman et al. (1991) outline several possible relationships. Depression and anxiety may underlie children's symptoms of ADHD or may be the result of the academic, family, and social difficulties often associated with ADHD. ADHD and comorbid disorders may be expressions of the

same disorder. Or perhaps symptoms of both ADHD and anxiety and mood disorders are due to other factors such as a genetic vulnerability or psychosocial stress.

There is evidence that rates of concurrent symptoms of depression and anxiety differ by ADHD subtype. Youth in the ADHD/C and ADHD/I subtypes experience higher rates of comorbid anxiety and depression than those with ADHD/HI (see Faraone et al., 1998). Nolan et al. (2001) report that symptoms of depression were highest among children with ADHD/I and ADHD/C and lowest for ADHD/HI in their sample of elementary school children. Their results also indicated that symptoms of generalized anxiety disorder were more severe in children with ADHD/C than the other two subtypes. Willcutt et al. (1999) also report that the inattentive dimension of ADHD symptoms was associated with depression and significant but less severe externalizing behavior.

Learning disorders (LD) are also highly comorbid with ADHD (Kaplan et al., 1994). LDs are perceptual handicaps in cognitive processing that produce disorders of reading, writing, or arithmetic. The DSM-IV (1994) defines a LD as a disorder in which an individual's performance on an individually administered standardized measure of reading, math, or writing is substantially below what would be expected for his/her age, education, and level of intelligence. In practice, a discrepancy of at least 2 standard deviations between achievement scores and IQ scores is often used. To meet criteria, the learning problems must also significantly interfere with academic achievement or daily activities.

Estimations of comorbidity indicate that 50% to 80% of children with ADHD also have a LD, and 20% to 25% of children with LDs also have ADHD (see Bellak & Black, 1992). Comorbid LDs are more common in boys with ADHD than girls with the disorder (Biederman et al., 2002). In their review of the literature, Biederman et al. (1991) observed a wide range of reported overlap between children with ADHD and LD (10-92%). They attribute this variability to differences between studies in selection criteria, sampling, measurement, and diagnostic criteria.

There is some evidence that LDs are more closely associated with the inattentive symptoms of ADHD than the hyperactive/impulsive. Baumgaertel et al. (1995) examined a sample of German school children and found that children with ADD-H experienced higher rates of daydreaming, internalizing symptoms, and LD than those with hyperactivity. Morgan et al. (1996) also noted higher rates of math LD in children with ADHD/I.

ADHD also often co-occurs with disruptive behavior disorders such as conduct disorder (CD) or oppositional defiant disorder (ODD). Roughly 75% of youth with ADHD experience additional difficulties with aggression, oppositional behavior, and defiance (Barkley, 1989; Kaplan et al., 1994). Roughly 45-70% of community and clinic youth with CD or ADHD also meet the criteria for the other disorder (see Kazdin, 1997). Boys with ADHD are more likely to have comorbid disruptive behavior disorders than girls with ADHD (Biederman et al., 2002). Children with ADHD and CD have a more

serious clinical courses and poorer outcomes than children with ADHD without CD (see Biederman et al., 1991; Eiraldi, Power, & Nezu, 1997; Lahey & Loeber, 1997).

Children with ADD and ODD generally experience similar, though less severe, difficulties as those with ADD plus CD (see Biederman, 1991). They experience higher rates of school dysfunction, as well as antisocial disorders and ADD among relatives than children with ADD alone, yet not as great a rate as children with ADD and CD. Given these similar but less severe features, some have suggested that ODD is a subsyndromal manifestation of CD and children with ADD plus ODD form an intermediate subgroup between ADD children and children with ADD and CD (see Biederman, 1991).

The comorbidity between ADHD and disruptive behavior disorders is most likely in individuals with ADHD/C or ADHD/HI (DSM-IV-TR, 2000; Decker, McIntosh, Kelly, Nickolls, & Dean, 2001; Eiraldi et al., 1997; Willcutt et al., 1999; Nolan et al., 2001; Teegarden & Burns, 1999). Lalonde, Turgay, and Hudson (1998) investigated the distribution of comorbid disruptive behavior disorders in each ADHD subtype among a clinical sample of children and adolescents. Youth with ADHD/I had significantly lower rates of ODD than those with ADHD/C (33% vs. 85%) or ADHD/HI (33% vs. 100%). The participants with ADHD/HI had significantly higher rates of CD than those with ADHD/I (57% vs. 0%) or those with the ADHD/C (57% vs. 8%).

The comorbid diagnoses associated with childhood ADHD (e.g., behavioral, mood, and anxiety disorders) are also evident in adults with childhood onset ADHD (Biederman et al., 1993). Conditions associated with ADHD in adults include LDs,

generalized anxiety disorder, antisocial behavior, drug and alcohol abuse, and dysthymic and cyclothymic disorders (Bellak & Black, 1992). There is evidence of a pattern of sequential diagnoses in which children are diagnosed with ADHD, then diagnosed with ODD in middle childhood, CD in adolescence, and antisocial personality disorder (APD) as an adult (see Bellak & Black, 1992; Laney, McBurnett, & Loeber, 2000).

APD is more common among adults previously diagnosed as ADHD in childhood (23% vs. 2.4% of the general population) (Klein & Mannuzza, 1991). The relationship between childhood ADHD, CD, and adult APD appears to be mediated by aggression (see Bellak & Black, 1992). About 25% of children with ADHD develop APD in young adulthood, and approximately 66% of these individuals eventually get arrested (Mannuzza, Klein, Konig, & Giampino, 1990). APD appears to provide a link between childhood ADHD and adult substance abuse and criminality; few individuals with ADHD and no APD go on to abuse drugs (see Bellak & Black, 1992; Klein & Mannuzza, 1991).

Children with ADHD and comorbid behavior disorders appear to share physiological characteristics with adult with APD. Herpertz et al. (2001) examined the psychophysiological responses of ADHD boys with and without CD and found that the boys with ADHD+CD exhibited low autonomic responses to orienting and startle stimuli similar to the pattern found in adults with psychopathic APD. The boys with ADHD alone did not demonstrate such a pattern.

Babinski, Hartsough, and Lambert (1999) conducted a prospective longitudinal study of the association between the two dimensions of ADHD (i.e., inattentiveness and

hyperactivity-impulsivity) and later criminal involvement from middle childhood to early adulthood. Their results indicated that childhood symptoms of hyperactivity/impulsivity and early conduct problems independently and jointly predict criminal activity in young adulthood among males. Children with hyperactivity/impulsivity or conduct problems were both at increased risk of later self-reported crime and official arrest records, and those with both were at the highest risk. Childhood symptoms of inattention, however, were not related to later criminal activity.

Not all adults with a history of childhood ADHD are at an equally high risk of antisocial behavior, substance abuse, and emotional distress; their difficulties are correlated with symptoms of ADHD persisting into adulthood (see Bellak & Black, 1992). Young adults with a history of ADHD are at greater risk than controls of APD (18% vs. 2%) and of substance use disorders (excluding alcohol; 16% vs. 4%); but it is those with residual symptoms of ADHD that are at the greatest risk (48% vs. 13%) (see Klein & Mannuzza, 1991).

Etiology of ADHD

The etiology of ADHD is complex and many factors appear to be involved. Psychosocial factors have not been strongly implicated in the etiology of ADHD, however stressful life events, family disequilibrium, and prolonged emotional deprivation may exacerbate symptoms of ADHD or trigger a pre-existing risk factor (Kaplan et al., 1994). For example, Graetz et al. (2001) reported a link between social adversity (i.e.,

single parent household, lower household income, less parental education, parental unemployment) and the ADHD/C subtype in their sample of Australian children and adolescents. A combination of genetic, biological, and environmental factors appear to play a role in the development and expression of ADHD, but little is known regarding the differences in etiology between the subtypes of the disorder (see Bellak & Black, 1992). The literature on genetic, prenatal and birth-related factors, and neurobiological deficits will be discussed.

Genetic Factors.

Studies of families, twins, and adoptions suggest a genetic basis for ADHD (see Sprich-Buckminster, Biederman, Milberger, Faraone, & Lehman 1993; Todd et al., 2001). Research suggests the heritability of ADHD is between 0.6 and 0.9 and an estimated 30% to 40% of youth with ADHD have a familial pattern of the disorder (Bellak & Black, 1992; see Todd et al., 2001). First-degree biological relatives of children with ADHD have an increased prevalence of ADHD, mood and anxiety disorders, conversion disorders, LDs, substance-related disorders, and APD (DSM-IV, 1994; Kaplan et al., 1994). Siblings of children with ADHD are at twice the risk of the general population of having ADHD (Kaplan et al., 1994). Todd et al. (2001) found ADHD concordance rates of 68% for monozygotic twins and 22% for dizygotic twins in their sample of adolescent female twins. Furthermore, in over 75% of the monozygotic twins who both had ADHD the twins had the same subtype of the disorder. Many

parents and adult siblings of children with ADHD also have ADHD (see Biederman, Faraone, Spencer et al., 1993).

The degree of genetic risk appears to be greater when ADHD is comorbid with antisocial behavior (Faraone, 2000). There is a greater familial risk of ADHD and antisocial disorders among relatives of children with ADHD with concomitant conduct disorder (see Biederman et al., 1991; Faraone, Biederman, Jetton, & Tsuang, 1997). Faraone, Biederman, Mennin, Russell, and Tsuang (1998) conducted a 4-year follow-up comparison of ADHD boys from Antisocial-ADHD families (those with either CD or APD in the probands or parent), from non-Antisocial-ADHD families, and non-ADHD controls. Results revealed that the persistence of ADHD symptoms in probands from both types of ADHD families did not differ, but the forms of psychopathology evident in probands and their siblings did. At follow-up, the Antisocial-ADHD families had higher rates of CD, APD, bipolar disorder, alcohol, drug, and tobacco use relative to the non-Antisocial-ADHD families and controls. The non-Antisocial-ADHD families also experienced increased psychopathology. Relative to controls, the non-Antisocial-ADHD families had elevated rates of ODD, major depression, anxiety disorders, school difficulties, LDs, and poorer aptitude, achievement, and psychosocial functioning. The authors conclude that Antisocial ADHD may be an etiologically and clinically distinct form of ADHD with prognostic significance for the child and his family members. Given the higher rates of antisocial disorders in the ADHD/C and ADHD/HI subtypes relative

to ADHD/I, these results may also suggest etiological differences between the ADHD subtypes.

Faraone, Biederman, Mick et al., (2000) examined the familial transmission of ADHD in relatives of girls with the disorder. First-degree relatives of girls with ADHD had a higher prevalence of ADHD, APD, mood disorders, anxiety disorders, and substance use disorders than relatives of controls. The rates of ADHD in relatives were comparable to the rates that have been reported in family studies of boys with ADHD. This contradicts the suggestion that girls require a greater “dose” of family risk factors to express ADHD, however there were lower rates of APD in the relative of ADHD girls than observed in the families of boys. There was no relationship between the ADHD girls’ subtype and that of their ADHD relatives, suggesting that subtypes do not “breed true” or represent a gradient of family severity. The authors conclude that ADHD subtypes share the same family risk factors and the variability in expression is due to environmental risk factors.

These results concur with those of Faraone, Biederman, and Friedman (2000) who also failed to show support for the hypothesis that ADHD subtypes would “breed true” within families or that subtypes represent a gradient of severity with the greatest familial risk in families of children with ADHD/C. In contrast, Neuman et al. (1999) did provide support for a genetic role in subtype determination. They found a higher proportion of monozygotic twins in the same latent class (either inattentive or combined) than dizygotic twins (80% and 52% respectively). Todd et al. (2001) suggest that forms of ADHD

identified through latent class analysis demonstrate greater family specificity than the subtypes operationalized by the DSM-IV (1994).

Despite the evidence for a genetic risk factor for ADHD, not all children with a genetic predisposition develop the disorder, and not all children with the disorder have a familial risk (see Sprich-Buckminster et al., 1993). If the disorder is not entirely genetic, environmental factors must also play a role in the etiology of ADHD.

Prenatal, Perinatal, & Postnatal Factors.

The presence of ADHD symptoms in infancy, the neurological soft signs, and the long-standing nature of the disorder suggest damage to the brain during the prenatal, perinatal, and postnatal periods of development. Such subtle damage to the central nervous system (CNS) could be the result of problems with circulation, toxins, metabolism, stress, or physical insult as the result of infection, inflammation, or trauma (see Kaplan et al., 1994). Prenatal and perinatal factors that have been associated with ADHD include prenatal toxic exposure, prematurity, prenatal mechanical insult to the CNS, low birth weight, maternal cigarette smoking, convulsions during pregnancy, low fetal heart rate during the second stage of labor, lower placental weight, breech presentation, and chorionitis (see Bellak & Black, 1992; Kaplan et al., 1994). Postnatal factors include viral encephalitis and head injury (see Bellak & Black, 1992):

The areas of the brain that are believed to play a role in the etiology of ADHD are particularly vulnerable to early hypoxic ischemic insults and may be damaged before other structures during any adverse events that occur during the antenatal and perinatal

periods (see Lou, Henriksen, Bruhn, Borner, & Nielsen, 1989). For example, the position of the striatum, between the anterior and middle cerebral arteries, increases the risk of neuronal damage to this region.

Sprich-Buckminster et al. (1993) examined the relationship between perinatal complications and ADD among children with and without comorbid disorders and familial risk of ADD. Their results revealed higher rates of pregnancy, delivery, and infancy complications (PDICs) among the children with nonfamilial comorbid ADD than in children with familial or noncomorbid ADD. The authors conclude that PDICs are a nonspecific risk factor for psychopathology including, but not restricted to, ADD.

Mick, Biederman, and Faraone (1996) examined whether season of birth may be risk factor for ADHD. Their results revealed a significant peak for births of ADHD children with LDs and for ADHD children without other psychiatric comorbidity (i.e., major depression, anxiety disorders, and/or conduct disorder) in September. This pattern suggests that exposure to winter infections during first trimester of pregnancy may account for some forms of ADHD.

Barkley (1998) reviews the evidence for different rates of perinatal and neonatal abnormalities among the ADHD subtypes. He reports that some studies have revealed a higher incidence of such birth-related factors in cases of ADD+H relative to ADD-H, however other researchers have failed to replicate this finding.

Biological/Neurological Factors.

A variety of neurobiological factors have been identified as potential causal factors in the development of ADHD. These include deficits in arousal, neurological abnormalities, and neurotransmitter deficiencies. Lecendreux, Konofal, Bouvard, Falissard, and Mouren-Siméoni (2000) examined the possibility of a sleep/arousal disorder underlying ADHD in children. Their results revealed no significant differences in nocturnal sleep between ADHD boys and normal controls. However, they did observe significant differences in the ADHD boys' daytime alertness. Relative to controls, the ADHD boys fell asleep more often and more easily during a 20-minute daytime quiet period. The authors suggest that the mechanism regulating sleepiness and alertness may be impaired in children with ADHD.

The subtle neurological deficits associated with ADHD also suggest the possibility of neurobiological factors in the disorder. The behavioral similarity of children with ADHD and individuals with frontal lobe damage has implicated this region in the development of ADHD. Animal studies indicate that lesion of the prefrontal cortex leads to an inordinate level of reactivity to external stimuli, hyperactivity, distractibility, and poor attentive capacity (Fuster, 1989). Similarly in humans, pathology of the frontal lobes is associated with attention deficits, including an increased distractibility, poor concentration, and difficulty ignoring irrelevant stimuli (Fuster, 1989).

Researchers suggest that delayed maturation of the frontal lobes may play a role in the etiology of ADHD (see Heaton, Chelune, Talley, Kay, & Curtiss, 1993; Stuss &

Benton, 1986; Welsh, 1994). The premotor and superior prefrontal cortex play an essential role in the control, preparation, and execution of motor activity, as well as in attention and the inhibition of inappropriate response (see Bellak & Black, 1992). In cases of ADHD, the underdeveloped frontal lobes may not be performing their normal inhibitory role leaving lower structures of the brain disinhibited (Kaplan et al., 1994).

Anatomical studies of the brain have suggested that dysfunction in the right frontal-striatal circuitry plays a role in ADHD. Castellanos et al. (1996) have utilized quantitative brain magnetic resonance imaging (MRI) techniques to compare the volume of brain regions among boys with and without ADHD. Their results revealed that the boys with ADHD had significantly less total cerebral volume than controls. Boys with ADHD had less volume in the prefrontal cortex, caudate nucleus, and globus pallidus, particularly on the right side of the brain.

Functional studies of the brain support the theory that impairment in the frontostriatal circuitry may play a role in ADHD (see Armstrong, Hayes, & Martin, 2001 for review). Positron emission tomography (PET) scans of children with ADHD show decreased cerebral blood flow and metabolic rates in frontal lobe areas relative to controls (see Kaplan et al., 1994). Zametkin et al. (1990) used PET scans to reveal decreased global cerebral glucose metabolism in adults with ADD of childhood onset relative to normal controls. Two of the regions with the greatest levels of decreased metabolism (the premotor and superior prefrontal cortex) are involved in the control of attention and motor activity. Zametkin et al. (1993) conducted a similar PET scan study

with adolescents with ADHD. The results did not reveal any difference from controls on global measures of metabolism, but the adolescents with ADHD did have significantly reduced regional glucose metabolism in the left anterior frontal lobe.

Lou et al. (1989) assessed the regional cerebral blood flow (CBF) in children with ADHD, children with ADHD plus other neurological symptoms, and controls using emission computed tomography. Their results indicated that the right striatal regions of the children with ADHD appeared hypoperfused relative to controls' and their sensorimotor regions (i.e., occipital lobe, and left sensorimotor and primary auditory regions) appeared hyperperfused. Hypoperfusion suggests low metabolic and functional activity in these regions. Among the children with ADHD plus other neurological symptoms, both striatal regions showed decreased CBF and a significant increase in CBF to the occipital lobe. Administration of methylphenidate was associated with clinical improvement and significant increase in CBF to the left striatal and posterior periventricular regions of children in both ADHD groups.

Lou et al.'s (1989) results suggest low neural activity in the striatal region of children with ADHD. This is consistent with animal models in which lesions to striatal structures (i.e., the head of the caudate) or prefrontal regions produces hyperactivity, as well as poor attention, memory consolidation, and performance on cognitive tasks (see Lou et al., 1989). The prefrontal cortex has efferent connects to the head of the caudate and is thought to mediate higher forms of attention (see Lou et al., 1989). Dysfunction of the caudate nucleus may be related to the increased activity observed in the primary

sensory and sensorimotor regions. The caudate is thought to inhibit polysensory perception, and decreased activity in the neostriatum may lead to a lack of inhibition of sensory perception. Lou et al. (1989) conclude that striatal dysfunction plays a central role in the pathogenesis of ADHD.

Metabolic studies have also implicated the prefrontal cortex in certain subtypes of ADHD. Hesslinger, Thiel, van Elst, Hennig, and Ebert (2001) investigated the metabolic neuropathology of the prefrontal cortex and striatum in unmedicated adult males with ADHD/I and ADHD/C relative to controls using ¹H-magnetic resonance spectroscopy (MRS). The results indicated that the ADHD/C men had lower levels of *N*-acetylaspartate (NAA), a neurometabolite whose depletion has been associated with neuronal dysfunction, in the left dorsolateral prefrontal cortex than the controls or those with ADHD/I.

Neurotransmitter systems, particularly the catecholamines, have also been implicated in the etiology of ADHD. Bellak and Black (1992) suggest that it is a deficiency of dopamine and norepinephrine (as well as serotonin in aggressive cases) behind ADHD symptoms. The effectiveness of stimulant drugs in treating ADHD supports the role of the catecholamines in ADHD. Stimulants are catecholamine agonists that enhance noradrenergic and dopaminergic transmission by promoting their release and blocking their reuptake (Grilly, 1994). Barkley (1998) suggests that dopamine may play a larger role in ADD+H while norepinephrine may be selectively involved in ADD-H.

Barkley (1998) reviews the literature suggesting different neurological mechanisms underlying the inattentive and hyperactive-impulsive forms of ADHD. He concludes that preliminary evidence suggests that ADD+H is associated with function abnormalities of the prefrontal-limbic pathway, particularly the striatum; and that ADD-H potentially involves posterior associative cortical areas, cortical-subcortical feedback loops, and the hippocampal system. Barkley (1998) cautions however that these are tentative conclusions and further study must address the neuroanatomical differences between the ADHD subtypes. Lockwood, Marcotte, and Stern (2001) also review the literature on the pathophysiological underpinnings of ADHD subtypes and conclude that the results of neuroimaging studies are inconsistent. They suggest that neuroanatomical and biochemical models of ADHD must be integrated to explain the etiology of different subtypes.

Assessment of ADHD

As is evident from the preceding discussion of the diagnostic criteria, clinical features, and etiology, ADHD is a complex disorder with many factors that may cloud its assessment and diagnosis. An accurate diagnosis of ADHD is particularly important because early identification and intervention of ADHD may help lessen the negative sequelae of ADHD such as poor self-image, academic problems, and interpersonal difficulties. Furthermore, children with the disorder may qualify for special services

from schools under the Individuals with Disabilities Education ACT (IDEA) and Section 504 of the Rehabilitation Act of 1973.

Treating the behaviors described in the DSM-IV (1994) diagnostic criteria as a checklist for diagnosing ADHD without including a comprehensive evaluation overlooks the many other possible sources of ADHD-like symptoms. Medical, psychological, and learning problems may manifest in symptoms very similar to ADHD and must be ruled out (Garber et al., 1996). Unfortunately, many children are diagnosed as having ADHD without the use of any standardized diagnostic measures and even more are diagnosed with only parent or teacher rating scales (see Garber et al., 1996). A wide range of assessment instruments has been developed to measure symptoms of ADHD and associated impairments. Some of the more commonly used methods are outlined below.

Informants' Reports & Observational Methods.

The report of parents and teachers is commonly used to assess symptoms of ADHD and structured interviews and behavior rating scales have been developed for this purpose. Examples of structured interviews for parents based on DSM criteria include the Diagnostic Interview for Children and Adolescents (DICA; Herjanic & Campbell, 1977), the Diagnostic Interview Schedule for Children (DISC; Costello, Edelbrock, & Castello, 1985), and the Schedule for Affective Disorders and Schizophrenia for School-Age Children (SADS; Chambers, Puig-Antick, Hirsh, et al., 1985). These structured interviews provide for DSM-IV (1994) diagnosis, but can be quite time-consuming to complete.

Mitis, McKay, Schulz, Newcorn, and Halperin (2000) recently presented findings that suggest reliance on a single informant's response to a structured interview can influence ADHD subtype classification. They examined the concordance between parent and teacher reports of ADHD symptoms among a referred sample of children using the ADHD module of the DISC. The agreement rate between parents and teachers was relatively poor and independent parent and teacher reports rarely led to the same subtype diagnosis. Cross-informant information usually led to a diagnosis of ADHD/C with the ADHD/I and ADHD/HI subtypes being relatively rare. The authors conclude that diagnoses of ADHD/I or ADHD/HI based on a single informant's report may be inaccurate.

A variety of objective rating measures have also been developed for parents and teachers to rate children's ADHD symptomatology. These include the parent and teacher versions of the Child Behavior Checklist (CBCL), the Conners Rating Scales (CRS), the Swanson, Nolan, and Pelham Questionnaire (SNAP-IV), and the Behavior Assessment System for Children (BASC); the Attention-Deficit/Hyperactivity Disorder Test (ADHDT); the ADD-H: Comprehensive Teacher Rating Scales (ACTeRS); and the Barkley Home Situations Questionnaire and School Situation Questionnaire (see AACAP Official Action, 1997).

Teachers' reports provide valuable information in the assessment of ADHD. To meet the DSM-IV (1994) criteria, symptoms of ADHD must be present in multiple settings and the classroom is often the setting in which attention deficits and

hyperactivity are most evident. Teachers can help identify if a child's learning difficulties are caused by ADHD or by poor attitude, maturational delays, or poor-self image, as well as describe how the child handles problems and peer relationships (Kaplan et al., 1994). In their review of the longitudinal data on informants' ratings of ADHD, Klein and Mannuzza (1991) conclude that children rated as having symptoms of ADHD by their teachers are more likely to have persistent difficulties with attention and hyperactivity than children rated as having symptoms of ADHD by their parents alone.

ADHD diagnosis can be particularly problematic in later childhood, adolescence, and adulthood when the assessment of the requisite early childhood symptoms is based on retrospective self- or parent-report. Self-report scales such as the Wender Utah Rating Scale have been developed to assess adults' childhood ADHD symptoms (Wender, 1985; Ward, Wender, & Reimherr, 1993). However, McCann, Scheele, Ward, and Roy-Byrne (2000) caution that adults being evaluated for ADHD are more likely than children to present with a preconceived belief that they have the disorder and a tendency to endorse symptoms that they believe will support their self-diagnosis.

Observational methods of assessment and solid state actigraphs have also been used to rate activity levels and the amount of time a child is on-task in the classroom and while completing laboratory tasks (Marks et al., 1999; Teicher, Ito, Glod, & Barber, 1996). Evidence of symptoms of ADHD may also be observed during a mental status exam or a neurological examination (Kaplan et al., 1994).

The structured interview, rating scales, and observational methods discussed in the preceding section can all provide valuable information about ADHD symptoms. However, none of these methods should be used in isolation and the assessment and diagnosis of ADHD should always strive to incorporate information from multiple sources about the child's behavior in a variety of contexts and assess for coexisting conditions (Herrerias, Perrin, & Stein, 2001).

Neuropsychological Assessment.

Neuropsychological evaluations typically include a comprehensive assessment of multiple cognitive domains and can be used in conjunction with informants' reports and observation to provide a broader picture of a child's functioning. Diagnoses based solely on behavioral descriptions such as the DSM have been criticized for oversimplifying complex conditions by focusing on a single behavioral characteristic (e.g., impaired attention) and neglecting to address extensive neuropsychological deficits (Reitan & Wolfson, 1992).

Neuropsychological assessment typically involves a battery of tests, including measures designed to assess attention, memory, executive functions, learning, intelligence, academics, motor skills, sensory-perceptual abilities, and behavioral and emotional functioning. There are several advantages to using a neuropsychological battery to assess a child with possible ADHD: 1) a more comprehensive understanding of a child's functioning in a variety of cognitive domains aids in differential diagnosis and in ruling out other explanations for a child's symptoms, 2) by using standardized

procedures, an individual's performance may be compared to age-appropriate normative standards, 3) identifying a child's strengths as well as weaknesses can help in treatment planning and the development of compensatory strategies, and 4) using neuropsychological tests pre- and post-treatment provides an objective means of gauging change over time and assessing the effectiveness of interventions (Jenkins et al., 1998).

Reviews of the neuropsychological performance of children with attention deficits with and without hyperactivity suggest differences between the subtypes (see Barkley, 1998; Houghton et al., 1999). Children with attention deficits without hyperactivity appear to have greater difficulty with focused attention, speed of information processing, memory, perceptual-motor speed, input analysis, and retrieval of stored information. In contrast, those with attention deficits and significant hyperactivity appear to have greater deficits in sustained attention, measures of frontal lobe functions, impulse control, resource allocation, executive function, and maintenance of effort.

Lockwood et al. (2001) utilized discriminant analysis to examine the ability to differentiate between ADHD/I and ADHD/C based on neuropsychological test performance. Their analyses yielded a discriminant function with 80% accuracy based on a combination of scores from the Controlled Oral Word Association Test, Wide Range Assessment of Learning and Memory – Story Memory, Syntactic Comprehension, Trial Making Test – B, and a Shape Cancellation Test.

In contrast, Chhabildas, Pennington, and Willcutt (2001) did not find distinct neuropsychological deficits in ADHD/I and ADHD/C children. Children with ADHD/C

in their sample performed within normal limits on neuropsychological tests if symptoms of inattention were controlled. They conclude that it is the inattentive symptoms of ADHD alone that contribute to neuropsychological impairment rather than hyperactivity or impulsivity. Nigg, Blaskey, Huang-Pollock, and Rappley (2002) suggest that the neuropsychological distinction between ADHD/I and ADHD/C may differ by gender.

The neuropsychological measures relevant to the present study are introduced below and their administration, scoring, reliability, validity, and normative data are discussed in more detail in the Measures section of the next chapter. Continuous performance tests (CPTs) are frequently included in neuropsychological evaluations to assess attention and impulsivity in children. The first CPT was developed in the 1950's to detect attention deficits in individuals with petit mal epilepsy (see Conners, 2000). Since that time, several forms of computerized CPTs have been developed to assess attention. In most CPT tasks, the examinee is instructed to press a button whenever a target stimulus is presented on a computer screen (e.g., X, or X following an A). The examinee must discriminate between the infrequently occurring target stimuli and the non-target stimuli and inhibit their responding until the appropriate time. CPTs are thought to involve several components of attention, including alertness, selective attention, and vigilance (see Seidel & Joschko, 1991).

Conners (1994) developed a CPT (version 3.0 and 3.1) in which the examinee responds to every stimulus except the target stimulus, X. Conners (1994 & 2000) proposes several advantages to having the examinee respond continuously except to the

rare target stimulus: 1) a larger sample of the examinee's response times, 2) more impulsive target errors, and 3) more variable foreperiod effects (i.e., the examinee is less able to predict when the next stimulus will occur). Conners (2000) has recently released a second version of his CPT, the CPT-II, which is available in the Windows platform. The CPT-II distinguishes between several profiles of scores: nonclinical, clinical, predominantly inattentive, and predominantly impulsive. It is these CPT-II profile patterns that will be used to define groups for the present study.

Ballard (2001) compared the Conners' response-inhibition version of the CPT with fast and slow versions of the traditional A-X paradigm in a sample of normal adults. The results revealed significant differences between the measures in task parameters, overall performance measures, performance changes over time, and susceptibility to the effects of anxiety and environmental noise. She concludes that the scores on the two tasks are not comparable, that different brain systems may underlie performance on the tasks, and that the Conners' CPT may measure executive control of attention to a greater extent than sustained attention.

CPT performance has been found to be affected by several factors including LDs, stimulant medication, CNS depressants, and aging (see Conners, 2000; Seidel & Joschko, 1991). CPT measures of inattention distinguish children with ADHD from controls (see Halperin et al., 1990) and children with DSM-III (1980) ADD+H from children with conduct disorder (O'Brien et al., 1992). Among adolescents, Fischer et al. (1990) found

that youth with a history of ADHD made more errors of omission and commission on Gordon's (GDS; 1987) CPT of vigilance than normal controls.

Krull and Lozano (2000) reported differences ADHD subtypes' performance on a CPT-type test, the Gordon Vigilance and Distractibility Tasks. The children with ADHD/C made significantly more commissive errors across all blocks than the ADHD/I group or normal controls. The ADHD/I children demonstrated poor sustained effort and began producing more commissive errors than controls as the test progressed.

Barkley (1998) states that CPTs are the only assessment instrument that directly measure inattention and impulsivity without contamination from other cognitive factors, and are the most reliable psychological test for discriminating children with ADHD from controls. However, despite good false positive rates, there is evidence that CPTs have an unacceptable rate of false negatives (children rated as having ADHD by their parents and teachers obtain normal CPT scores) and normal scores may be uninterpretable (see Barkley, 1998). Others have suggested that the CPT is able to distinguish between adults with ADHD and controls, but not between individuals with ADHD and other psychiatric disorders (Walker, Shores, Troller, Lee, & Sachdev, 2000). Riccio, Reynolds, Lowe, and Moore (2002) suggest that poor performance on the CPT be interpreted as a sign of dysfunction rather than suggestive of a specific etiology or diagnosis. The American Academy of Pediatrics (2000) and Conners (2000) also caution that despite the usefulness of the CPT for identifying attention problems, it should not be used in isolation as a diagnostic instrument for ADHD and is best included as part of a full evaluation.

Neuropsychological evaluations also typically include tests of learning and memory. Attention plays a key role in our ability to learn and form memories. If incoming information is inadequately registered or distorted by poor attention, our ability to subsequently organize it, relate it to past experience, and remember it is severely limited (Reitan & Wolfson, 1992). The California Verbal Learning Test – Children’s Version (CVLT-C; Delis, Kramer, Kaplan, & Ober, 1994) is an assessment of verbal learning and memory that is used to identify memory impairments secondary to learning disabilities, mental retardation, neurological disorder, psychiatric problems, and attention-deficit disorders (Delis et al., 1994). The CVLT-C entails the child learning a shopping list over several trials and then recalling it after an interference task and after a delay.

Neuropsychological tests of executive functions, such as the Wisconsin Card Sorting Test (WCST) may also be affected by deficits in attention. The WCST was originally developed by Grant and Berg (1948 as cited in Stuss & Benton, 1986) to assess abstraction abilities and flexibility of thinking in normal individuals, but it has since demonstrated sensitivity to cerebral damage and has become widely used as a neuropsychological instrument (see Heaton, 1981). The WCST is utilized to assess executive functions such as abstract reasoning, conceptualization, problem solving, the ability to maintain set, and the ability to shift cognitive strategies in response to changes in environmental contingencies (see Heaton, et al., 1993).

The WCST has demonstrated sensitivity to dysfunction in the frontal lobes, but Heaton et al. (1993) caution that labeling the WCST a measure of “frontal” functioning oversimplifies the complexity of the frontal lobes and overlooks the other potential causes of impaired executive functioning. The similarity between the behaviors of individuals with frontal lobe damage and the symptoms of ADHD has led researchers to examine the performance of children with ADHD on the WCST.

Research suggests that children with ADHD demonstrate impaired performance on the WCST. Comparisons of the WCST performance of children with ADHD and age-matched normal controls have revealed that children with ADHD complete significantly fewer categories and make more perseverative errors and perseverative responses than control groups (see Heaton et al., 1993). The WCST manual (Heaton et al., 1993) suggests that the relative pattern of performance on the WCST and collateral instruments may be useful for assessing the impaired executive functions of youth with ADHD. However, studies utilizing adolescent ADHD samples have not revealed impairments in WCST performance (Barkley, Grodzinsky, & DuPaul, 1992; Fischer et al., 1990).

Treatment of ADHD

Once ADHD has been identified, early intervention should attempt to lessen its impact on a child’s life. As previously discussed, ADHD is associated with academic problems, strained relationships with peers and family, and comorbid disorders in childhood and adulthood. Treatment for ADHD should strive to not only alleviate the

acute symptoms of ADHD, but to address these associated difficulties as well. The results of the NIMH Collaborative Multisite Multimodal Treatment Study of Children with Attention-Deficit/Hyperactivity Disorder (MTA) study suggest that the optimal treatment for ADHD depends in part on what comorbid disorder are present (Jensen, Hinshaw, Kraemer, et al., 2001). Pharmacological and psychosocial interventions for ADHD and what is known about the subtypes' responsiveness to treatment are discussed below.

Pharmacological Treatment.

Pharmacological treatment has long been considered the first-line treatment for ADHD with an estimated 2-2.5% of school-age children in North America receiving some medication for ADHD symptoms (see Greenhill, 1998), but the use of psychotropics in children has not been without controversy. Critics have proposed that the use of drugs to treat ADHD stunts children's growth, causes aggressive behavior, and increases the likelihood that a child will later abuse drugs; however research has not supported these claims (see Garber et al., 1996; Hechtmen et al., 1984; Klein & Mannuzza, 1991).

The use of pharmacotherapy for the treatment of ADHD also contributes to the complexity of diagnosing the disorder. Considerable caution must be used in diagnosing a disorder in which the treatment of choice is medication. A positive response to pharmacological intervention among individuals with ADHD includes decreased motor activity, slowed thinking, improve parent-child interaction, decreased aggression,

diminished talkativeness, increased problem-solving with peers, and less subjective stress (see Bellak & Black, 1992; Greenhill, 1998). However, a positive response to medication is not a diagnostic litmus test for ADHD (see Garber et al., 1996). Normal children respond to ADHD medications with the same decreased motor activity, increased vigilance, and improved learning as children with ADHD, and 20% to 30% of children with ADHD do not respond positively to medications (see Garber et al., 1996; Rapoport et al., 1980).

Two main classes of medications are most commonly used to treat ADHD: psychostimulants and antidepressants. Stimulants include methylphenidate (Ritalin; and an extended-release form, Concerta), dextroamphetamine (Dexedrine), and pemoline (Cylert) (Bellak & Black, 1992; Wolraich et al., 2001). Review articles (AACAP Official Action, 2002; Greenhill, 1998; Wender, 1998) suggest that approximately 70% of ADHD children and 60% of adults with ADHD respond positively to stimulants compared to a 10% response rate to placebo. Methylphenidate has been shown to have a normalizing affect on areas of the brain that have been implicated in the etiology of ADHD. Methylphenidate increases the metabolism of glucose in rats' mesencephalic, diencephalic, and basal ganglia regions, and decreases the metabolic rate in the motor cortex (see Lou et al., 1989). In humans, methylphenidate has been shown to activate central brain regions, particularly the left striatum, and to tend to decrease activity in primary sensory regions in the occipital, temporal, and parietal lobes (Lou et al., 1989).

Treatment with stimulants has been found to affect children's performance on neuropsychological tests. Receiving psychostimulant medication improves children's performance on measures of attention such as the CPT (see Halperin et al., 1990). Malone and Swanson (1993) found that compared to placebo, methylphenidate treatment significantly reduced impulsive responding and overall errors among children with ADHD on a task similar to the Matching Familiar Figures Test (MFFT). The authors note that the reaction time for correct responses did not differ between the placebo and drug conditions and conclude that stimulant treatment positively affects the efficiency of children's thinking, rather than merely slowing it down. Improvements have also been noted on learning measures, reading comprehension, spelling recall, and arithmetic (Greenhill, 1998).

Some research suggests that treatment with psychostimulants in childhood may have positive effects on youth's adult outcome. Hechtman et al. (1984) compared young adults with childhood onset ADHD who had been treated with psychostimulants for at least 3 years with those who had not received pharmacotherapy and with a matched normal control group. Overall, they found that the young adults who had childhood ADHD experienced significantly more difficulties than normal controls in many areas (e.g., school, work, debt, personality disorders). There were also significant differences within the ADHD group; those who had been treated with psychostimulants in childhood had fewer car accidents, stole less while they were in elementary school, viewed their childhood more positively, were less aggressive, needed less current psychiatric

treatment, and had better social skills and self-esteem than those who had not been treated with medication. The authors conclude that stimulant treatment may not eliminate educational and work difficulties, but many reduce social ostracism and result in a more positive view of self and others.

Gammon and Brown (1993) discuss the limitations of psychostimulants. These include their ineffectiveness in approximately 30% of individuals with ADD, their disruption of sleep and appetite, their short half life that can lead to mood swings throughout the day, their ineffectiveness in treating the comorbid conditions associated with ADHD, and their possible side effects of irritability and dysphoria. Other potential side effects of stimulant use include weight loss, tics, jitteriness, stomachache, headache, and dizziness (AACAP Official Action, 2002; Greenhill, 1998).

Little research has examined differences between the ADHD subtypes in responsiveness to psychostimulants. Barkley, DuPaul, and McMurray (1991) examined the clinical response of children with ADD+H and ADD-H to three doses levels of methylphenidate (5, 10, or 15 mg bid). Their results revealed more of the ADD-H children had either no clinical response (24% vs. 5%) or responded best to the low dose (35%). In contrast, most of the ADD+H children (95%) responded positively to medication and the majority responded best to a moderate to high dose (71%). To the extent that ADD-H corresponds to ADHD/I and ADD+H is equivalent to ADHD/C, these results provide preliminary support for the need to consider ADHD subtype in the use of stimulant medications.

As an alternative to psychostimulants, antidepressants are used to treat ADHD. Barkley (1998) suggests that ADHD children with comorbid internalizing disorders such as depression or anxiety are more likely to have poor or adverse responses to stimulants and may be more appropriate for antidepressant medications. Tricyclic antidepressants (TCAs) used to treat ADHD include imipramine (Tofanil) and desimipramine (Norpramine) (Bellak & Black, 1992). TCAs have been found less effective than stimulant treatment overall and have several limitations, including: a lack of improvement in concentration, sedation in some individuals, serious possible cardiovascular side effects, and toxicity in overdose (Gammon & Brown, 1993).

The antidepressant selective serotonin reuptake inhibitors (SSRIs) such as fluoxetine (Prozac) and sertraline (Zoloft) have also been used to treat ADHD. There is limited support for the use of SSRIs alone to treat ADHD, but they may be used in combination with stimulants to treat children who do not respond to treatment with stimulants alone or children with comorbid mood disorders (see Barkley, 1998).

Gammon and Brown (1993) examined the effectiveness of combining methylphenidate and fluoxetine with psychosocial treatment for the treatment of children with ADHD who had failed to improve with stimulant treated alone. Their results indicated that while receiving the combined drug therapy, the children's grades improved, they experienced improved concentration, had fewer mood swings, and experienced less irritability, oppositionality, anxiety, and depressive symptoms.

Atypical antidepressants, such as bupropion hydrochloride (Wellbutrin), have also shown promise in the treatment of ADHD. A multisite, double-blind, placebo-controlled trial of bupropion hydrochloride in ADD+H demonstrated significant treatment effects on a CPT, teacher and parent ratings of conduct problems and hyperactivity/impulsivity, and a short-term memory retrieval test (Conners et al., 1996). Bupropion has also demonstrated effectiveness in the treatment of adult ADHD (see Wender, 1998; Wender & Reimherr, 1990).

Psychosocial Treatments.

Psychosocial interventions for ADHD are used either alone or in conjunction with pharmacotherapy. The recent controversy surrounding the prescription of psychotropic medications to preschoolers has highlighted the importance of implementing behavioral, family, and school interventions before initiating drug treatment, as well as throughout treatment if medications are prescribed (Levant, 2000; Zito et al., 2000). In her review of adolescent outcomes of children with ADHD treated with stimulants in childhood, Hechtman (1985) observed that youth who participated in studies that combined stimulants with psychosocial interventions (e.g., individual, group, and/or family therapy; parent training) had more positive outcomes than those that received stimulants alone.

Psychosocial interventions can be tailored to target the needs of the individual child. An evaluation by a specialist in LDs may identify ways to improve a child's study techniques and academic performance (see Bellak & Black, 1992). Modifications in the child's home and school environment may also help manage symptoms of ADHD

(Garber et al., 1996). Psychotherapy and family therapy can address issues of self-esteem and relationships with peers and family. Many families of children with ADHD benefit from psychoeducational training on the disorder, referrals to organizations for ADHD, and bibliotherapy (Bellak & Black, 1992).

Behavioral contingency-based interventions have demonstrated greater effectiveness than strictly cognitive approaches (see Ervin, Bankert, & DuPaul, 1996; Hinshaw, Klein, & Abikoff, 1998). Hinshaw et al. (1998) review two forms of behavioral interventions: 1) direct contingency management, and 2) clinical behavior therapy. Direct contingency management utilizes reward and response cost techniques in a specialized setting. Direct contingency management has demonstrated short-term reductions in ADHD symptoms, but the benefits often fail to generalize outside of the specialized setting in which the reinforcement schedule is applied. Even in the specialized setting, the effectiveness of direct contingency management appears to be less than stimulants. However, research suggests that the combination of pharmacotherapy and direct contingency management can lead to a lowering of the dosages of medication needed to achieve the same effect.

The second behavior intervention reviewed by Hinshaw et al. (1998), clinical behavior therapy, includes parent training and consultation with the child's teacher to modify expectations and the classroom environment, increase positive attention, and implement a schedule of reinforcement and time-outs or response costs in both the home and school. This intervention has demonstrated statistically and clinically significant

decreases in some ADHD symptoms, but rarely decrease problem behavior to a normal level and the effects remain smaller than those found in psychostimulant research.

The Present Research

The literature reviewed thus far illustrates the complexity of accurately assessing and diagnosing ADHD and the importance of understanding the differences between the subtypes of this disorder. ADHD subtypes are only clinically useful if they provide differential predictions regarding etiology, course, outcome, comorbidity, or treatment response (Barkley, 1998). There is considerable support for differences in the ADHD subtypes' course and comorbidity, and preliminary evidence for differences in etiology and treatment response. Some researchers even suggest that ADHD/I differs significantly enough from ADHD/C to be considered separate and unique childhood psychiatric disorders (Barkley, 1998; Milich, Balentine, & Lynam, 2001). Others contend that although this suggestion is not without merit, further research is needed before any such division of ADHD subtypes into separate disorders can be considered (Barkley, 2001; Hinshaw, 2001; Laney, 2001; Pelham, 2001).

Given that the literature reviewed supports the clinical meaningfulness of subtyping ADHD, it is important to consider subtype in the assessment and diagnosis of the disorder. The importance of comprehensive assessment in the accurate diagnosis of ADHD has been emphasized, yet the value of many psychological tests in identifying subtypes of the disorder has been explored on only a limited basis. The CPT-II lends

itself to this analysis by classifying many profiles as either inattentive or impulsive, but no research to date has examined whether these CPT-II classifications are clinically meaningful. Do children with inattentive and impulsive profiles differ in expected ways based on the literature on ADHD subtypes? The present research addressed this question by comparing the performance of children with inattentive and impulsive CPT-II profiles on demographic factors and on measures of learning, memory, executive function, hyperactivity, inattention, learning problems, and internalizing disorders. Specifically, their performance on the CVLT-C and WCST, their teacher and self-report BASC ratings, and their demographics and diagnoses were compared.

Hypotheses.

1. Children with nonclinical CPT-II profiles were expected to exhibit less impairment on the measures being examined (i.e., BASC, CVLT-C, WCST) and have fewer ADHD diagnoses than those with clinical profiles.
2. Children with inattentive and impulsive CPT-II profiles were expected to differ in ways consistent with the literature on differences between ADHD subtypes.
 - a. Specifically, relative to children with inattentive profiles, the children in the impulsive group were expected to be younger, include a greater proportion of boys, have more comorbid behavior disorders, fewer learning and memory problems, lower ratings of internalizing symptoms, higher ratings of hyperactivity, greater executive function deficits, and lower ratings of inattention.

Method

Participants

The participants were drawn from archival files of children seen for neuropsychological evaluation at Montana Neurobehavioral Specialists. These children were primarily Caucasian and from the Missoula, Montana area. They were referred for evaluation by their parents, schools, psychologists, and primary care physicians.

The files of children 8 to 16 years of age who completed the measures examined in this study were selected for inclusion. This age range was chosen to maximize the number of participants while remaining within the appropriate age range for the measures being examined. Children with seizure disorders or who have had significant traumatic brain injury (i.e., a loss of consciousness of > 10 minutes), or who have a Full Scale IQ score (FSIQ) of less than 82 (85 ± 3 for 68% confidence level) on the Wechsler Intelligence Scale for Children, Third Edition (WISC-III) were excluded from the study to minimize the potential impact of traumatic brain injury or low intellectual functioning on the dependent measures. Several children had been administered the WISC-III on more than one occasion. For those with multiple FSIQ scores, the score closest to the normative mean of 100 was selected. The FSIQ score was estimated based on subtest age scaled scores for children who did not complete the full WISC-III. Only children on no medication, psychostimulants, or SSRIs at the time of testing were included in the sample.

Procedures

The files of children that met the inclusion criteria were assigned an identification number to ensure confidentiality, and the cross-references list of the children's names is maintained at Montana Neurobehavioral Specialists. The information collected from each selected file included demographic information (i.e., age, gender, race/ethnicity, WISC-III FSIQ score, education, handedness, medications, diagnoses), and test scores on the measures in question (i.e., CPT-II, BASC, CVLT-C, WCST). Standardized scores were collected rather than raw scores to ensure that the performance of children of different ages was compared to age-appropriate norms.

All measures were individually administered and scored by trained psychometric technicians at Montana Neurobehavioral Specialists as part of a full neuropsychological assessment. Clinical neuropsychologists have reviewed the results of the children's testing and have made diagnoses and treatment recommendations.

Measures

Conners' Continuous Performance Test II (CPT-II).

The approximately 14 minute long "standard" mode of the Conners' CPT-II for Windows was used as a measure of inattention and impulsivity (Conners, 2000). IBM compatible computers with 16-inch monitors and Windows 98 operating systems were used to administer the CPT-II. During the CPT-II, the child is instructed to watch the computer and press the space bar as soon as they see any letter except X flash on the screen. The accuracy of the keyboard as a response device in reaction time paradigms

has been questioned (Segalowitz & Graves, 1990). Nonetheless, the space bar was used in the CPT-II standardization testing and was utilized as recommended by the CPT-II manual (Conners, 2000) in the present study. Following the instructions, approximately 1 inch tall, bold-faced letters of the alphabet are presented for 250 milliseconds in six blocks. Within each block are three 20 trial sub-blocks with different inter-stimulus-intervals (ISIs) of 1, 2, or 4 seconds.

The Conners' CPT-II produces three types of basic measures. The first, omission errors, is the number of nontarget stimuli (i.e., letters other than X) to which the child did not respond. Omission errors may be the result of inattention or of slow responding. Commission errors are responses committed to the target stimulus, X, rather than inhibiting response until another letter is presented. The third measure is response time measured in milliseconds (ms). The CPT-II response time measures examine both the speed and consistency with which the child responds. The CPT-II reportedly uses the multimedia timer with one millisecond resolution rather than the Windows timer to achieve better timing accuracy. The CPT-II also contains a built in timing validation feature that compares the time the test takes to complete against the exact time that the program should run and alerts the clinician to any discrepancy.

The CPT-II classifies response times that are less than 100 milliseconds as perseverations and does not include them in response time calculations. This change was made from Conners' (1994) original CPT because it is physiologically impossible for the respondent to process the stimulus and react this quickly. Perseverative responses are typically the results of anticipatory responding, perseverating, or randomly responding.

The results of the CPT-II are expressed in T-scores and percentiles relative to individuals of the same gender and age group in a general population sample, an ADHD clinical sample, or neurologically impaired clinical adults. The age groups for the CPT-II are broken down into two-year intervals for children and adolescents (i.e., 6-7, 8-9, 10-11, 12-13, 14-15, and 16-17). The adults' age groups are 18-34, 35-54, and 55+. The T-scores produced by the CPT-II have a mean of 50 and a standard deviation of 10. High T-scores and percentile ranks (i.e., $T \geq 60$, $PR \geq 85$) are indicative of moderate to markedly atypical performance for all measures of the CPT-II. Isolated atypical scores should be interpreted with caution; two or more atypically high scores suggest possible attentional problems.

The general population sample of the CPT-II is composed of 1,920 individuals (47.2% male). The CPT-II clinical sample includes 378 individuals with ADHD and 223 adults with neurological impairment (69.4% and 55.6% male, respectively). The most common diagnoses among the neurological sample are post-concussive syndrome (29%) and other organic brain syndrome (21%). No neurologically impaired CPT-II norms are available for children. The ethnic composition of the CPT-II nonclinical sample is 59.9% White and the ethnic composition of the two clinical samples are not reported.

The results of the CPT-II also indicate the child's attentiveness (d' , ability to discriminate targets from non-targets), and degree of risk-taking (β , frequency of responses). A change from Conners' CPT to CPT-II is the use of maximum likelihood estimation and the Newton-Raphson method to calculate d' and β . These calculations utilize the respondent's reaction time as an indicator of confidence in their response.

Impulsive and inattentive responding can produce different patterns of scores on the CPT-II. Conners (2000) suggests that if multiple measures of the CPT-II are elevated, the clustering of the atypical scores should be examined to determine the type of impairment. Attention problems are related to poor performance on measures of omissions, commissions, slow hit reaction time, hit reaction time standard error, variability, d' , hit reaction time by ISI, and hit standard error by ISI. The pattern of atypical CPT-II scores suggestive of impulsivity includes fast hit reaction time and high rates of commission errors and perseverations. The two patterns of elevated scores (i.e., primarily inattentive and primarily impulsive) were used to define groups in the present study.

The earlier Conners' CPT (1994) produced an overall index score based on the weighted sum of the scores that best distinguished ADHD children from general population cases in the normative sample. Conners (1994) suggested cutoff points based on this overall index score: overall index scores < 8 suggested no attention problems, 8-11 was considered borderline, and > 11 suggested impaired attention. Among the children 6 to 17 years old in the normative sample, these cutoff points yielded a 9.6% false negative rate (clinical cases scoring < 8), a 5.9% false positive rate (general population cases scoring > 11), and 12.0% of individuals fell in the borderline range. The overall index score cutoffs were cross-validated with an independent clinical sample and age and sex matched controls from the general population sample. Among 6 to 17 year olds in this second sample, the results indicated a false positive rate of 13.5% and a false negative rate of 26.1%. Kirlin (2000) examined the relationship between these CPT cutoff scores and a clinical sample of children's performance on measures of learning and

executive function. The results revealed that the performance of children with attention deficits (CPT indexes > 11) differed significantly from those without attention problems (indexes < 8) on two measures of the CVLT-C, the Semantic Cluster Ratio and the List-A Trial-5 Free Recall.

Conners' more recent version of the CPT, the CPT-II, still calculates overall index scores, but no longer utilizes this score as its main summary statistic. In its place, the CPT-II classifies the respondent's profile as either clinical or nonclinical and provides a confidence index that reflects the percentage of cases with such a profile that would be correctly classified as clinical. The confidence index scores range from 0 to 100 with indexes above 50 when the profile more closely matches a clinical profile and indexes less than 50 if the profile matches a nonclinical pattern.

Conners (2000) reviews the psychometric properties of the CPT-II. The split-half reliabilities for the measures of the CPT based on the original standardization sample range from .73 for β to .95 for hit reaction time. The CPT-II test-retest correlation coefficients of 23 participants with a mean inter-test interval of three months range from .05 to .92. Conners (2000) notes that the lengthy time period between tests for some participants probably contributed to the low test-retest correlations observed on some measures.

Conners (2000) also reviews the evidence for the validity of the CPT-II including an examination of the relationship between the CPT overall index score and parent and teacher rating of ADHD symptoms using the Conners Rating Scales – Revised. The results reveal significant positive correlations between children's CPT index score and parent rated inattention and psychosomatic symptoms. Teacher ratings of perfectionism

were significantly negatively correlated with the children's overall CPT index. Conners (2000) reviews several other investigations of the relationship between CPT performance and parent and teacher rating scales such as Achenbach's Child Behavior Checklist (CBCL) and Teacher Report Form (TRF) that found limited relationships between the measures.

Conners (1994) examined the utility of the CPT to identify cases of ADHD among individuals with ADHD or ADD, ADHD with a comorbid diagnosis, and a clinical group with other diagnoses (e.g., ODD, anxiety disorders) in the original standardization sample. The results revealed significant differences between the two ADHD groups and the other group on most of the CPT measures. Similar comparisons using the CPT-II standardization sample have also revealed significantly poorer performance among ADHD groups than nonclinical groups on most CPT-II measures. Several independent researchers have also reported support for the CPT's ability to distinguish between ADHD and non-clinical samples (see Conners, 2000 for review). However, Conners (2000) notes that the CPT has demonstrated relatively poor specificity when discriminating between ADHD and other clinical groups. He cautions that CPT-II results should always be combined with other sources of information to arrive at diagnoses of ADHD.

California Verbal Learning Test – Children's Version (CVLT-C).

The CVLT-C is an assessment of children's verbal learning and memory with a normative sample of 920 children, 5 to 16 years of age (Delis et al., 1994). The CVLT-C measures the quantity of verbal material the child learns as well as the strategies and processes involved in learning. The task involves the child listening to and recalling

items from two shopping lists, the Monday list and the Tuesday list. Each list is composed of 15 items, with five items from each of three semantic categories (i.e., fruit, playthings, clothing). For all Immediate Recall trials, items are presented at the rate of approximately one word per second with each item following an item from a different semantic category. For the first five trials, the child is presented with and asked to recall the Monday shopping list. Then the Tuesday list is presented and recalled for one trial as an interference task. The child is then asked to recall items from the Monday list only for a Short-Delay Free-Recall trial, and then asked to recall items from the Monday list by semantic category for a Short-Delay Cued-Recall trial. After a 20-minute delay of other nonverbal tests, the child is asked to recall items from the Monday list for the Long-Delay Free-Recall trial, and to recall items from the Monday list by semantic category for the Long-Delay Cued-Recall trial. Finally, the child completes a Recognition trial in which they are to identify items from the Monday list from a long list of verbally presented shopping items.

The CVLT-C produces several measures of learning and memory, including: 1) level of recall and recognition for all trials; 2) use of learning strategies, such as semantic or serial clustering; 3) serial-position effects; 4) learning rate across trials; 5) consistency of items recalled across trials; 6) the effect of proactive and retroactive interference on recall; 7) retention of learned material over a short and long delay; 8) effect of cueing and recognition on performance; 9) discriminability, false positives, and response bias during a recognition task; and 10) perseveration and intrusions.

Two scores of the CVLT-C related to attention, learning, and memory will be examined in this study: 1) List-A Trial-5 Free Recall, and 2) Semantic Cluster Ratio.

List-A Trial-5 Free Recall is the final trial of free recall for the Monday shopping list and reveals the effects of repeated trials on recall. The Semantic Cluster Ratio gauges the child's use of semantic clustering as an active learning strategy. This score is calculated by dividing the observed degree of semantic clustering by the expected level. Low scores suggest that the child did not utilize semantic clustering strategies and either recalled the items in serial order or in no organized fashion. These two scores were included in the present study because previous research examining whether children with poor or normal attention as measured by the CPT differ in their CVLT-C performance has revealed the greatest difference between groups on these measures (Kirlin, 2000).

Delis et al. (1994) discuss the reliability and validity of the CVLT-C. Trials 1 through 5 appear to have a high degree of internal consistency: the average across-trial coefficient alpha is .85, the average across-semantic-category reliability coefficient is .72, and the average coefficient alpha correlation across-word is .81. The test-retest correlations of CVLT-C scores differ by age of the child and range from .17 to .90. Delis et al. (1994) suggest that the theoretical and research foundations of the CVLT-C provide evidence of its content related and criterion related validity. Factor analyses of the CVLT-C suggest that it has the same general six-factor structure as the adult version. The correlation between the CVLT-C List-A Trials 1-5 raw score total and the WISC-R Vocabulary standard score ranges from .32 to .40, suggesting that these tests are mildly related (9% to 16% shared variance), but for the most part measure different cognitive domains.

Kramer, Knee, and Delis (2000) recently examined the usefulness of the CVLT-C for identifying the verbal learning impairments associated with dyslexia. Their results

revealed that relative to controls with matched gender, age, and WISC-R Vocabulary scores, children with dyslexia learned the list items more slowly, recalled fewer items on List-A Trial-5 and delayed trials, and performed more poorly during the recognition trial. The children with dyslexia appeared to have less efficient rehearsal and encoding mechanisms and deficits in encoding, but normal retention and retrieval abilities once information is acquired. The authors conclude that the CVLT-C is a useful tool for understanding the deficits underlying childhood learning problems.

Behavioral Assessment System for Children (BASC).

The BASC is a multimethod system for evaluating behavioral and emotional disorders among youth 2 ½ to 18 years of age in school, clinic, and hospital settings (Reynolds & Kamphaus, 1998). The BASC includes five components: youth self-report, teacher-report, parent-report, a structured developmental history, and a classroom observation system. The BASC rating scales include adaptive as well as clinical dimensions of personality, behavioral, and emotional disorders. The primary uses of the BASC are aiding in differential diagnosis, educational classification, and the design of treatment plans.

The BASC Teacher Rating Scale (TRS) is composed of a list of observable behaviors that the teacher rates the child as engaging in *Never*, *Sometimes*, *Often*, or *Almost always*. The TRS produces an overall score (i.e., the Behavioral Symptom Index) and five broad domains of composite scales. These include Externalizing Problems (i.e., Aggression, Hyperactivity, Conduct Problems), Internalizing Problems (i.e., Anxiety, Depression, Somatization), School Problems (i.e., Attention Problems, Learning Problems), Other Problems (i.e., Atypicality, Withdrawal), and Adaptive Skills (i.e.,

Adaptability, Leadership, Social Skills, Study Skills). The TRS includes three versions for children of different age ranges (2 ½-5, 6-11, and 12-18). Normative data for the TRS includes a set of clinical norms as well as general population national norms broken down by age and gender. The TRS also includes an *F* validity scale to detect a negative response set (“fake bad”). The BASC Student Observation System (SOS) is used to assess both positive and negative child behaviors observed in the classroom. The observer codes the child’s behavior in 3-second intervals every 30 second over the course of 15 minutes.

The BASC Parent Rating Scale (PRS) is similar to the TRS in format, age ranges, and norms. The PRS does not include the School Problems composite scale, or the Learning Problems or Study Skills scales. The Structured Developmental History (SDH) gathers information about the youth’s family, health, social, and developmental history and may be completed by the parent(s) or by the clinician during an interview.

The Self-Report of Personality (SRP) is composed of statements that the youth rates as *True* or *False*. There are forms for two age ranges: 8-11 and 12-18. The SPR produces four composite scores and an overall Emotional Symptoms Index. The composite scales are: Clinical Maladjustment (i.e., Anxiety, Atypicality, Locus of Control, Social Stress, Somatization), School Maladjustment (i.e., Attitude to School, Attitude to Teachers, Sensation Seeking), Other Problems (i.e., Depression, Sense of Inadequacy), and Personal Adjustment (i.e., Relations with Parents, Interpersonal Relations, Self-Esteem, Self-Reliance). Two of these scales are found on the adolescent version of the SRP but are not included on the child form (i.e., Somatization and

Sensation Seeking). The SRP also includes three validity scales: *F* for “Fake Bad”, *L* for “Fake Good” (adolescent version only), and *V* to detect invalid responding.

Three scores of the child and adolescent versions of the BASC TRS and two scores of the child and adolescent versions of the SRP will be examined in the present study. The scores from the TRS include the Attention Problems, Hyperactivity, and Learning Problems scales. The Attention Problem and Hyperactivity scales were chosen to examine the concurrent validity of the inattentive and impulsive profiles of the CPT-II. The Learning Problems scale will be included to examine whether the children with primarily inattentive clinical CPT-II profiles experience higher rates of learning difficulty, as the literature on ADHD subtypes would suggest. The two scores from the SRP to be examined are the Depression and Anxiety scales. These self-report scales are included to examine whether children with primarily inattentive profiles experience more internalizing symptoms than children with normal or primarily impulsive profiles. All BASC TRS and SRP scores are expressed as linear T-scores and percentile ranks with high scores (i.e., $T \geq 60$) representing negative or undesirable characteristics. On the clinical scales, the categorical descriptions are *Clinically Significant* for T-scores > 69 , *At-Risk* for T-scores of 60-69, *Average* for 41-59, *Low* for 31-40, and *Very Low* for T-scores < 31 .

Reynolds and Kamphaus (1998) review the development, standardization, and psychometric properties of the BASC. The normative sample for the TRS and SRP includes 1,259 children and 809 adolescents drawn from public and private school and daycares across the United States. Within each gender, the samples were weighted so that the representation of each racial/ethnic group was consistent with U.S. population

percentages. Children with special-education classification were included in the general population sample in the proportion that they occurred in the regular classrooms sampled (4.0%-10.1% depending on age and gender).

The clinical normative sample for the BASC consists of children and adolescents with emotional and behavioral problems. This American and Canadian sample was drawn from community mental health centers, hospital and university outpatient and inpatient services, school programs and classrooms for children with emotional and behavioral disorders, juvenile detention centers, and children recruited for the general population sample who had previously been diagnosed with behavioral or emotional problems. The most prevalent diagnoses or classifications among the clinical sample were Behavior Disorder, CD, and ADHD. Approximately three quarters of the TRS clinical sample is male, most likely reflecting the higher rates of attention-deficit and disruptive behavior disorders in boys than girls.

Reynolds and Kamphaus (1998) review the internal consistency, test-retest reliability, and interrater reliability data for the BASC TRS. For the BASC TRS scales being examined in the present study, the coefficient alpha reliabilities among children and adolescents in the general population sample range from .83 to .94. Among the clinical sample, the coefficient alpha reliabilities range from .83 to .92. The test-retest correlations for children rated twice by the same teacher two to eight weeks apart range from .92 to .93 on these three scales. Their interrater reliability coefficients range from .69 to .93 for the child TRS form.

Reynolds and Kamphaus (1998) also review the reliability of the BASC SRP. Among the general normative sample, the coefficient alpha reliabilities for the

Depression scale of the SRP range from .85 to .90, and for the Anxiety scale range from .84 to .88. For the clinical sample, the coefficient alpha reliability of the Anxiety scale is .87 for the child SRP and .85 for adolescent SRP. The coefficient alpha reliability for the Depression scale of both the child and adolescent SRP is .89. The test-retest reliability for the Anxiety scale of the SPR over several weeks is .77 for the child form and .80 for the adolescent form. For the Depression scale, the test-retest reliability is .75 for the child SRP and .77 for the adolescent SRP. Reynolds and Kamphaus (1998) also report the seven-month stability coefficient of the SRP as .66 for the Anxiety scale and .54 for the Depression scale.

Reynolds and Kamphaus (1998) also review the evidence for the validity of the BASC TRS and SRP. Comparisons between teacher reported clinical symptoms using the BASC TRS and other instruments such as the Teacher Rating Scale, Revised Behavior Problem Checklist, and the Burks' Behavior Rating Scale reveal high correlations between corresponding scores, particularly measures of externalizing or school problem behaviors scales. The BASC manual also reports the profiles of eight clinical groups (i.e., CD, behavior disorders, depression, emotional disturbance, ADHD, LD, mild mental retardation, and autism) relative to the general population norms. The ADHD profile includes elevations on the Attention Problems, Hyperactivity, and Learning Problem scales, and low scores on the Study Skills scale.

Several researchers have examined the ability of the BASC to identify ADHD subtypes. Vaughn, Riccio, Hynd, and Hall (1997) examined the discriminant validity of the BASC and Achenbach's CBCL and TRF for diagnosing ADHD/I and ADHD/C. Their results revealed both measures accurately detected ADHD/C, but the BASC PRS

and TRS were more accurate in identifying ADHD/I than the CBCL or TRF. The BASC TRS was also more accurate in identifying non-ADHD cases than the TRF.

Manning and Miller (2001) also investigated the diagnostic utility of the BASC PRS and TRS for identifying childhood ADHD and differentiating between subtypes. Their results revealed that the children with ADHD did score significantly higher than controls on most BASC scales, but that the scale T-scores did not necessarily fall in the At-Risk or Clinically Significant range. They also reported that the ADHD/I and ADHD/II children differed significantly on several BASC scales; the children with ADHD/I received higher Atypicality ratings and the ADHD/II children were rated higher on the Hyperactive, Aggression, and Conduct Problems scales.

Reynolds and Kamphaus (1998) outline the evidence for the validity of the BASC SRP including its relationship with several other self-report scales (i.e., the MMPI, the Achenbach YSR, the Behavior Rating Profile, and the Children's Personality Questionnaire). The correlations between the adolescent SRP and the MMPI are .76 for Anxiety and Psychasthenia and .43 for the two measures' Depression scales. For adolescent girls completing both the SRP and the Achenbach YSR, the correlations are .65 for Anxiety and the Internalizing scale, and .59 for the Depression and Depressed scales. Among adolescent boys, the correlations between the SRP and the YSR form are .71 for Anxiety and Internalizing and .43 for Depression and Depressed. The BASC manual also reports the profiles of seven clinical groups (i.e., CD, behavior disorder, depression, emotional disturbance, ADHD, LD, and mild mental retardation) of children and adolescents relative to the general population sample. The ADHD profile is

relatively flat and suggests that the SRP is not particularly sensitive to many of the difficulties of ADHD.

Wisconsin Card Sorting Test (WCST).

The WCST will be used as a measure of executive functions such as problem solving and concept formation. The test consists of two decks of 64 response cards each depicting forms (triangles, stars, crosses, or circles) of varying color (red, green, yellow, or blue) and quantity (one, two, three, or four). The child is instructed to match each of the response cards to one of four key cards (a single red triangle, two green stars, three yellow crosses, or four blue circles). The child is not told how to match the cards, but is informed whether each card was correctly or incorrectly sorted after each response. The instructions indicate that there is no time limit on the WCST. Once the child has matched ten consecutive cards correctly, the sorting principle is changed without warning (e.g., sorting by color to sorting by form) until the child has successfully completed six categories (two of each sorting principle) or has finished both decks of cards.

Various forms of administration and scoring of the WCST have been used by different researchers. For the cases examined in the present study, the procedures outlined in the manual (Heaton, 1981; Heaton, et al., 1993) were used with one variation. The response cards were handed to the child one at a time rather than as an entire deck. This method was employed to avoid the child shuffling the deck or proceeding without feedback from the last response.

WCST normative data from several samples are available for individuals 6 ½ to 89 years of age, and education-corrected norms are available for adults over 20 years of age (see Heaton et al., 1993). The original normative study described by Heaton (1981)

suggests that the perseverative response score is the best predictor of brain damage, particularly focal frontal lobe involvement.

Trials to 1st Category was chosen as the score from the WCST to be examined in the present study. Past research has demonstrated that a two-variable discriminant function including this WCST score and the Semantic Cluster Ratio score of the CVLT-C correctly classified 67% of a clinical sample of 9 to 12 year old children to groups defined by poor CPT and normal CPT performance (Kirlin, 2000).

There is evidence of good interscorer and intrascorer reliability using the Heaton (1981) scoring system for the WCST with adults, children, and adolescents, as well as with experienced and novice scorers (see Heaton et al., 1993). However, others have suggested that the interscorer reliability of perseveration is low and have attempted to clarify the manual's scoring criteria (see Flashman, Horner, Freides, 1991). Heaton et al. (1993) review the evidence for the validity of the WCST in measuring executive functioning in a wide range of adult, child, and adolescent clinical groups including children with ADHD.

Results

All of the following analyses were conducted using SPSS for Windows, Version

9. An alpha level of .05 was used for all statistical tests of significance. First the descriptive statistics of the sample will be reviewed, followed by comparisons of the CPT-II groups' performance on the dependent measures. Finally, the results of a discriminant functions analysis for group membership will be discussed.

Sample Descriptive Statistics

Data was collected on 40 children who met the inclusion criteria for the present study. The majority of the sample was male ($n = 32$ [80%]) and of unspecified race/ethnicity. Two of the children (5%) were identified as American Indian and the other children in the sample were most likely Caucasian given the demographics of the region. The participants had a mean age of 10.9 years ($SD = 2.11$; range = 8 to 16) and a mean grade level of 5.2 ($SD = 1.99$; range = 2nd to 10th grade). The participants' mean WISC-III FSIQ score was 101.1 ($SD = 10.75$; range of 82 to 123). Most children in the sample were right handed ($n = 37$ [92.5%]) and the majority were on no medication at the time of testing ($n = 27$ [67.5%]). Of those taking psychotropic medication, the most commonly taken class of drugs was stimulants ($n = 7$ [17.5%]), followed by equal numbers of participants taking either a SSRI or a combination of a SSRI and a stimulant ($n = 3$ [7.5%] for each).

Over half of the children in the sample had received multiple diagnoses ($\underline{n} = 23$ [57%]). Most had an ADHD diagnosis ($\underline{n} = 38$ [95%]). None were diagnosed as having strictly ADHD/HI. Fifty-five percent ($\underline{n} = 22$) had been diagnosed with ADHD/C and 40% were diagnosed ADHD/I ($\underline{n} = 16$). The next most common classes of diagnoses were anxiety and mood disorders ($\underline{n} = 6$ [15%] each), followed by disruptive behavior disorders ($\underline{n} = 5$ [13%]). LDs were diagnosed in 8% of the sample ($\underline{n} = 3$).

Descriptive statistics were also run on the dependent clinical measures: the Behavioral Assessment System for Children (BASC) Self Report of Personality (SRP) and Teacher Rating Scale (TRS), the Wisconsin Card Sorting Task (WCST), and the California Verbal Learning Test for Children (CVLT-C). Table 1 presents the means, standard deviations, ranges, and percent of cases beyond the clinical cut-off on the dependent measures for the entire sample. A T-score of at least one standard deviation (10 points) from the normative mean in the clinical direction was used as the clinical cut-off. This cut-off captures the children whose performance fell in the *at-risk* to *clinically significant* range on the dependent clinical measures. On the BASC TRS, higher T-scores represent greater impairment as rated by the children's teachers. Likewise, higher T-scores on the BASC SRP suggesting greater self-reported psychopathology. On the CVLT-C, higher T-scores reflect better performance on the final trial of a list learning task. Higher T-scores on the CVLT-C Semantic Cluster Ratio suggest a greater utilization of active learning strategies during the learning trials of the task. For Trials to First Category of the WCST, higher scores suggest better initial performance on a novel concept formation task. The range of T-scores on the WCST Trials to First Category was limited by the normative data which classifies all scores within one standard deviation of

the mean as having a percentile rank > 16 without assigned a more specific standardized score.

Table 1
Means, Standard Deviations, Ranges, & Percent beyond Clinical Cut-off of Dependent Measures for Sample

<u>Measures</u>	<u>Mean T-Score</u>	<u>Standard Deviation</u>	<u>Range</u>	<u>% Beyond Cut-off</u>
BASC TRS¹				
Attention Problems	63.5	9.48	39-76	70%
Hyperactivity	60.4	12.81	40-83	55%
Learning Problems	60.1	10.60	41-86	55%
BASC SRP¹				
Depression	51.3	10.32	41-80	20%
Anxiety	50.6	8.88	34-70	15%
CVLT-C²				
List-A Trial-5 Free Recall	48.4	9.96	25-70	28%
Semantic Cluster Ratio	49.3	10.71	25-75	28%
WCST²				
Trials to 1 st Category	40.4	2.23	31-41	10%

¹ Higher T-scores reflect higher rates of psychopathology on these measures

² Higher T-scores reflect better performance on these measures

Correlational analyses did not reveal any significant relationships between age and the children's performance on the clinical measures. Table 2 presents the Pearson correlations between the dependent measures. As might be expected, there was a significant positive correlation between teachers' ratings of attention problems and hyperactivity ($r = .68, p < .01$), as well as attention problems and learning problems ($r = .63, p < .01$) on the BASC TRS. There was also a significant positive correlation between the children's self-reported depression and anxiety on the BASC SRP ($r = .64, p < .01$). On the CVLT-C, there was a significant positive correlation between the use of

semantic clustering as a learning strategy and the children's performance on the final trial of the list learning task ($r = .39, p < .05$).

Table 2
Correlations between Clinical Measures

Measures	CPT-II		TRS			SRP		CVLT-C		WCST
	1	2	3	4	5	6	7	8	9	10
CPT-II										
1. Omissions	--	.13	-.02	.06	-.04	-.02	.12	-.19	.22	.18
2. Commissions		--	.08	.07	.14	.14	.03	-.06	-.01	-.10
BASC TRS										
3. Attention Problems			--	.68**	.63**	.07	.08	.15	.13	-.19
4. Hyperactivity				--	.26	.03	.07	.08	.11	-.18
5. Learning Problems					--	.03	-.03	-.07	-.07	.16
BASC SRP										
6. Depression						--	.64**	.02	-.00	-.25
7. Anxiety							--	-.08	-.02	-.29
CVLT-C										
8. List-A Trial-5 Free Recall								--	.39*	-.21
9. Semantic Cluster Ratio									--	.07
WCST										
10. Trials to 1 st Category										--

Note. ** $p < .01$, * $p < .05$

Comparisons Between CPT-II Groups

Preliminary comparisons were performed on the characteristics of the groups defined by Conners' CPT-II (see Table 3). Most of the children's CPT-II score profiles were classified as clinical ($n = 24$ [60%]). Demographically, an independent-samples two-tailed t test revealed that the children with clinical and nonclinical profiles differed significantly only in gender, with significantly more girls in the nonclinical ($n = 7$) than clinical group ($n = 1$), $t(18) = 2.939, p < .05$. Thirty-five percent ($n = 14$) of the children

produced CPT-II profiles with an equal number of inattentive and impulsive score elevations, to be termed an indeterminate profile. However, 42.5% of the participants performed in the clinical range on a greater number of inattentive scores ($n = 17$), and 22.5% produced more impulsive profiles ($n = 9$). The children with inattentive, impulsive, and indeterminate profiles did not differ significantly in age, FSIQ score, diagnoses, or gender. The majority of the participants received more elevated commission than omission scores ($n = 25$ [62.6%]), and equal numbers had at least a 10 point T-score difference between their omission and commission scores ($n = 8$ [20%] for both omission > commission and commission > omission). Those with more omission or commission errors did not differ significantly in age, gender, diagnoses, or FSIQ score.

Table 3
Demographics of CPT-II Groups

	% of Sample	% Male	% ADHD	Mean Age	Mean FSIQ
CPT-II Groups					
Clinical vs. Nonclinical					
Clinical	60.0	95.8*	95.8	11.0 (2.44)	100.5 (11.22)
Nonclinical	40.0	56.3*	93.8	10.7 (1.54)	102.0 (10.28)
Profile Type					
Inattentive	42.5	88.2	94.1	10.6 (2.18)	98.0 (12.15)
Impulsive	22.5	66.7	100	11.8 (1.99)	102.4 (8.00)
Indeterminate	35.0	78.6	92.9	10.7 (2.09)	104.0 (10.12)
Omission vs. Commission					
Om > Com	37.5	86.7	100	10.9 (2.87)	98.7 (10.76)
Com > Om	62.5	76.0	92.0	10.9 (1.56)	102.5 (10.70)

Note. * Groups differ at $p < .05$

The clinical scores of the groups defined by the children's CPT-II profiles were compared using t tests and analysis of variance (ANOVA). A t test comparing the means of the children with clinical and nonclinical CPT-II profiles on the dependent measures (BASC TRS and SRP, CVLT-C, and WCST) revealed no significant differences. Given the gender differences between these two groups, this comparison was followed-up with an ANOVA using gender as a covariate. The analysis of covariance (ANCOVA) was also not significant.

An oneway ANOVA comparing the clinical scores of the children with inattentive, impulsive, and indeterminate CPT-II profiles revealed a significant difference on the CVLT-C Semantic Cluster Ratio, $F(2,37) = 6.79, p < .01$. Post hoc Bonferroni comparisons indicated that the children with impulsive profiles utilized semantic clustering significantly less ($M = 39.44, SD = 9.50$) than children in both the inattentive ($M = 50.59, SD = 9.33$) and indeterminate groups ($M = 53.93, SD = 9.44$) and that the later two groups did not differ significantly. This ANOVA also yielded a nonsignificant trend for BASC SRP Anxiety, $F(2,37) = 2.79, p = .07$, suggesting the children with impulsive CPT-II profiles may have reported higher rates of anxiety ($M = 56.44, SD = 8.28$) than the children with inattentive ($M = 48.94, SD = 6.77$) or indeterminate profiles ($M = 48.71, SD = 10.35$). The mean T-scores on the clinical measures for the inattentive, impulsive, and indeterminate CPT-II groups may be seen in Table 4.

Table 4
Means of Clinical Measures for Inattentive, Impulsive, & Indeterminate CPT-II Groups

Measures	Inattentive n = 17		Impulsive n = 9		Indeterminate n = 14	
	M	SD	M	SD	M	SD
BASC TRS¹						
Attention Problems	64.47	10.63	61.56	11.28	63.50	6.94
Hyperactivity	59.59	12.96	58.67	14.07	62.43	12.49
Learning Problems	61.88	13.30	58.56	8.59	58.86	8.21
BASC SRP¹						
Depression	49.59	9.10	56.78	10.86	49.93	10.89
Anxiety	48.94	6.77	56.44 _a	8.28	48.71	10.35
CVLT-C²						
List-A Trial-5 Free Recall	47.65	8.50	43.89	8.58	52.14	11.55
Semantic Cluster Ratio	50.59	9.33	39.44 _b	9.50	53.93	9.44
WCST²						
Trials to 1 st Category	40.88	0.49	39.67	3.32	40.29	2.67

¹ Higher T-scores reflect higher rates of psychopathology on these measures

² Higher T-scores reflect better performance on these measures

_a Mean differs from those in same row at $p = .07$

_b Mean differs from those in same row at $p < .05$

A t test comparing the children with higher CPT-II omission and commission scores did not suggest a significant difference between groups on the BASC TRS or SRP, CVLT-C, or WCST (see Table 5). A second t test utilizing the more stringent 10-point T-score discrepancy between CPT-II omissions and commissions to define groups also failed to identify significant differences.

Table 5
Means of Clinical Measures for Omission & Commission CPT-II Groups

<u>Measures</u>	<u>Omissions > Commissions</u>		<u>Commissions > Omissions</u>	
	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>
BASC TRS¹				
Attention Problems	64.1	7.86	63.1	10.47
Hyperactivity	61.6	11.26	59.6	13.83
Learning Problems	58.2	10.77	61.2	10.56
BASC SRP¹				
Depression	49.1	7.30	52.6	11.72
Anxiety	50.3	8.74	50.7	9.14
CVLT-C²				
List-A Trial-5 Free Recall	47.7	10.67	48.8	9.71
Semantic Cluster Ratio	52.7	9.42	47.2	11.09
WCST²				
Trials to 1 st Category	40.9	0.52	40.1	2.77

Note. ¹ Higher T-scores reflect higher rates of psychopathology on these measures

² Higher T-scores reflect better performance on these measures

Multiple Discriminant Analysis

Multiple discriminant analysis was used to describe differences between the groups defined by the CPT-II based on their multivariate profiles of scores on the other clinical measures, as well as to derive a classification rule based on these differences and assess its predictive accuracy.

The dependent variable for the discriminant analysis was CPT-II profile type, either primarily inattentive, primarily impulsive, or indeterminate with equal numbers of inattentive and impulsive elevations. The independent variables were the children's selected T-scores on the other clinical measures: the BASC TRS and SRP, the CVLT-C, and the WCST. Demographic variables such as age, gender, and FSIQ score were not

included because previous analyses had indicated they did not differ significantly between groups. Seven independent variables were included with a 1:6 variable to participant ratio. Ideally, it is recommended that discriminant analysis utilize a ratio closer to 1:20 with at least 20 participants per group, but the present study met the minimum criteria of the smallest group size exceeding the number of independent variables. The normality of the seven independent variables was examined using Kolmogorov-Smirnov's test of normality with Lilliefors significance correction. The results indicated that all of the variables with normally distributed with the exception of BASC SRP Depression and WCST Trials to 1st Category. Multiple discriminant analysis assumes multivariate normality of the independent variables for the purpose of significance testing, but can accommodate violation of this assumption without significantly compromising the reliability of the significance test so these two variables were included in the analysis (StatSoft, Inc., 2002).

Using a stepwise computational method to compute the discriminant function, the independent variables were entered into the function one at a time by sequentially adding the variable that contributed the most discriminating power (see Grimm & Yarnold, 1995; Hair et al., 1995; Tabachnick & Fidell, 1996). Variables that were not useful in discriminating between the groups were not included in the discriminant function. A probability of F criterion of .05 was used for entry into the function and probability level of .10 was required for removal.

The total value analysis method was used to specify the probabilities of classification. This method computes the probability of membership based on the group size to determine a weighted optimal cutting score. Mahalanobis D^2 was chosen as the

measure of statistical significance for the discriminatory power of the resulting function. This measure adjusts for unequal variance and is appropriate for use with the stepwise method (see Hair et al., 1995).

The discriminant analysis yielded two two-variable functions. The two variables entered into the functions included CVLT-C Semantic Cluster Ratio and BASC SRP Anxiety. The discriminant loading values are the simple linear correlations between each variable and the discriminant function, and are considered valid means of assessing the relative importance of each variable in discriminating between groups (Hair et al., 1995). For the first function, the variables' discriminant loadings were .76 for Semantic Cluster Ratio and -.48 for the SRP Anxiety score. The discriminant loadings for the second function were .65 for Semantic Cluster Ratio and .86 for SRP Anxiety. The standardized canonical discriminant function coefficients and the group centroids of each of the variables may be seen in Table 6.

Table 6
Standardized Canonical Discriminant Function Coefficients & Functions at Group Centroids

	<u>Standardized Canonical Discriminant Function Coefficients</u>		<u>Functions at Group Centroids</u>		
	Semantic Cluster Ratio	SRP Anxiety	Indet	Inatn	Imp
Function 1	.894	-.663	.588	.253	-1.392
Function 2	.493	.776	.077	-.077	.025

Note. Indet = Indeterminate group
Inatn = Inattentive group
Imp = Impulsive group

Table 7 depicts the multivariate results of the three-group discriminant analysis. The first function is significant as measured by the Chi-square statistic and contributes to

the variance accounted for by the model, but the second function does not achieve statistical significance.

Table 7
Results of Three-Group Discriminant Analysis

	<u>% of Variance</u>	<u>Canonical Correlation</u>	<u>Wilks' Lambda</u>	<u>Chi-square</u>	<u>df</u>	<u>p</u>
Function 1	99.2	.622	.61	18.06	4	.001
Function 2	.8	.071	.995	.187	1	.666

Using the discriminant function and the weighted cutting scores determined by the total value analysis, each case was classified to one of the three groups on the basis of its discriminant score. Table 8 presents the classification matrices for the three-group discriminant analysis for both the original analysis sample and for a cross-validated sample. The results of the discriminant analysis conducted with the original sample were cross-validated using the *U*-method. The *U*-method is a form of the “leave-one-out” estimator of classification accuracy. In this procedure, each observation was eliminated in turn from the sample and then classified by the classification rule generated with the remaining sample. The proportion of observations removed and then correctly classified produces a valid and consistent estimate of the classification accuracy rate (Hair et al., 1995). The classification results of the cross-validation sample misclassified two more cases than the results obtained with the original analysis sample.

Table 8
Classification Matrices for Three-Group Discriminant Analysis for Original Analysis & Cross-Validation Samples

True Group Membership	Predicted Group Membership		
	Indeterminate	Inattentive	Impulsive
Original Analysis Sample (52.5% accuracy rate)			
Indeterminate	5 [35.7%]	8 [57.1%]	1 [7.1%]
Inattentive	5 [29.4%]	10 [58.8%]	2 [11.8%]
Impulsive	0 [0%]	3 [33.3%]	6 [66.7%]
Cross-validated Sample (47.5% accuracy rate)			
Indeterminate	4 [28.6%]	9 [64.3%]	1 [7.1%]
Inattentive	6 [35.3%]	9 [52.9%]	2 [11.8%]
Impulsive	0 [0%]	3 [33.3%]	6 [66.7%]

In the original analysis sample, 52.5% of the cases were correctly classified. The classification rate in the cross-validation sample was 47.5% using the *U*-method of sequentially predicting each case's group membership based on the discriminant function calculated with the remaining sample. The proportional chance criterion was used as a measure of predictive accuracy (see Hair et al., 1995). Based on the size of the three groups in the sample, this criterion suggested that a function should demonstrate a hit rate greater than 35% to exceed the odds of correctly classifying cases to the groups by chance alone. An acceptable level of predictive accuracy is generally considered to be at least one-fourth greater than chance, or in this case 44%.

As is evident in the scatterplot of the three groups' two discriminant function values (Figure 1). Function 1 distinguishes the impulsive group from the indeterminate group relatively successfully. The inattentive and indeterminate groups appear more

difficult to isolate on the basis of their multivariate profiles. As suggested by its lack of significance, the second function contributes little to the distinction between groups.

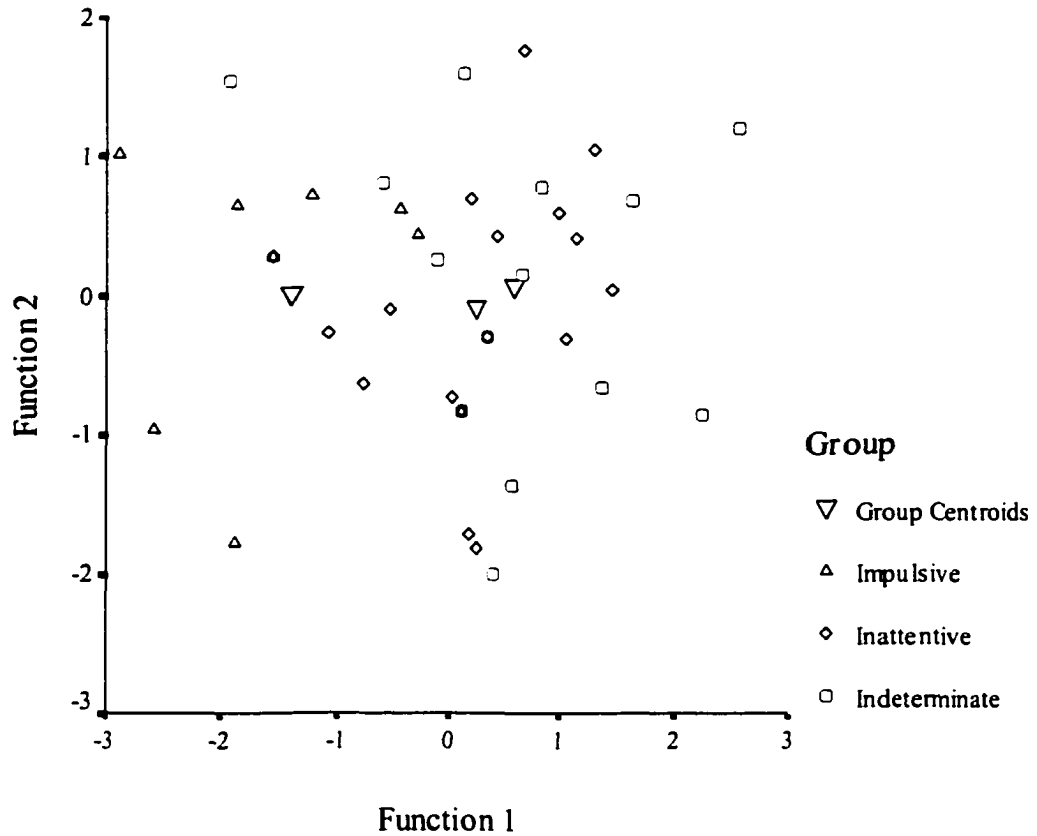


Figure 1. Scatterplot of three groups' values on discriminant functions 1 and 2

Discussion

The first hypothesis, that children with nonclinical CPT-II profiles would exhibit less impairment on the other clinical measures (BASC TRS and SRP, CVLT-C, and WCST) and have fewer ADHD diagnoses than those with clinical profiles was not supported by the results of the present study. The majority (60%) of the sample obtained clinical CPT-II profiles. Comparison of the clinical and nonclinical CPT-II groups yielded differences only in gender. There was no evidence of greater impairment on the clinical measures among the children with clinical CPT-II profiles relative to those with nonclinical profiles. There was also no evidence of significant diagnostic differences between the clinical and nonclinical CPT-II groups. Almost all of the children in the sample had been diagnosed with ADHD, most likely reflecting the high prevalence of the diagnosis in clinical samples of children referred for neuropsychological evaluation.

The second hypothesis was that the children with inattentive and impulsive CPT-II profiles would differ in ways consistent with the literature on ADHD subtypes. The results of the present study did not support this hypothesis. Thirty-five percent of the current sample obtained profiles that did not demonstrate a preponderance of either inattentive or impulsive problems, suggesting that many times CPT-II results may not suggest an ADHD subtype. Of those that did demonstrate a profile consistent with either predominantly inattentive or impulsive difficulties, there were no significant differences in age, diagnoses, or gender. The only significant difference observed was in the use of

semantic clustering during the CVLT-C. Given the literature on greater learning problems in the ADHD/I subtype relative to the ADHD/HI subtype, it was expected that those with inattentive CPT-II profiles would exhibit greater impairment on a learning task such as the CVLT-C; but it was the impulsive group who in fact performed significantly worse. Normatively, the mean Semantic Cluster Ratio score ($T = 39$) for the children with impulsive CPT-II profiles was roughly one standard deviation below the mean.

Although this result was unexpected, there is support in the literature for an association between impulsivity and less use of active learning strategies. The underutilization of an organizational strategy to complete the CVLT-C task may be due to executive dysfunction, rather than learning deficits per se. The organization of information for the purpose of encoding it and retrieving it from memory may be seen as an executive function dependent on attention for optimal performance. As discussed in the introduction, the frontal lobes are believed to play an important role in executive functions and it has been proposed that their delayed maturation may play a role in the neurobiology of ADHD. Damage to the prefrontal cortex has been associated with deficits in the organization of the use of strategy (see Cohen, 1997). The literature on the neuropsychological test performance of the ADHD subtypes suggests that children with ADHD/HI exhibit greater executive dysfunction than the other two groups (see Barkley, 1998; Houghton et al., 1999). Barkley (1998) also suggests that attention deficits with hyperactivity/impulsivity are associated with functional abnormalities of the prefrontal- limbic pathway to a greater extent than attention deficits without hyperactivity/impulsivity.

There are normal maturational changes associated with the use of learning strategy. Research suggests that as children age they increasingly develop competency in the use of strategies such as semantic clustering to encode and retrieve information from memory (see Boyd, 1988, Delis et al., 1994). Children eight and under rarely approach learning and memory tasks with an organized strategy. Between the ages of nine and twelve, children begin to use mnemonic strategies with increasing frequency, and continue to develop use of these skills into adolescence. T-scores were used in the present research rather than raw scores so that each participant's performance was compared to the appropriate norms for his/her age. Perhaps the children who produced impulsive CPT-II profiles are experienced delayed maturation of the frontal lobes and developing strategic learning skills at a slower rate than their peers. This possibility highlights the importance of assessing learning skills in children with ADHD and considering the need for academic remediation.

The results also revealed a trend for those with impulsive CPT-II profiles to report higher levels of anxiety than those with inattentive or indeterminate profiles. This also ran counter to the hypothesis that the children with predominantly inattentive profiles would report more internalizing symptoms as has been reported with the ADHD/I subtype. Although these results did not support the hypothesis, the potential relationship between self-reported anxiety and laboratory-measured impulsivity raises several interesting possibilities. Many measures of anxiety distinguish between *trait* anxiety, a stable individual difference in anxiety proneness, and *state* anxiety, the respondent's current transient level of anxiety. Obviously, these two forms of anxiety are related; the higher an individual is on trait anxiety, the greater the likelihood that they are currently

experiencing a high level of state anxiety. Individual differences in trait anxiety may be due to the individual interpreting more situations as dangerous (threat of loss, criticism, or harm), having experienced more intense or frequent anxiety in the past, greater ease of physiological arousal, and/or greater perceived likelihood of experiencing anxiety in the future (see Barlow, 1988; Reineke, Dattilio, & Freeman, 1996; Spielberger, Goruch, Luschene, Vagg, & Jacobs, 1983). The BASC SRP Anxiety subscale appears to measure trait anxiety to a greater extent than state anxiety. An interaction between high trait anxiety and high levels of stress has been shown to increase children's state anxiety and negatively impact their cognitive performance (Houston, Fox, Forbes, 1984; Meijer, 2001). Perhaps the children who rated themselves higher on trait anxiety were also those most likely to experience state anxiety under the situational stress of neuropsychological testing and produce an impulsive CPT-II profile. It is possible that the scores comprising the impulsive CPT-II profile (i.e., fast hit reaction time, high rates of commission errors, perseverations) are those most affected by state anxiety. This possibility is supported by Epstein, Goldberg, Conners, and March's (1997) report that cognitive anxiety such as worry resulted in more impulsive responding among their clinical sample of boys on Conners' earlier version of the CPT.

The potential relationship between anxiety and CPT-II impulsivity observed in the present study may also provide support for Ballard's (2001) claim that performance on the Conners' CPT-II response-inhibition paradigm is influenced by an interaction between environmental volume and respondent anxiety. Her research has suggested that adults who reported higher rates of anxiety make fewer CPT errors of commission in loud environments than in more quiet settings. The CPT-II's in the present research were

administered under relatively quiet conditions. Future research may further explore the potential impact of anxiety level and environmental conditions on children's CPT-II performance. Clinically, this finding raises the possibility that ADHD children's impulsive behavior may be due in part to anxiety. This highlights the importance of assessing comorbid conditions in children with ADHD and considering comorbid conditions in treatment selection. The results of the NIMH Multimodal Treatment Study of ADHD (MTA) study demonstrated that most children with ADHD responded more favorably to pharmacotherapy or a combination of medication and behavioral interventions than to behavioral treatment alone or routine community care. However, further analyses revealed that children with ADHD and a comorbid anxiety disorder responded most favorably to behavioral and combination treatments (Jenkins, Hinshaw, Kraemer et al., 2001; Jenkins, Hinshaw, Swanson, et al., 2001).

Even given the relatively elevated Anxiety score, the mean SRP Anxiety score of the children with impulsive profiles was still normatively within the average range ($T = 56$). Interestingly, Manning and Miller (2001) also reported that the relatively elevated BASC scores for their ADHD sample were also still within the average range normatively. This level of anxiety is most likely not associated with subjective distress or significant impairment in functioning. However, there were children in the sample that reported anxiety in the Clinically Significant range ($T\text{-score} > 69$). For children with significant anxiety, there are several treatment options. Anxiolytics and antidepressants with anti-anxiety properties are sometimes used, but the safety and effectiveness of most of these medications has not been established with children. Cognitive-behavioral approaches pairing imaginal and *in vivo* exposure to anxiety provoking stimuli with

education about identifying anxious feelings, relaxation techniques, and coping strategies have also been used to treat anxiety in children (see Levin, Ashmore-Callahan, Kendall, & Ichii, 1996).

After testing the hypothesis that the inattentive, impulsive, and indeterminate CPT-II groups would differ, multiple discriminant analysis was used to further explore the differences between the groups and to assess the predictive accuracy of a classification rule based on their multivariate profiles. The discriminant function analysis suggested that membership in this study's indeterminate, inattentive, and impulsive groups may be predicted with 47.5% accuracy using two functions based on children's CVLT-C Semantic Cluster Ratio and the BASC SRP Anxiety score. The discriminant loadings suggested the Semantic Cluster Ratio score best differentiated between groups. The BASC SRP Anxiety score contributed very little to the functions' ability to differentiate between groups and the second function failed to reach statistical significance. As discussed in the Results section, the 47.5% hit rate significantly exceeds the rate that could be achieved assigning cases to groups by chance alone, but it should be viewed with caution. An internal classification analysis with no hold-out sample such as the present study can bias the predictive accuracy upward. The small sample size of the present study can also contribute to instability in the discriminant function generated. The results should be viewed with caution unless replicated with a larger independent sample.

The third and final hypothesis was that the groups defined by elevations on either the omission or commission scores of the CPT-II would demonstrate differences on the dependent measures consistent with the literature on ADHD subtypes. This hypothesis

was also not supported. The children with at least a 10-point discrepancy between omissions and commissions did not differ significantly in age, gender, diagnoses, or scores on the BASC TRS or SRP, the CLVT-C, or WCST. The failure to identify significant differences does not support implications for ADHD subtype based on these two CPT-II scores alone.

As discussed in the introduction, the ADHD subtypes defined in DSM-IV (1994) continue to raise controversy. Moffitt, Caspi, Dickson, Silva, and Stanton (1996) discuss the usefulness of subtyping disorders and state that clinicians and research will only differentiate between subtypes if doing so provides useful information regarding etiology, course, complicating features, prognosis, and/or treatment. The literature reviewed suggests that the ADHD subtypes differ sufficiently for their identification to convey useful information. Despite these differences between the subtypes, few assessment measures have demonstrated a reliable ability to differentiate between them. The CPT-II appears to lend itself to the distinction between inattentive and impulsive problems, but the results of the present study do not provide support for the use of the CPT-II to identify ADHD subtypes. In the present sample, the children identified as having primarily problems of inattention did not differ much from those whose primary difficulty was identified as impulsivity. Most tellingly, the two groups did not differ in teacher-rated symptoms of inattention and hyperactivity. As discussed in the introduction, the classroom is often the place where such ADHD symptoms are most obvious and teachers are generally exposed to enough children to rate what is age-appropriate versus atypical behavior. If these clinic-based measures of inattention and impulsivity were strongly related to children's everyday activity, one would expect a

significant difference between groups in teacher rated behavior. As reviewed in the Measures section of the Method chapter, previous research has provided mixed support for a relationship between children's performance on the Conners' CPT and their teachers' ratings of behavior (see Conners, 2000). Future research is needed to explore the concurrent validity of the CPT-II's inattentive and impulsive profiles with rating scales for these behaviors, as well as the implications of the CPT-II profiles for identifying ADHD subtypes.

The results of the present study must be viewed in light of its limitations. The sample size met the minimum criteria to perform the statistical analyses, but was small. The small sample size limits the power of the present study to detect differences between groups and the results may not be as stable as those achieved with a larger sample size. The sample was also limited in diversity. None of the children in the sample were diagnosed with ADHD/HI. This may reflect the rarity of this diagnosis relative to the other ADHD subtypes especially in older children (Biederman et al., 1997; Faraone et al., 1998; Lahonde et al., 1998; Nolan et al., 1999). A coding issue could also have impacted the identification of cases of ADHD/HI in the present sample. ADHD/I is coded as 314.00 in the DSM-IV (1994), but both ADHD/HI and ADHD/C are coded as 314.01, making it difficult to differentiate which subtype was diagnosed by reviewing a child's chart unless it is explicitly stated. The sample was also limited by being predominantly male. This too most likely reflects the skewed gender ratio of ADHD, particularly in clinical samples (DSM-IV-TR, 2000; Nolan et al., 1999). Although, race/ethnicity was unspecified in most cases, the majority of participants in the present study were most likely Caucasian given the demographics of Montana. The sample was also limited by

the lack of a nonclinical control group for comparison, as well as the lack of control for comorbid diagnoses or psychotropic medication use. As a result of these limitations, the results should be replicated with larger, more diverse samples before any effort is made to generalize to other populations.

Future research may improve upon the generalizability of this study by replicating with a larger sample and with children from different settings. The stability and validity of the discriminant function is uncertain until examined with an independent sample. Other potential areas of investigation include examining the relationship between CPT-II profiles and other measures, including a normal control group for comparison, and further examining the influence of comorbid conditions and psychotropic medication use.

Given the complexity and importance of assessing and diagnosing ADHD and its subtypes, the topic is likely to continue to arouse interest, as well as public and scientific controversy. Future research should continue to explore how to better assess children's inattentiveness and impulsivity and contribute to our understanding of the differences between the ADHD subtypes. The results of present study as well as those of the recent NIMH Collaborative Multisite Multimodal Treatment Study of Children with ADHD (Jensen, Hinshaw, Kraemer, et al., 2001) highlight the importance of assessing not only ADHD children's inattentive and impulsive symptoms, but of considering the implications of comorbid conditions such as anxiety, learning problems, and executive dysfunction for treatment selection. Most importantly, future research must continue to address the translation of our ADHD assessment findings into useful suggestions for clinical treatment and academic remediation.

References

- AACAP Official Action (1997). Summary of the practice parameters for the assessment and treatment of children, adolescents, and adults with ADHD. Journal of the American Academy of Child and Adolescent Psychiatry, 36, 1311-1317.
- AACAP Official Action (2001). Practice parameter for the use of stimulant medications in the treatment of children, adolescents, and adults. Journal of the American Academy of Child and Adolescent Psychiatry, 41, 26S-49S.
- Achenbach, T. M., & Edelbrock, C. S. (1981). Behavior problems and competencies reported by parents of control and disturbed children aged four through sixteen. Monographs of the Society for Research in Child Development, 46, 1, serial no. 188.
- American Academy of Pediatrics (2000). Clinical practice guidelines: Diagnosis and evaluation of the child with Attention-Deficit/Hyperactivity Disorder. Pediatrics, 105, 1158-1170.
- American Psychiatric Association (1968). Diagnostic and statistical manual of mental disorders (2nd ed.). Washington, DC: American Psychiatric Association.
- American Psychiatric Association (1980). Diagnostic and statistical manual of mental disorders (3rd ed.). Washington, DC: American Psychiatric Association.
- American Psychiatric Association (1987). Diagnostic and statistical manual of mental disorders (3rd ed., revised). Washington, DC: American Psychiatric Association.
- American Psychiatric Association (1994). Diagnostic and statistical manual of mental disorders (4th ed.). Washington, DC: American Psychiatric Association.
- American Psychiatric Association (2000). Diagnostic and statistical manual of mental disorders (4th ed., text revision). Washington, DC: American Psychiatric Association.
- Applegate, B., Lahey, B. B., Hart, E., Biederman, J., Hynd, G. W., Barkley, R. A., Ollendick, T., Rick, P. J., Greenhill, L., McBurnett, K., Newcorn, J. H., Kerdyk, Garfinkel, B., Waldman, I., & Shaffer, D. (1997). Validity of the age-of-onset criterion of ADHD: A report from the DSM-IV field trails. Journal of the American Academy of Child and Adolescent Psychiatry, 36, 1211-1221.

- Armstrong, C. L., Hayes, K. M., & Martin, R. (2001). Neurocognitive problems in attention deficit disorder: Alternative concepts and evidence for impairment in inhibition of selective attention. Annals of the New York Academy of Sciences, 931, 196-215.
- Babinski, L. M., Hartsough, C. S., & Lambert, N. M. (1999). Childhood conduct problems, hyperactivity-impulsivity, and inattention as predictors of adult criminal activity. Journal of Child Psychology and Psychiatry, 40, 347-355.
- Ballard, J. C. (2001). Assessing attention: Comparison of response-inhibition and traditional continuous performance tests. Journal of Clinical and Experimental Neuropsychology, 23, 331-350.
- Barkley, R. A. (1989). Ritalin treatment for attention deficit hyperactivity disorder. In D. W. Maxey, How to own and operate an attention deficit kid: A booklet for parents and teachers (pp. 40-44).
- Barkley, R. A. (1998). Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment (2nd ed.). New York: The Guilford Press.
- Barkley, R. A. (2001). The inattentive type of ADHD as a distinct disorder: What remains to be done [Abstract]. Clinical Psychology: Science & Practice, 8, 489-501.
- Barkley, R. A., DuPaul, G. J., & McMurray, M. B. (1991). Attention deficit disorder with and without hyperactivity: Clinical response to three dose levels of methylphenidate. Pediatrics, 87, 519-531.
- Barkley, R. A., Grodzinsky, G., & DuPaul, G. J. (1992). Frontal lobe functions in attention deficit disorder with and without hyperactivity: A review and research report. Journal of Abnormal Child Psychology, 20, 163-187.
- Barlow, D. H. (1988). Anxiety and its disorders: The nature and treatment of anxiety and panic. New York: The Guilford Press.
- Baumgaertel, A., Wolraich, M. L., & Dietrich, M. (1995). Comparison of diagnostic criteria for attention deficit disorders in a German elementary school sample. Journal of the American Academy of Child and Adolescent Psychiatry, 34, 629-638.
- Beiser, M., Dion, R., & Gotowiec, A. (2000). The structure of attention-deficit and hyperactivity symptoms among native and non-native elementary school children. Journal of Abnormal Child Psychology, 28, 435-437.
- Bellak, L., & Black, R. B. (1992). Attention-deficit hyperactivity disorder in adults. Clinical Therapeutics, 14, 138-147.

- Biederman, J., Faraone, S. V., Spencer, T., Wilens, T., Norman, D., Lapey, K. A., Mick, E., Lehman, B. K., & Doyle, A. (1993). Patterns of psychiatric comorbidity, cognition, and psychosocial functioning in adults with attention deficit hyperactivity disorder. American Journal of Psychiatry, *150*, 1792-1798.
- Biederman, J., Faraone, S. V., Weber, W., Russell, R., Rater, M., & Park, K. (1997). Correspondence between DSM-III-R and DSM-IV attention-deficit/hyperactivity disorder. Journal of the American Academy of Child and Adolescent Psychiatry, *36*, 1682-1687.
- Biederman, J., Mick, E., Faraone, S. V., Braaten, E., Doyle, A., Spencer, T., Frazier, E., & Johnson, M. A. (2002). Influence of gender on attention deficit hyperactivity disorder in children referred to a psychiatric clinic. American Journal of Psychiatry, *159*, 36-42.
- Biederman, J., Newcorn, J., & Sprich, S. (1991). Comorbidity of attention deficit hyperactivity disorder with conduct, depressive, anxiety, and other disorders. American Journal of Psychiatry, *148*, 564-577.
- Boyd, T. A. (1988). Clinical assessment of memory in children. In M. G. Tramontana & S. R. Hooper (Eds.), Assessment issues in child neuropsychology (pp. 281-312). New York, NY: Plenum Press.
- Cantwell, D. P., & Baker, L. (1992). Attention deficit disorder with and without hyperactivity: A review and comparison of matched groups. Journal of the American Academy of Child and Adolescent Psychiatry, *31*, 432-438.
- Carlson, C. L., Shin, M., & Booth, J. (1999). The case for DSM-IV subtypes in ADHD. Mental Retardation and Developmental Disabilities Research Reviews, *5*, 199-206.
- Carte, E. T., Nigg, J. T., & Hinshaw, S. P. (1996). Neuropsychological functioning, motor speed, and language processing in boys with and without ADHD. Journal of Abnormal Child Psychology, *24*, 481-498.
- Castellanos, F. X., Giedd, J. N., Marsh, W. L., Hamburger, S. D., Vaituzis, A. C., Dickstein, D. P., Sarfatti, S. E., Vauss, Y. C., Snell, J. W., Rajapakse, J. C., & Rapoport, J. L. (1996). Quantitative brain magnetic resonance imaging in Attention-Deficit Hyperactivity Disorder. Archives of General Psychiatry, *53*, 607-616.
- Chamber, W. J., Puig-Antich, J., Hirsch, M., et al. (1985). The assessment of affective disorders in children and adolescents by semi-structured interview. Archives of General Psychiatry, *42*, 696-702.
- Chan, E., Zhan, C., & Homer, C. J. (2002). Health care use and costs for children with attention-deficit/hyperactivity disorder: National estimates from the medical

- expenditure panel survey. Archives of Pediatric and Adolescent Medicine, 156, 504-511.
- Chhabildas, N., Pennington, B. F., & Willcutt, E. G. (2001). A comparison of the neuropsychological profiles of the DSM-IV subtypes of ADHD [Abstract]. Journal of Abnormal Child Psychology, 29, 529-540.
- Cohen, M. J. (1997). CMS: Children's memory scale manual. San Antonio: The Psychological Corporation.
- Conners, C. K. (1994). Conners' continuous performance test computer program 3.0: User's manual. North Tonawanda, NY: Multi-Health Systems, Inc.
- Conners, C. K. (2000). Conners' Continuous Performance Test (CPT-II): Computer program for Windows technical guide and software manual. North Tonawanda, NY: Multi-Health Systems, Inc.
- Conners, C. K., Casat, C. D., Gualtieri, C. T., Weller, E., Reader, M., Reiss, A., Weller, R. A., Khayrallah, M., & Ascher, J. (1996). Bupropion hydrochloride in attention deficit disorder with hyperactivity. Journal of the American Academy of Child and Adolescent Psychiatry, 34, 1314-1321.
- Costello, E. J., Edelbrock, C. S., & Costello, A. J. (1985). Validity of the NIMH Diagnostic Interview Schedule for Children: A comparison between psychiatric and pediatric referrals. Journal of Abnormal Child Psychology, 13, 579-595.
- Dane, A.V., Schachar, R. J., & Tannock, R. (2000). Does actigraphy differentiate ADHD subtypes in a clinical research setting? Journal of the American Academy of Child and Adolescent Psychiatry, 39, 752-760.
- Decker, S. L., McIntosh, D. E., Kelly, A. M., Nicholls, S. K., & Dean, R. S. (2001). Comorbidity among individuals classified with attention disorders [Abstract]. International Journal Neuroscience, 110, 43-54.
- Delis, D. C., Kramer, J. H., Kaplan, E., & Ober, B. A. (1994). California Verbal Learning Test - Children's Version: Manual. San Antonio: The Psychological Corporation.
- Eiraldi, R. B., Power, T. J., & Nezu, C. M. (1997). Patterns of comorbidity associated with subtypes of attention-deficit/hyperactivity disorder among 6- to 12-year-old children. Journal of the American Academy of Child and Adolescent Psychiatry, 36, 503-514.

- Epstein, J. N., Goldberg, N. A., Conners, C. K., & March, J. S. (1997). The effects of anxiety on continuous performance test functioning in an ADHD clinical sample. Journal of Attention Disorder, *2*, 45-52.
- Ervin, R. A., Bankert, C. L., & DuPaul, G. J. (1996). Treatment of attention-deficit/hyperactivity disorder. In M. A. Reineke, F. M., Dattilio, & A. Freeman (Eds.), Cognitive therapy with children and adolescents (pp. 38-61). New York: The Guilford Press.
- Faraone, S. V. (2000). Genetics of childhood disorders: XX, ADHD, Part 4: Is ADHD genetically heterogeneous? Journal of the American Academy of Child and Adolescent Psychiatry, *39*, 1455-1457.
- Faraone, S. V., Biederman, J., & Friedman, D. (2000). Validity of DSM-IV subtypes of attention-deficit/hyperactivity disorder: A family study perspective. Journal of the American Academy of Child and Adolescent Psychiatry, *39*, 300-307.
- Faraone, S. V., Biederman, J., Jetton, J. G., & Tsuang, M. T. (1997). Attention deficit disorder and conduct disorder: Longitudinal evidence for a familial subtype. Psychological Medicine, *27*, 291-300.
- Faraone, S. V., Biederman, J., Mennin, D., Russell, R., & Tsuang, M. T. (1998). Familial subtypes of attention deficit hyperactivity disorder: A 4-year follow-up study of children from antisocial-ADHD families. Journal of Child Psychology and Psychiatry, *39*, 1045-1053.
- Faraone, S. V., Biederman, J., Mick, E., Williamson, S., Wilens, T., Spencer, T., Weber, W., Jetton, J., Kraus, I., Pert, J., & Zallen, B. (2000). Family study of girls with attention deficit hyperactivity disorder. American Journal of Psychiatry, *157*, 1077-1083.
- Faraone, S. V., Biederman, J., Weber, W., & Russell, R. L. (1998). Psychiatric, neuropsychological, and psychosocial features of DSM-IV subtypes of attention-deficit/hyperactivity disorder: Results from a clinically referred sample. Journal of the American Academy of Child and Adolescent Psychiatry, *37*, 185-193.
- Fischer, M., Barkley, R. A., Edelbrock, C. S., & Smallish, L. (1990). The adolescent outcome of hyperactive children diagnosed by research criteria: II. Academic, attentional, and neuropsychological status. Journal of Consulting and Clinical Psychology, *58*, 580-588.
- Flashman, L. A., Horner, M. D., & Freides, D. (1991). Note on scoring perseveration on the Wisconsin Card Sorting Test. The Clinical Neuropsychologist, *5*, 190-194.

- Fuster, J. M. (1989). The prefrontal cortex: Anatomy, physiology, and neuropsychology of the frontal lobe (2nd ed.). New York: Raven Press.
- Gammon, G. D., & Brown, T. E. (1993). Fluoxetine and methylphenidate in combination for treatment of attention deficit disorder and comorbid depressive disorder. Journal of Child and Adolescent Psychopharmacology, 3, 1-10.
- Garber, S. W., Garber, M. D., & Spizman, R. F. (1996). Beyond Ritalin. New York: Harper Perennial.
- Goodyear, P. & Hynd (1992). Attention-deficit disorder with (ADD/H) and without (ADD/WO) hyperactivity: Behavioral and neuropsychological differentiation. Journal of Clinical Child Psychology, 21, 273-305.
- Graetz, B. W., Sawyer, M. G., Hazell, P. L., Arney, F., & Baghurst, P. (2001). Validity of DSM-IV ADHD subtypes in a nationally representative sample of Australian children and adolescents. Journal of the American Academy of Child & Adolescent Psychiatry, 40, 1410-1417.
- Grant, D. A., & Berg, E. A. (1948). A behavioral analysis of degree of reinforcement and ease of shifting to new responses in a Wiegler-type card-sorting problem. Journal of Experimental Psychology, 38, 404-411. As cited in Stuss, D. T., & Benson, D. F. (1986). The frontal lobes. New York: Raven Press.
- Greenhill, L. L. (1998). Childhood attention deficit hyperactivity disorder: Pharmacological treatments. In P. E. Nathan & J. M. Gorman (Eds.), A guide to treatments that work (pp. 42-64). New York: Oxford University Press.
- Grilly, D. M. (1994). Drugs and Human Behavior (2nd ed.). Boston: Allyn and Bacon.
- Grimm, L. G., & Yarnold, P. R. (1995). Reading and understanding multivariate statistics. Washington, DC: American Psychiatric Association.
- Hair, J. F., Jr., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). Multivariate data analysis with readings (4th ed.). New Jersey: Prentice Hall.
- Halperin, J. M., Newcorn, J. H., Sharma, V., Healey, J. M., Wolfe, L. E., Pascualvaca, D. M., & Schwartz, S. (1990). Inattentive and noninattentive ADHD children: Do they constitute a unitary group? Journal of Abnormal Child Psychology, 18, 437-499.
- Heaton, R. K. (1981). A manual for the Wisconsin Card Sorting Test. Psychological Assessment Resources, Inc.
- Heaton, R. K., Chelune, G. J., Talley, J. L., Kay, G. G., & Curtiss, G. (1993). Wisconsin Card Sorting Test manual. Psychological Assessment Resources, Inc.

- Hechtman, L. (1985). Adolescent outcome of hyperactive children treated with stimulants in childhood: A review. Psychopharmacological Bulletin, 21, 178-191.
- Hechtman, L., Weiss, G., & Perlman, T. (1984). Young adult outcome of hyperactive children who received long-term stimulant treatment. Journal of the American Academy of Child Psychiatry, 23, 261-269.
- Herjanic, B., & Campbell, W. (1977). Differentiating between psychiatrically disturbed children on the basis of a structured interview. Journal of Abnormal Child Psychology, 5, 127-143.
- Herpertz, S. C., Wenning, B., Mueller, B., Qunaibi, M., Sass, H., & Herpertz-Dahlmann, B. (2001). Psychophysiological responses in ADHD boys with and without conduct disorder: Implications for adult antisocial behavior. Journal of the American Academy of Child and Adolescent Psychiatry, 40, 1222-1230.
- Herrera's, C. T., Perrin, J. M., & Stein, M. T. (2001). The child with ADHD: Using the AAP Clinical Practice Guidelines. American Family Physician, 63, 1803-1810.
- Hesslinger, B., Thiel, T., Tebartz van Elst, L., Hennig, J., & Ebert, D. (2001). Attention-deficit disorder in adults with or without hyperactivity: Where is the difference? A study in humans using short echo ¹H-magnetic resonance spectroscopy. Neuroscience Letter, 304, 117-119.
- Hinshaw, S. P. (2001). Is the inattentive type of ADHD a separate disorder [Abstract]? Clinical Psychology: Science & Practice, 8, 498-501.
- Hinshaw, S. P., Klein, R. G., & Abikoff, H. (1998). Childhood attention deficit hyperactivity disorder: Nonpharmacological and combination treatments. In P.E. Nathan & J.M. Gorman (Eds.), A guide to treatments that work (pp. 26-41). New York: Oxford University Press.
- Houghton, S., Douglas, G., West, J., Whiting, K., Wall, M., Langsford, S., Powell, L., & Carroll, A. (1999). Differential patterns of executive function in children with attention-deficit hyperactivity disorder according to gender and subtypes. Journal of Child Neurology, 14, 801-805.
- Houston, B. K., Fox, J. E., & Forbes, L. (1984). Trait anxiety and children's state anxiety, cognitive behaviors, and performance under stress [Abstract]. Cognitive Therapy & Research, 8, 631-641.
- Hudziak, J. J., Heath, A. C., Madden, P., Reich, W., Bucholz, K. K., Slutske, W., Bierut, L. J., Neuman, R. J., & Todd, R. D. (1998). Latent class and factor analysis of DSM-IV ADHD: A twin study of female adolescents. Journal of the American Academy of Child and Adolescent Psychiatry, 37, 848-857.

- Jackson, B., & Farrugia, D. (1997). Diagnosis and treatment of adults with attention deficit hyperactivity disorder. Journal of Counseling and Development, 75, 312-319.
- Jenkins, M., Cohen, R., Mallory, P., Salloway, S., Johnson, E. G., Penn, J., & Marcotte (1998). Neuropsychological measures which discriminate among adults with residual symptoms of attention deficit disorder and other attentional complaints. The Clinical Neuropsychologist, 12, 74-83.
- Jensen, P. S., Hinshaw, S. P., Kraemer, H. C., Lenora, N., Newcorn, J. H., Abikoff, H. B., March, J. S., Arnold, L. E., Cantwell, D. P., Conners, C. K., Elliott, G. R., Greenhill, L. L., Hechtman, L., Hoza, B., Pelham, W. E., Severe, J. B., Swanson, J. M., Wells, K. C., Wigal, T., & Vitiello, B. (2001). ADHD comorbidity findings from the MTA study: Comparing comorbid subgroups. Journal of the American Academy of Child & Adolescent Psychiatry, 40, 147-158.
- Jensen, P. S., Shervette, R. E., Xenakis, S. N., & Richters, J. (1993). Anxiety and depressive disorders in attention deficit disorder with hyperactivity: New findings. American Journal of Psychiatry, 150, 1203-1209.
- Kaplan, H. I., Sadock, B. J., & Grebb, J. A. (1994). Kaplan and Sadock's synopsis of psychiatry: Behavioral sciences, clinical psychiatry (7th ed.). Baltimore: Williams & Wilkins.
- Kazdin, A. E. (1997). Practitioner review: Psychosocial treatments for conduct disorders in children. Journal of Psychology and Psychiatry, 38, 161-178.
- Kirlin, K. (2000). Attention deficits as measured by Conners' CPT and children's performance on neuropsychological measures of learning and executive function. Unpublished master's thesis, University of Montana, Missoula.
- Klein, R. G., & Mannuzza, S. (1991). Long-term outcome of hyperactive children: A review. Journal of the American Academy of Child and Adolescent Psychiatry, 30, 383-387.
- Kramer, J. H., Knee, K., & Delis, D. C. (2000). Verbal memory impairments in dyslexia. Archives of Clinical Neuropsychology, 15, 83-93.
- Krull, K., & Lorano, V. (2000). Progression of performance on the Gordon Vigilance and Distractibility Tasks in ADHD subtypes [Abstract]. Journal of the International Neuropsychological Society, 6, 121-122.
- Lahey, B. B. (2001). Should the combined and predominantly inattentive types of ADHD be considered distinct and unrelated disorders? Not now, at least [Abstract]. Clinical Psychology: Science & Practice, 8, 494-497.

- Lahey, B. B., & Loeber, R. (1997). Attention-deficit/hyperactivity disorder, oppositional defiant disorder, conduct disorder, and adult antisocial behavior: A life span perspective. In D. M. Stoff, J. Breiling, & J. D. Maser (Eds.), Handbook of antisocial behavior (pp. 51-59). New York: John Wiley & Sons, Inc.
- Lahey, B. B., Applegate, B., McBurnette, K., Biederman, J., Greenhill, L., Hynd, G. W., Barkley, R. A., Newcorn, J., Jensen, P., Richters, J., Garkinkel, B., Kerdyk, L., Frick, P. J., Ollendick, T., Perez, D., Hart, E. L., Waldman, I., & Shaffer, D. (1994). DSM-IV field trials for attention deficit hyperactivity disorder in children and adolescents. American Journal of Psychiatry, *151*, 1673-1685.
- Lahey, B. B., McBurnett, K., & Loeber, R. (2000). Are attention-deficit/hyperactivity disorder and oppositional defiant disorder developmental precursors to conduct disorder? In A. J. Sameroff, M. Lewis, & S. M. Miller (Eds.), Handbook of developmental psychopathology (2nd ed.) (pp. 431-443). New York: Plenum Press.
- Lahey, B. B., Pelham, W. E., Stein, M. A., Loney, J., Trapani, C., Nugent, K., Kipp, H., Schmidt, E., Lee, S., Cale, M., Cold, E., Hartung, C. M., Willcutt, E., & Baumann, B. (1998). Validity of DSM-IV attention-deficit/hyperactivity disorder for young children. Journal of the American Academy of Child and Adolescent Psychiatry, *37*, 695-702.
- Lalonde, J., Turgay, A., & Hudson, J. I. (1998). Attention-deficit hyperactivity disorder subtypes and comorbid disruptive behaviour disorders in a child and adolescent mental health clinic. Canadian Journal of Psychiatry, *43*, 623-628.
- Lamminmäki, T., Ahonen, T., Närhi, V., & Lyytinen, H., & de Barra, H. T. (1995). Attention deficit hyperactivity disorder subtypes: Are there differences in academic problems? Developmental Neuropsychology, *11*, 297-310.
- Lecendreux, M., Konofal, E., Bouvard, M., Falissard, B., & Mouren-Siméoni, M. C. (2000). Sleep and alertness in children with ADHD. Journal of Child Psychology and Psychiatry, *41*, 803-812.
- Levant, R. F. (2000). White House meeting on mental health of children. APAGSREP e-mail.
- Levin, H. S., Eisenberg, H. M., & Benton, A. L. (1991). Frontal lobe function and dysfunction. New York: Oxford University Press.
- Levin, M. R., Ashmore-Callahan, S., Kendall, P. C., & Ichii, M. (1996). Treatment of separation anxiety disorder. In M. A. Reineke, F. M., Dattilio, & A. Freeman (Eds.), Cognitive therapy with children and adolescents (pp. 153-174). New York: The Guilford Press.

- Lockwood, K. A., Marcotte, A. C., & Stern, C. (2001). Differentiation of attention-deficit/hyperactivity disorder subtypes: Application of a neuropsychological model of attention. Journal of Clinical Experimental Neuropsychology, *23*, 317-330.
- Lou, H. C., Henriksen, L. Bruhn, P., Borner, H., & Nielsen, J. B. (1989). Striatal dysfunction in attention deficit and hyperkinetic disorder. Archives of Neurology, *46*, 48-52.
- Maedgen, J. W., & Carlson, C. L. (2000). Social functioning and emotional regulation in the attention deficit hyperactivity subtypes. Journal of Clinical Child Psychology, *29*, 30-42.
- Malone, M. A., & Swanson, J. M. (1993). Effects of methylphenidate on impulsive responding in children with attention-deficit hyperactivity disorder. Journal of Child Neurology, *8*, 157-163.
- Manning, S. C., & Miller, D. C. (2001). Identifying ADHD subtypes using the Parent and Teacher Rating Scales of the Behavior Assessment Scale for Children. Journal of Attention Disorders, *5*, 41-51.
- Mannuzza, A., Klein, R. G., Konig, P. H., & Giampino, T. L. (1990). Childhood predictors of psychiatric status in the young adulthood of hyperactive boys: A study controlling for chance associations. In L. N. Robbins & M. Rutter (Eds.), Straight and devious pathways from childhood to adulthood (pp. 279-299). Cambridge: Cambridge University Press.
- Marks, D. J., Himelstein, J., Newcorn, J. H., & Halperin, J. M. (1999). Identification of AD/HD subtypes using laboratory-based measures: A cluster analysis. Journal of Abnormal Child Psychology, *27*, 167-175.
- McCann, B. S., Scheele, L., Ward, N., & Roy-Byrne, P. (2000). Discriminant validity of the Wender Utah Rating Scale for Attention-Deficit/Hyperactivity Disorder in adults. Journal of Neuropsychiatry and Clinical Neuroscience, *12*, 240-245.
- Meijer, J. (2001). Stress and the relation between trait and state anxiety [Abstract]. Psychological Reports, *88*, 947-964.
- Mick, E., Biederman, J., & Faraone, S.V. (1996). Is season of birth a risk for attention-deficit hyperactivity disorder? Journal of the American Academy of Child and Adolescent Psychiatry, *35*, 1470-1476.
- Milich, R., Balentine, A. C., & Lynam, D. R. (2001). ADHD combined type and ADHD predominantly inattentive type are distinct and unrelated disorders [Abstract]. Clinical Psychology: Science & Practice, *8*, 463-488.

- Mitsis, E. M., McKay, K. E., Schulz, K. P., Newcorn, J. H., & Halperin, J. M. (2000). Parent-teacher concordance for DSM-IV attention-deficit/hyperactivity disorder in a clinic-referred sample. Journal of the American Academy of Child and Adolescent Psychiatry, *39*, 308-313.
- Moffitt, T. E., Caspi, A., Dickson, N., Silva, P., & Stanton, W. (1996). Childhood-onset versus adolescent-onset antisocial conduct problems in males: Natural history from ages 3 to 18 years. Development and Psychopathology, *8*, 399-424.
- Morgan, A. E., Hynd, G.W., Riccio, C. A., & Hall, J. (1996). Validity of DSM-IV ADHD predominantly inattentive and combined types: Relationship to previous DSM diagnoses/subtype differences. Journal of the American Academy of Child and Adolescent Psychiatry, *35*, 325-333.
- Murphy, K. R., Barkley, R. A., & Bush, T. (2002). Young adults with attention deficit hyperactivity disorder: Subtype differences in comorbidity, educational, and clinical history. Journal of Nervous and Mental Disease, *190*, 147-157.
- Neuman, R. J., Todd, R. D., Heath, A. C., Reich, W., Hudziak, J. J., Bucholz, K. K., Kuperman, S., Hesselbrock, V., & Reich, T. (1999). Evaluation of ADHD typology in three contrasting samples: A latent class approach. Journal of the American Academy of Child and Adolescent Psychiatry, *38*, 25-33.
- Nigg, J. T., Blaskey, L. G., Huang-Pollock, C. L., & Rappley, M. D. (2002). Neuropsychological executive functions and DSM-IV ADHD subtypes. Journal of the American Academy of Child & Adolescent Psychiatry, *41*, 59-66.
- Nolan, E. E., Gadow, K. D., & Sprafkin, J. (2001). Teacher reports of DSM-IV ADHD, ODD, and CD symptoms in schoolchildren. Journal of the American Academy of Child and Adolescent Psychiatry, *40*, 241-249.
- Nolan, E. E., Volpe, R. J., Gadow, K. D., & Sprafkin, J. (1999). Developmental, gender, and comorbidity differences in clinically referred children with ADHD. Journal of Emotional and Behavioral Disorder, *7*, 11-20
- O'Brien, J. D., Halperin, J. M., Newcorn, J. H., Sharma, V., Wolf, L., & Morganstein, A. (1992). Psychometric differentiation of conduct disorder and attention deficit disorder with hyperactivity. Developmental and Behavioral Pediatrics, *13*, 274-277.
- Pelham, W. E., Jr. (2001). Are ADHD/I and ADHD/C the same or different? Does it matter [Abstract]? Clinical Psychology: Science & Practice, *8*, 502-506.
- Pick, J. P., Pitcher, T. M., & Hay, D. A. (1999). Motor coordination and kinaesthesia in boys with attention deficit-hyperactivity disorder. Developmental Medicine & Child Neurology, *41*, 159-165.

- Rapoport, J. L., Buchsbaum, M. S., Weingartner, H., Zahn, T. P., Ludlow, C., & Mikkelsen, E. J. (1980). Archives of General Psychiatry, *37*, 933-943.
- Reineke, M.A., Dattilio, F. M., & Freeman, A. (Eds.), Cognitive therapy with children and adolescents (pp. 38-61). New York: The Guilford Press.
- Reitan, R. M., & Wolfson, D. (1992). Neuropsychological evaluation of older children. South Tucson, AZ: Neuropsychology Press.
- Reynolds, C. R., & Kamphaus, R. W. (1998). BASC: Behavioral assessment system for children, manual. Circle Pines, MN: American Guidance Services, Inc.
- Riccio, C. A., Reynolds, C. R., Lowe, P., & Moore, J. J. (2002). The continuous performance test: A window on the neural substrates for attention. Archives of Clinical Neuropsychology, *17*, 273-282.
- Segalowitz, S. J., & Grave, R. E. (1990). Suitability of the IBM XT, AT, and PS/2 keyboard, mouse, and game port as response devices in reaction time paradigms. Behavior Research methods, Instruments, & Computers, *22*, 283-289.
- Seidel, W. T., & Joschko, M. (1991). Assessment of attention in children. The Clinical Neuropsychologist, *5*, 53-66.
- Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). Manual for the State-Trait Anxiety Inventory. Palo Alto, CA: Consulting Psychologist Press, Inc.
- Sprich-Buckminster, A., Biederman, J., Milberger, S., Faraone, S. V., & Lehman, B. K. (1993). Are perinatal complications relevant to the manifestation of ADD? Issues of comorbidity and familiarity. Journal of the American Academy of Child and Adolescent Psychiatry, *32*, 1032-1037.
- StatSoft, Inc. (2002). Discriminant function analysis. In Electronic Statistics Textbook [On-line]. Tulsa, OK: StatSoft. Available: <http://www.statsoft.com/textbook/stathome.html>
- Stuss, D. T., & Benson, D. F. (1986). The frontal lobes. New York: Raven Press.
- Tabachnick, B. G., & Fidell, L. S. (1996). Using multivariate statistics (3rd ed.). New York: HarperCollins College Publishers.
- Teegarden, L. A., & Burns, G. L. (1999). 12-month stability of ADHD, opposition defiant disorder, and conduct disorder symptoms in kindergarten through fifth grade children based on a single information source: Usefulness of teacher ratings for the

- creation and study of the ADHD subtypes. Child & Family Behavior Therapy, 21, 53-70.
- Teicher, M. H., Ito, Y., Glod, C. A., & Barber, N. I. (1996). Objective measurement of hyperactivity and attentional problems in ADHD. . Journal of the American Academy of Child and Adolescent Psychiatry, 35, 334-342.
- Todd, R. D., Rasmussen, E. R., Neuman, R. J., Reich, W., Hudziak, J. J., Bucholz, K. K., Madden, P. A. F., & Heath, A. (2001). Familiality and heritability of subtypes of attention deficit hyperactivity disorder in a population sample of adolescent female twins. American Journal of Psychiatry, 158, 1891-1898.
- Vaughn, M. L., Riccio, C. A., Hynd, G. W., & Hall, J. (1997). Diagnosing ADHD (predominantly inattentive and combined type subtypes): Discriminant validity of the Behavioral Assessment System for Children and the Achenbach Parent and Teacher Rating Scales. Journal of Clinical Child Psychology, 26, 349-357.
- Walker, A. J., Shores, E. A., Trollor, J. N., Lee, T., & Sachdev, S. (2000). Neuropsychological functioning of adults with attention deficit hyperactivity disorder. Journal of Clinical and Experimental Neuropsychology, 22, 115-124.
- Ward, M. F., Wender, P. H., & Reimherr, F. W. (1993). The Wender Utah Rating Scale: An aid in the retrospective diagnosis of childhood attention deficit hyperactivity disorder. American Journal of Psychiatry, 150, 885-890.
- Welsh, M. C. (1994). Executive function and the assessment of attention deficit hyperactivity disorder. In N. C. Jordan & J. Goldsmith-Phillips (Eds.), Learning disabilities: New directions for assessment and intervention (pp. 21-42). Boston: Allyn and Bacon.
- Wender, P. H. (1985). Wender AQCC (Adult Questionnaire-Childhood Characteristics) scale. Psychopharmacology Bulletin, 21, 927-928.
- Wender, P. H. (1998). Pharmacotherapy of attention-deficit/hyperactivity disorder in adults. Journal of Clinical Psychiatry, 59, 76-79.
- Wender, P. H., & Reimherr, F. W. (1990). Bupropion treatment of attention-deficit/hyperactivity disorder in adults. American Journal of Psychiatry, 147, 1018-1020.
- Wender, P. H., Wolf, L. E., & Wasserstein, J. (2001). Adults with ADHD. An overview. Annals of the New York Academy of Sciences, 931, 1-16.
- Willcutt, E. G., Pennington, B. F., Chhabildas, N. A., Friedman, M. C., & Alexander, J. (1999). Psychiatric comorbidity associated with DSM-IV ADHD in a nonreferred

sample of twins. Journal of the American Academy of Child and Adolescent Psychiatry, *38*, 1355-1362.

Wolraich, M. L., Greenhill, L. L., Pelham, W., Swanson, J., Wilens, T., Palumbo, D., Atkins, M., McBurnett, K., Bukstein, O., & August, G. (2001). Randomized, controlled trial of oros methylphenidate once a day in children with attention-deficit/hyperactivity disorder [Abstract]. Pediatrics, *108*, 883-892.

Wolraich, M. L., Hannan, J. N., Baumgaertel, A., & Feurer, I. D. (1998). Examination of DSM-IV criteria for attention deficit/hyperactivity disorder in a country-wide sample. Journal of Development and Behavioral Pediatrics, *19*, 162-168.

Zametkin, A. J., Liebenauer, L. L., Fitzgerald, G. A., King, A. C., Minkunas, D. V., Herscovitch, P., Yamada, E. M., & Cohen, R. M. (1993). Brain metabolism in teenagers with attention-deficit hyperactivity disorder. Archives of General Psychiatry, *50*, 333-340.

Zametkin, A. J., Nordahl, T. E., Gross, M., King, C., Semple, W. E., Rumsey, J., Hamburger, S., & Cohen, R. M. (1990). Cerebral glucose metabolism in adults with hyperactivity of childhood onset. The New England Journal of Medicine, *323*, 1361-1366.

Zito, J. M., Safer, D. J., dosReis, S., Gardner, J. F., Boles, M., & Lynch, F. (2000). Trends in the prescribing of psychotropic medications to preschoolers. Journal of the American Medical Association, *283*, 1025-1030.