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ABSTRACT

Attention Deficit Hyperactivity Disorder (ADHD) is the most prevalent of the childhood behavioral disorders, yet is widely misunderstood and often difficult to correctly diagnose. Using a neuropsychological framework, this study explored the usefulness of the Wechsler Intelligence Scale for Children-Third Edition (WISC-III) and Wisconsin Card Sorting Test in the diagnosis of ADHD. A sample of 90 children ages 6-12 were divided into four diagnostic groups: (1) pure ADHD; (2) ADHD with a learning disability (ADHD/LD); (3) a clinical group with a diagnosis other than ADHD and/or learning disability; and (4) a control group of normals. Significant group main effects were revealed for the WISC-III Intelligence Quotient (IQ) scores (Full Scale IQ, Verbal IQ, and Performance IQ) and factor based scores (Verbal Comprehension Index, Perceptual Organization Index, Freedom of Distractibility Index, and Processing Speed Index (PSI)) with no age main effects or Age X Group interactions revealed. The ADHD group performed significantly poorer than the control group on all WISC-III IQ scores and on all the factor based scores except PSI. Other results are presented and discussed, and recommendations are made for future research. Contains 82 references, 17 figures and tables. (Author/RB)

THE USEFULNESS OF THE WECHSLER INTELLIGENCE SCALE FOR CHILDREN–THIRD EDITION AND THE WISCONSIN CARD SORTING TEST IN THE DIAGNOSIS OF ATTENTION-DEFICIT HYPERACTIVITY DISORDER

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THE USEFULNESS OF THE WECHSLER INTELLIGENCE SCALE FOR CHILDREN–THIRD EDITION AND THE WISCONSIN CARD SORTING TEST IN THE DIAGNOSIS OF ATTENTION-DEFICIT HYPERACTIVITY DISORDER

A Dissertation

Presented to

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Doctor of Philosophy

by

Elleen Hooper

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Using a neuropsychological framework, this study explored the usefulness of the Wechsler Intelligence Scale for Children–Third Edition and Wiscosin Card Sorting Test in the diagnosis of Attention-Deficit Hyperactivity Disorder. A sample of 90 children ages 6-12 (mean age = 8.53) were divided into four diagnostic groups: (a) pure ADHD, (b) ADHD with a learning disability (ADHD/Learning Disability), (c) a clinical group with a diagnosis other than ADHD and/or learning disability, and (d) a control group of normals. Utilizing a 4 x 3 factorial design, Group x Age comparisons were made to determine if a specific pattern of performance on the WISC-III and WCST would differentiate the ADHD group from the ADHD/LD, Clinical, and Control groups.

Significant group main effects were revealed for the WISC III IQ scores (Full Scale IQ, Verbal IQ, Performance IQ) and factor based scores (Verbal Comprehension Index, Perceptual Organization Index, Freedom of Distractibility Index, Processing Speed Index) with no age main effects or Age x Group interactions revealed. The ADHD group performed significantly poorer than the Control group on all WISC-III IQ scores and on all the factor based scores except PSI. No specific pattern of significant differences emerged to distinguish the

ADHD group from the ADHD/LD or Clinical group. However, the ADHD group did demonstrate the poorest performance in comparison to the ADHD/LD and Clinical groups of the FSIQ, VIQ, PIQ,VCI and POI.

Significant group main effects for the WCST were revealed for Percent Correct and Categories Achieved. Significant Age main effects and Group x Age interactions were revealed for Percent Correct, Categories Achieved, Perseveration Errors, and unexpectedly for Percent of Conceptual Level Responses. Significant group differences were only revealed for the 8-9 year olds with no specific pattern emerging. Some significant maturational gains were demonstrated, but the results varied for the different diagnositic groups with no pattern of consistent gains noted.

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CHAPTER 1

LITERATURE REVIEW

Introduction

Attention-deficit Hyperactivity Disorder (ADHD) (APA, 1987) is the most prevalent of the childhood behavioral disorders with approximately 3 to 5% of the childhood population having the disorder (Barkley, 1990). This conservative estimate hinges on how ADHD is defined, the population studied, and the geographic location surveyed. Nevertheless, this disorder appears to exist across cultures with some fluctuation related to national/ethnic groups (Ross & Ross, 1982). According to Ross and Ross (1982), the male to female ratio for ADHD is 3:1. However, Barkley (1990) estimated that on the average a 6:1 male to female ratio was cited in most studies for clinic-referred samples of children with a range of ratios from 2:1 to 10:1.

As a psychiatric diagnosis, ADHD is defined in terms of problematic behaviors reflecting inattention, impulsivity, and hyperactivity. These problematic behaviors must be unexpected and not explained by developmental or mental level, thought disorder, or affective disorder (Pennington, 1991). However, these behavior characteristics can also be manifested by children with other psychiatric disorders making it important that the defining characteristics of ADHD provide a standard for accurate differential diagnosis (Werry, 1988). For example, depression, mania, primary disorders of vigilance, narcolepsy, primary disorders of conduct, task-dependent attention disorders, and acquired focal neurological deficits can present as ADHD (Weinberg & Emslie, 1991).

The task of correctly diagnosing ADHD is also compounded by the issue of comordibity or the high likelihood that a child with one disorder will have a second psychiatric disorder. This is often found with the diagnoses of ADHD, Oppositional Defiant Disorder, Conduct Disorder, and Learning Disability (Barkley, 1990). Additionally, numerous questions related to the etiology or cause of ADHD can also add confusion to the diagnostic process. Multiple etiologies including environmental and psychosocial factors (Hartsough and Lambert, 1982), genetic factors (Stewart, DeBlois, & Cummings, 1980), medical factors (Wender, 1987), and neuroanatomical and neurophysiological factors (Hunt, Minderra, & Cohen, 1985; Lou, Hendersen, & Bruhn, 1984; Mattes, 1980) have been suggested by research.

Despite the prevalence of ADHD and the amount of research focused on the disorder, it remains misunderstood, characterized by its heterogeneous qualities with no unitary etiology identified. It is this controversy related to etiology and problems of comorbidity that has led to difficulties in the conceptualization of ADHD as a distinct disorder. Barkley (1990) posits that with the development of consensus criteria for clinical diagnosis or for research, and with greater attention to the study of "pure" cases of ADHD, a better and more critical test of the notion of ADHD as a distinct disorder can be addressed.

Research examining the link between symptoms of ADHD and frontal lobe dysfunction has attempted to bring more understanding to the neuroanatomical and/or neurophysiological underpinnings of the disorder. Findings of some of the studies have indicated that dysfunctioning in the prefrontal/frontal lobes can result in the symptoms of impulsivity, poor attention, hyperactivity and poor response regulation and inhibition which are hallmark characteristics of ADHD (Chelune, Ferguson, Koon, & Dickey, 1986; Hynd, Semrud-Clikeman, Lorys, Novey, & Eliopulos, 1990; Voeller & Heilman, 1988). Specifically, the executive functions of the frontal lobe which involve strategic planning, impulse control, organized search, and flexibility in thought and actions appear to be negatively affected (Welsh, Pennington, & Grossier, 1991). Although a hypothesis proposing frontal lobe dysfunction does not provide a complete explanation for the etiology of ADHD, it does provide a framework for the explanation of many of the symptoms associated with the disorder.

The evaluation of frontal lobe functioning in children has been subject to controversy related to the absence of neurological tests that are standardized on children and address developmental issues (Welsh & Pennington, 1988). Out of necessity, researchers have used adult measures sensitive to frontal lobe functioning and compared the performance of children with the performance of adults with frontal lobe lesions or some type of neuropathology. However, in the last two decades strides have been made in the establishment of developmental norms for some of the adult measures sensitive to frontal lobe functioning.

In particular, the Wisconsin Card Sorting Test (WCST) (Heaton, 1981), a test sensitive to frontal lobe functioning in adults, has been the subject of much research pertaining to children diagnosed with ADHD (Barkley, Grodzinsky, & DuPaul, 1992). This research led to the establishment of an expanded WCST manual which includes developmental norms for children (Heaton, Chelune, Tally, Kay, & Curtiss, 1993).

This present study will be based on the research developed by Chelune, Ferguson, Koon, and Dickey (1986) where the neuropsychological performance of children with ADHD was compared with matched controls using a battery of tests which included the WCST. For this study, a neuropsychological framework will be used to explore the assessment and diagnosis of ADHD using the WCST and the Wechsler Intelligence Scale for Children–Third Edition (WISC-III) (Wechsler, 1991). Using children ages 6 to 12, this study will compare the performance of a "pure" ADHD group, an ADHD and learning disability (ADHD/LD) group, a clinical group of children not diagnosed with ADHD or a learning disability, and a control group of "normal" children.

In the next section, an overview of the existing literature as it applies to this study will be addressed. The overview will include issues related to the establishment of a definition and diagnosis of "pure" ADHD cases, issues related to the development of a frontal lobe hypothesis exploring the etiology of ADHD, and issues related to the operationalizing of prefrontal/frontal lobe functioning in children using neurological measures with emphasis on the WCST. The study on which the current research is based will be reviewed. A brief exploration of the usefulness of the WISC-III in the diagnostic process will be made. Finally, the specific research questions related to the WISC-III and WCST will be addressed.

Overview of the Literature

Although agreement is found in the behavioral elements of ADHD, the underlying neuroanatomical and/or neurophysiological mechanisms of the disorder remain unclear (Chelune & Baer, 1986). Conners and Wells (1986) point out that research in ADHD is faced with a dilemma: A better behavioral definition of ADHD is needed to yield homogeneous subtypes more likely to have a unitary etiology and pathophysiology, yet it is hard to define such subtypes without knowing the etiology and pathophysiology. Nevertheless, research criteria which provide uniform guidelines in the diagnosis of "pure" cases must be utilized so that issues of comorbidity and ineffective diagnosis will not hinder the task of discovering a unitary etiology for ADHD.

Historically, the European criteria for diagnosis of ADHD has been far more stringent than the criteria established in the United States (Barkley, 1990; Pennington, 1991). This discrepancy between European and American diagnostic criteria was addressed in an international symposium (Sergeant, 1988). A general consensus established that subjects selected for ADHD research should meet the following minimal standards: (a) reports of problems with activity and attention from at least two independent sources (home, school, clinic); (b) endorsement of at least three of four difficulties with activity and three of four difficulties with attention; (c) onset before age 7 years; (d) duration of 2 years; (e) significantly elevated scores on parent/teacher ratings of these symptoms; and (f) the exclusion of retardation, autism and psychosis (Barkley, 1990). Additionally, research has stressed the importance of addressing a subject's biological, medical, and social history beginning with prenatal considerations in the diagnosis of pure cases of ADHD (Barkley, 1990; Lambert & Hartsough, 1984; Pennington, 1991). For example, Lambert and Hartsough (1984) have identified the predispositional domains of prenatal/perinatal factors and childhood constitutional make-up and temperament as biological contributors of hyperactivity; and the domains of parent characteristics and attitudes, and home environment as social contributors of hyperactivity.

The heterogeneous qualities of ADHD, the associated issues of comorbidity, and the numerous questions surrounding the etiology of this disorder create the need for a multi-faceted diagnostic process. Barkley (1987) suggested that the behavioral assessment of ADHD should address the following concerns: (a) assessment of the primary symptoms of sustained attention, impulse control, and overactivity; (b) extensive medical, psychometric, and academic evaluation to rule out co-existing problems and to clarify issues of comorbidity; (c) utilization of instruments/methods which have established developmental normative data; (d) use of methods that address the chronicity of the disorder from a wide range of ages with adequate normative data for each developmental stage; (e) inclusion of multiple sources of information from both diverse settings and caregivers; and (f) the evaluation of the social reciprocity influence of parent/child interactions in the maintenance of the oppositional behaviors. Within this evaluation process, Barkley (1990) maintains that the child's cognitive abilities are the key neuropsychological factors to be examined. He posits that deficits in executive processes, rule-governed behavior, and behavioral inhibition constitute the essence of ADHD and make a neuropsychological evaluation imperative for the diagnosis, treatment and prognosis of this disorder.

Using a neuropsychological framework, Pennington (1991) conceptualizes "true" ADHD as a subgroup, both within the wider group of children now identified as ADHD and within the broader category of executive function deficits or difficulties with goal-directed behaviors (planning, organized search, and impulse control) (Welsh, Pennington, & Grossier 1991). Currently, very little is known about the prevalence of executive functioning deficits in children and the possible contribution of frontal lobe dysfunction to a wide variety of behavioral pathologies. Part of the problem in determining the prevalence of executive function disorders is that the behavioral symptoms of executive function disorders overlap considerably with the symptoms of other childhood psychiatric disorders, many of which have been traditionally conceptualized as arising from faulty social environments (Pennington, 1991).

Generally speaking, there appears to be a broad consensus that executive functions are dependent on prefrontal areas of the brain and that dysfunction in these areas disrupts the organization and control of behavior. In a broader sense, dysfunction in the prefrontal areas can cause executive function deficits related to organizational skills, planning, future-oriented behavior, set-maintenance, self-regulation, selective attention, vigilance, inhibition and creativity which are characteristic problems associated with the diagnosis of ADHD (Fuster, 1985; Pennington, 1991; Stuss & Benson, 1986). According to Barkley (1990), empirical evidence is increasingly suggesting that it is the behavioral class of impulsivity and hyperactivity, or poor response regulation and inhibition, that underlies ADHD. Douglas (1988) also posits that a generalized self-regulatory deficit which is present across visual, auditory, motor, and perceptual modalities is responsible for the problems observed in ADHD children.

Specific empirical findings do appear to lend support to a neuropsychological explanation of the behavioral sequelae associated with ADHD. Lou, Hendersen, and Bruhn (1984) found an association between anterior or cerebral dysfunction and poor impulse control and behavioral problems in children. Several studies have associated dysfunction in the frontal lobes anterior and medial to the precentral motor cortex with ADHD in children (Chelune et al., 1986; Gualtieri & Hicks, 1985; Mattes, 1980). Additionally, researchers have noted reciprocal connections in the frontal cortex between the reticular activating system (RAS) and diencephalic region (Drewe, 1975; Fuster, 1980; Luria, 1973) with dysfunction in these connections producing problems in arousal, attention, and vigilance.

A frontal lobe hypotheses may be unable to completely explain the etiology of different forms of ADHD, but it can provide a framework for explaining many of the findings associated with the disorder. In his review of clinical, neuropsychological, and electrocephalographic studies, Mattes (1980) noted similarities between symptomatology expressed by adult patients with frontal lobe dysfunctions and children diagnosed with ADHD. Specifically, patients with lesions in the prefrontal areas have difficulty suppressing ongoing activities despite environmental feedback that they are no longer appropriate (perseveration) and demonstrate increased reactivity to extraneous stimuli, which results in deficient goal-directed behavior (distractibility and impulsivity) (Chelune et al., 1986). Konorski (1967) linked hyperactivity/hyperreactivity, part of the behavioral sequelae associated with frontal lobe regions, with a disturbance in higher level of cortical inhibition in the form of inhibitory cortical reflexes, or an absence of inhibition of orienting responses that therefore become stronger. In addition, frontal lobe (anterior) damage has been associated with a behavioral syndrome of impulsivity and social inappropriateness (Stuss & Benson, 1984). Benson (1991) posited that subjects with normal basal posterior functioning and normal intelligence will not be able to perform effectively if a prefrontal cortex disturbance exists since the prefrontal cortex appears to influence the stable routine activity performed by the basal and posterior cortex and nervous system structures.

Evaluation of the frontal lobe hypothesis from a neuropsychological framework has been complicated by the controversy as to when the behaviors attributed to frontal lobe functioning reach functional maturity (Chelune et al., 1986). Traditionally, the development of the prefrontal areas has been seen as occurring late in the course of normal brain development (Huttenlocher, 1979).

Luria (1973) has suggested that the prefrontal regions do not begin to become prepared for action until the child is between ages 4 and 7. However, Golden (1981) posited that functional maturity of the frontal areas does not occur until adolescence. Interestingly, more recent neuroanatomical, (Rakic, Bougeois, Zecevic, Eckenhoff, & Goldman-Rakic, 1986), neuropsychological (Diamond & Goldman-Rakic, 1987) and neuroimaging (Chugani & Phelps, 1986) data all converge on the second half of the first year of life as an early important transition in prefrontal anatomical and functional development. Moreover, findings from developmental research would argue strongly against a late onset for the first emergence of prefrontal functions in behavior, since functions like selective attention, inhibition, and anticipation are observable quite early in life (Pennington, 1991).

However, different executive function tasks reach developmental plateaus at different ages (Passler, Issac, & Hynd, 1985; Welch, Pennington, Ozonoff, Rouse, & McCabe, 1990). Research has suggested that the prefrontal regions begin to myelinate at age 4 (Reines & Goldman, 1980) and undergo a period of rapid fissuration and brain-to-body development from ages 6 to 8 (Rourke, Bakker, Fisk, & Strang, 1983). Interestingly, Benson (1991) has suggested that the delay in the laying down of myelin may be an explanation for the ADHD syndrome. Additionally, Epstein (1978) has noted spurts in brain growth at ages 2-4, 6-8, 10-12, and 14-16 which roughly correspond with changes in cognitive development similar to those postulated by Piaget (Phillips, 1969).

In order to evaluate the frontal lobe hypothesis related to ADHD, appropriate assessment tools are necessary. Welsh, Pennington and Grossier (1991) noted that attempts to operationalize prefrontal and frontal functioning in children has concentrated on adult neuropsychological measures with little adaptation for the child's developmental level (Applelof & Augustine, 1986; Chelune & Baer, 1986; Kirk & Kelly, 1986). The Wisconsin Card Sorting Test (WCST) has been found to be very sensitive to frontal lobe disorders in adults (Milner, 1963; Robinson, Heaton, Lehman, & Stilson, 1980). Using the standardized form of the WCST (Heaton, 1981) and attempting to maintain a developmental perspective of frontal lobe functioning, Chelune and Baer (1986) conducted a study for the purpose of developing norms for children. Supported by other research (Passler, Issac, & Hynd, 1985), Chelune and Baer (1986) demonstrated that those behaviors presumed to be dependent on frontal lobe functioning, develop rapidly from the age of 6 and essentially reach adult levels of functioning by age 10. The development of the WCST norms for children may be able to lend valuable information to the explanation of the frontal lobe hypothesis while also helping to distinguish between a maturational or deficit explanation of test findings related to ADHD. However, measures of frontal lobe functioning or executive functions must establish norms for children with a developmental framework underpinning the results (Pennington, 1991). The Study conducted by Chelune and Baer (1986) laid a beginning foundation for the establishment of children's norms for the WSCT and became part of the expanded WCST manual (Heaton et al., 1993) which includes a section of developmental norms for children and adolescents.

In a subsequent study, Chelune, Ferguson, Koon, and Dickey (1986) compared neuropsychological performance of ADHD and matched controls using the WCST, KABC, Progressive Figures, Color Forms, and PPVT. The results of the study indicated that the cognitive/behavioral difficulties associated with ADHD are relatively distinct and circumscribed. The children did not differ from controls on the most general intellectual or mental processing measures.

Rather, they differed on tasks requiring sustained attention and utilizing environmental feedback to regulate goal-directed activities. In contrast to the control group, the ADHD group consistently performed poorly on the WCST in sorting for categories, made more perseveration errors and obtained a lower overall percentage correct. From these findings, Chelune et al. (1986) postulated that ADHD may be related to a dysfunction in the inhibitory forebrain system. Whether this dysfunction is related to a maturational lag was not made clear. However, it appears that ADHD children make appropriate maturational gains on the WCST, but at a level approximately two years behind their matched cohorts. Hynd, Hern, Voeller, and Marshall (1991) concluded that it would be impossible to demonstrate that the deficits in frontal lobe functioning were unique to ADHD since the study (Chelune et al., 1986) did not include a clinic control group. However, the evidence suggesting that frontal cortex functioning may be deficient in children with ADHD was found to be provocative (Hynd et al., 1991).

Despite the concerns expressed by Hynd et al., 1991, the WCST has a history of distinguishing between ADHD children and controls (Boucagnani & Jones, 1989; Chelune & Thompson, 1987; Douglas, 1980; Douglas & Peters, 1979; Gorenstein, Mammato, & Sandy, 1989; Tant & Douglas, 1982). Barkley, Grodzinsky, and DuPaul (1992) reviewed 22 studies of pre-adolescent hyperactive children and discovered that only 6 out of the 11 studies using the WCST found poorer performance in the hyperactive children. Additionally, the study reported by Barkley and others (1992) failed to detect differences in WCST variables among child groups with ADHD, ADD, learning disabilities, and normals. The failure to detect differences was attributed to limited sample size (Barkley et al., 1992). Most studies using high statistical power to evaluate WCST performance of pre-adolescent children have found ADD to perform the task less well than normals (McBurnett, Harris, Swanson, Pfiffner, Tamm, & Freeland, 1993).

Pennington (1991) noted that the term executive functioning can be defined both from a cognitive and neurological perspective. However, no consensus has been reached on a cognitive taxonomy of executive functions or on a neuropsychological theory of how and where these executive functions are localized within the prefrontal areas (Pennington, 1991). It is hoped that this study may address some of these issues as WISC-III and the WCST are examined as tools in the assessment of ADHD.

Although general intelligence does not correlate with neuropsychological measures of executive functions (Douglas, 1983; Matson & Fischer, 1991; Mattes, 1980; Welsh, Pennington, & McCabe, 1987), the WISC-III can provide valuable diagnostic data that can build on the data provided by WCST (Heaton, 1981; Heaton, Chelune, Talley, Kay, & Curtiss, 1993). As a measure of general intelligence, the WISC-III is useful and appropriate for psychoeducational assessment, diagnosis of exceptionality among school-aged children, clinical and neuropsychological assessment, and research (Psychological Corporation, 1991). It is posited that the WISC-III can address some of the diagnostic issues related to vigilance (Digit Span), sustained attention (Coding), divided attention (Digit Span), impulsivity (Mazes), focused attention and persistence (Arithmetic), processing speed (Coding and Symbol Search), freedom from distractibility (Arithmetic and Digit Span), verbal comprehension abilities, perceptual organization abilities, and a general level of intellectual potential (Goldstein & Goldstein, 1990; Matson & Fischer, 1991; Psychological Corporation, 1991).

The purpose of this study is to explore the assessment and diagnosis of ADHD using a neuropsychological framework. The present study will be based on the concepts developed by Chelune et al. (1986). However, the study will be expanded to include a pure ADHD group, an ADHD group with a learning disability (ADHD/LD), a clinical group of children who are neither diagnosed with ADHD nor a learning disability, and a control group of normal children (ages 6-12). A neuropsychological evaluation will include the WCST, WISC-III, Wechsler Individual Achievement Test (WIAT) (Psychological Corporation, 1992), Conners' Parent and/or Teacher Rating Scales (DuPaul, 1990), Home Situational Questionnaire and School Situational Questionnaire (Barkley, 1990). Additionally, a structured outline covering developmental factors, medical history, treatment history, school history, social history, family environment history, family history and diagnostic criteria will be completed by the parent and followed by a short interview. Those children diagnosed as ADHD will meet the minimal requirements for the DSM-IIIR diagnosis as determined by medical records, a structured interview, and Parent and/or Teacher Rating Scales (Chelune et al., 1986), as well as the guidelines established by the international symposium (Sergeant, 1988).

Similarities and differences of the neuropsychological performance between the groups will be examined to evaluate the following hypotheses related to the WISC-III and WCST.

Hypothesis 1 predicts that the "pure" ADHD group will demonstrate a performance pattern on the WISC-III that will distinguish it from the ADHD/LD, Clinical, and Control groups. Specifically, a distinct pattern of poorer performance on all levels of the WISC-III will distinguish the "pure" ADHD group from the Control group. For the WISC-III IQ scores: (a) It is expected that the Control group will demonstrate the highest Full Scale IQ (FSIQ), Verbal IQ (VIQ), and Performance IQ (PIQ) in comparison to the "pure" ADHD, ADHD/LD, and the Clinical groups; (b) the "pure" ADHD group will demonstrate the poorest performance of all the groups; and (c) no systematic pattern of differences between the "pure" ADHD, ADHD/LD and Clinic groups is expected on the PIQ and the VIQ. For the factor based indexes, it is expected that: (a) The Control group will demonstrate the highest means for Verbal Comprehension Index (VCI), Perceptual Organization Index (POI), Freedom from Distractibility Index (FDI), and Processing Speed Index (PSI) in comparison to the "pure" ADHD, ADHD/LD, and Clinical groups; (b) the "pure" ADHD group will obtain the lowest means in comparison to the other groups; and (c) no systematic pattern of differences between the "pure" ADHD, ADHD/LD, and Clinical groups is expected to emerge on the VCI, POI, FDI and PSI.

Hypothesis 2 predicts that the "pure" ADHD group will demonstrate a performance pattern on the WCST that will distinguish it from the ADHD/LD, Clinical, and Control groups. Specifically, it is expected that the "pure" ADHD will demonstrate poor performance for Percent Correct, Categories Achieved and Perseveration Errors in comparison to the Control group, ADHD/LD group, and the Clinical group (Chelune et al., 1986).

Additionally, it is predicted that all groups will demonstrate maturational gains on the WCST. It is expected that: (a) The "pure" ADHD group gains will be at a level consistently lower than the norm group, the ADHD/LD group, or the Clinical group; and (b) some of the ADHD/LD group's ADHD symptoms will not be associated with impaired functioning, but will be a secondary symptom resulting from coping with the specific learning disability (Pennington, 1991).

CHAPTER 2

METHOD

Subjects

The testing population consisted of 90 school-aged children between the ages of 6-12 years who obtained at least an 85 IQ on the WISC-III FSIQ, VIQ, or PIQ. The subjects were divided into four diagnostic groups (Table 1). The males out-numbered the females approximately 2:1 (57 males to 33 females).

Table 1

Group Summaries of Age and Sex

Group	M	SD	Males	Females
ADHD	8.25	1.78	16	7
ADHD/LD	8.67	1.80	14	7
Clinical	8.52	1.81	16	9
Control	8.67	1.80	11	10

Pure ADHD Group Criteria

Those children diagnosed as ADHD met the minimal requirements for the DSM-IIIR diagnosis as determined by available medical records, completion of a history questionnaire by a parent to be followed by a short interview, and Conners' Parent and/or Teacher Rating Scales (Chelune et al., 1986). The following criteria were also followed: (a) problems with attention and activity must be reported in at least two independent sources; (b) endorsement by parent and/or teacher on three of the four difficulties with activity and three of the four with attention; (c) a 2 standard deviation above the norm on either of the hyperactivity scales for both the Conners Teacher and Parent Scales; (d) demonstration of pervasiveness of the problem behaviors in both the home and school environments; and (e) developmental history demonstrating an onset before age 7 and symptoms for the past 2 years (Barkley, 1990; Sergeant, 1988). Prenatal and perinatal factors, temperment factors, parental attitudes and home environment predisposing a child to ADHD will also be considered (Lambert & Hartsough, 1984).

ADHD/LD Group Criteria

The children in this group met the criteria established for a diagnosis of ADHD and must meet criteria demonstrating a learning disability. Learning disabilities were identified using the discrepancy model between intellectual potential and achievement as demonstrated by the WISC-III and WIAT. To prevent biasing against children with visual or auditory deficits, the higher of the FSIQ, VIQ or PIQ was used to estimate intellectual potential. A 20-point discrepancy model established by the South Carolina State Department of Education since 1979 (W.M. McQueen, personal communication, October, 1993), representing a 1 1/3 standard deviation between intellectual potential and achievement was utilized to distinguish those children meeting the criteria for one or more of the identified areas of learning disability as established by the

Individual with Disabilities Education Act (IDEA); (U.S. Department of Education, 1992), which replaced Public Law 94-142.

Clinical Group Criteria

The clinical group consisted of children receiving services because of a clinical diagnosis other than ADHD and/or a learning disability. This group of children were diagnosed with either an affective disorder, mood disorder, or disorder of conduct. None of the children were diagnosed with a thought disorder or psychosis.

Control Group Criteria

Children in the control did not meet the criteria for ADHD or learning disability and had no identified clinical diagnosis. None of the children had a past or current referral to a psychologist or clinic.

Tests

Table 2 gives a listing of the battery of instruments used in the evaluation of each subject in the study.

Table 2

Instruments Used in the Study

Instrument	Author
Wisconsin Card Sorting Test (WCST)	Heaton, 1981 Heaton, Chelune, Tally, Kay, Curtis, 1993
Wechsler Intelligence Scale for Children–Third Edition (WISC-III)	Wechsler, 1991
Wechsler Individual Achievement Test (WIAT)	Psychological Corporation, 1992
Conners' Parent and Teacher Rating Scales	Conners, 1969, 1970, 1989
ADHD Clinic Parent Interview Form	Barkley, 1991
Home and School Situation Questionnaires–Revised	DuPaul, 1990

For the purpose of this study, the evaluation of test results was limited to the WCST and WISC-III. However, the instruments referred to in Table 2 were used in the diagnosis and placement of subjects in the four diagnostic groups.

The Wisconsin Card Sorting Test is a measure of perseverative thinking, concept formation, and problem solving which has been shown to discriminate between frontal and nonfrontal brain lesions in adults (Heaton, 1981). The WCST utilizes stimulus and response cards which have figures varying in form, color, and number. After instructions are given, the subject is instructed to sort a deck of response cards to match the stimulus cards. Although the subject is never told how to sort the cards, the task is to sort 10 cards to color, 10 cards to form, and 10 cards to number. The subject is told whether he or she is correct or incorrect after each response. To count as a success, the 10 cards must be sorted consecutively to the correct category. An interruption in the sequence results in a return to the criterion of 10 consecutive correct responses. Some of the scores derived on the WCST are: Total Percent Correct, Categories Achieved (concept formation), Perseveration Errors (a response that would have been correct during the previous category), Perseverative Responses, Percent of Perseveration Erros, Percent of Conceptual Level Responses, and Failure to Maintain Set (interruption of the correct sorting strategy after either three consecutive correct unambiguous responses or after any five consecutive correct responses). The WCST test has been extensively used in research for over two decades. In a sample of normal children and adolescents the WCST demonstrated moderate to good reliability (Harris, 1990).

The WISC-III evaluates children ages 6 through 16. It contains 13 subtests, 6 in the Verbal Scale and 7 in the Performance Scale. Five subtests in each scale are designated as standard tests and combine to give a measure of general intelligence as measured by the Full Scale IQ. The Verbal Scale subtests include Information, Similarities, Vocabulary, Comprehension, and Arithmetic. The Performance Scale contains Picture Completion, Block Design, Picture Arrangement, Coding and Object Assembly subtests. The remaining subtests of Digit Span in the Verbal Scale and Symbol Search and Mazes in the Performance Scale are supplemental. Symbol Search and Coding combine to give a measure of Processing Speed. Arithmetic and Digit Span combine to produce a measure labeled Freedom from Distractibility. Picture Completion, Picture Arrangement, Block Design, and Object Assembly give a measure Perceptual Organizational skills. Comprehension, Vocabulary, Similarities, and Information give a measure of Verbal Comprehension skills. According to the WISC-III manual, the Perceptual Organization, Freedom of Distractibility and Processing Speed Indexes tend to have a higher correlation with neuropsychological measures than the Verbal Comprehension Index (Information, Similarities, Comprehension, and Vocabulary). Reliability coefficients for the IQ scales and Factor Based Scores were as follows: FSIQ: .96; VIQ: .95; PIQ: .91; VC Index: .94; PO Index: .90; FD Index: .87; and PS Index: .85. Prewett and Matavich (1994) found substantial correlation (.81) between the WISC-III Full Scale IQ and the Stanford Binet Test Composite.

Procedures

Prior to the administration of the test battery, the purpose of the study was explained to the parents/guardians and children. They were also given a brief overview of the testing instruments, allowed to ask questions, given an explanation of their rights and freedom of choice about participation in the study. The consent form was signed by the parent/guardian, the child, and the examiner and a copy given to the parent/guardian.

All children in the "pure" ADHD and ADHD/LD group were medication free (Ritalin, Cylert or Dexadrine) at least 16 hours prior to testing. The children in the Clinical group remained on all other prescribed psychotropic medication and in this regard were not medication free 16 hours prior to testing.

Inter-rater reliability was not obtained. However, five graduate students trained to specific criteria presented in the Measurement/Assessment I course at the Rosemead School of Psychology, Biola University individually administered the battery of tests to the children in the subject pool. The administration of the

WISC-III and WIAT were taught in the Measurement and Assessment I course and Lab component. The administration of the WCST test was conducted by the investigators who were familiar with the standardized procedures. Standardized procedures for all the tests were strictly followed by the five graduate students. The WISC-III, WIAT, and WCST were computer scored to provide a larger measure of accuracy in the scoring of the different instruments.

Each examiner had the parent or guardian complete the necessary forms (Conners' Parent Rating Scale, Home Situation Questionnaire, ADHD Clinic Parent Interview questions), and conducted a short interview to clarify information on the ADHD Parent Interview form. Examiners also ensured that the Conners' Teacher Behavior Rating Scale and School Situation Questionnaire were sent to the teacher. After the testing process was completed, a written summary of the testing results for each child was prepared by the two investigators. These summaries were then sent to the parents.

The children used in the study were obtained from various clinics and private schools in Southern California. The children in the ADHD, ADHD/LD and Clinical groups were obtained from both clinic and private school sources. The Control group was derived solely from children who attended one of the private schools.

Research Design

The research was conducted using four groups (ADHD, ADHD/LD, Clinical, and Control divided into three age classifications (6-7 years, 8-9 years, and 10-12 years). Each group contained 20-25 subjects. A 4 x 3 factorial design was utilized to perform AGE x GROUP comparisons. ANOVAs were run to determine if significant Group Main Effects, Significant Age Main Effects or

Group x Age interactions were revealed for any of the WISC-III and WCST variables. One-way ANOVAs with Tukey HSD follow-up tests were used to further analyze significant results.

CHAPTER 3

RESULTS

The first hypothesis stated that the "pure" ADHD will demonstrate a performance pattern on the WISC-III that will distinguish it from the ADHD/LD, Clinical and Control groups. It was expected that the "pure" ADHD would perform poorer than the Control group on all levels of the WISC-III (IQ scores, factor based scores, and subtests). The Control group was predicted to demonstrate the best performance on all levels of the WISC-III in comparison to the "pure" ADHD, ADHD/LD, and Clinical groups, with the "pure" ADHD having the poorest performance. No systematic differences were expected across the "pure" ADHD, ADHD/LD, and Clinical group with no specific pattern forming to distinguish the groups.

A 3 (Age) x 4 (Group) Analysis of Variance (ANOVA) was performed for each of the three WISC-III IQ scores (FSIQ, VIQ, PIQ) and the four factor based indexes (VC, PO, FD, PS). Significant Group main effects were found for the three WISC-III IQ scores and four factor based scores. Significant Group main effects for the WISC-III IQ scores were as follows: FSIQ, $\underline{F}$ (3, 78) = 4.567, $\underline{p} < .005$; VIQ, $\underline{F}$ (3,78) = 4.356, $\underline{p} < .007$; and PIQ, $\underline{F}$ (3, 78) = 3.176, $\underline{p} < .005$. The following significant Group main effects were noted for the factor based scores: VC, $\underline{F}$ (3, 78) = 3.176, $\underline{p} <.029$; PO, $\underline{F}$ (3, 78) = 4.604, $\underline{p} < .005$; FD, $\underline{F}$ (3, 78) = 8.197, $\underline{p} < .000$; and PS, $\underline{F}$ (3,78) = 4.149, $\underline{p} < .009$. No Age main effects or Group x Age interactions were revealed.

The significant group main effects were further analyzed using one-way ANOVAs with follow-up multiple range Tukey-HSD tests to determine specifically which groups differed significantly for the WISC-III IQ scores and factor based indexes. In Table 3, the means and standard deviations of the WISC-III IQ scores, factor based indexes, and subtests are presented with indication of significant group differences at the .05 level.

The results of the follow-up tests only partially supported the Hypothesis 1 statement that the "pure" ADHD group will demonstrate a performance pattern on the WISC-III that will distinguish it from the ADHD/LD, Clinical, and Control group. A significant difference at the .05 level was demonstrated between the "pure" ADHD group and the Control group for the WISC-III IQ scores (FSIQ, VIQ, PIQ) and the factor based indexes (VCI, POI, FDI, PSI) supporting the Hypothesis 1 prediction of a pattern of poorer performance by the "pure" ADHD group in comparison to the Control group. Although the "pure" ADHD performed poorer than the Control group on all the subtests, a significant difference at the .05 level was only demonstrated by Information, Comprehension, Coding, Picture Arrangement, Arithmetic, Object Assembly, and Digit Span.

Additionally, with respect to Hypothesis 1, the Control group demonstrated the highest FSIQ, VIQ, and PIQ means in comparison to the "pure" ADHD group, ADHD/LD group, and Clinical group with the "pure" ADHD obtaining the lowest IQ means of all the groups (Table 3). Although the Control group performed better than the other groups, a specific pattern was not supported by the statistical analyses. The Control group performed significantly better than the "pure" ADHD group only for the FSIQ, VIQ, and PIQ and the ADHD/LD group for VIQ.

As expected the "pure" ADHD group demonstrated the poorest performance for the FSIQ, VIQ, and PIQ in comparison to the ADHD/LD, Clinical, and Control groups (Table 3). However, the statistical analyses gave only partial support to the notion of a specific pattern emerging to distinguish the "pure" ADHD group from the ADHD/LD, Clinical, and Control groups. The "pure" ADHD group obtained significantly lower results than the Control group for FSIQ, VIQ, and PIQ and significantly lower results than the ADHD/LD and Clinical for only PIQ.

As predicted by Hypothesis 1, statistical anaylses revealed no systematic pattern of performance for the VIQ and PIQ emerging among "pure" ADHD, ADHD/LD, and Clinical groups with no specific pattern forming to distinguish the groups. In fact, the only suggested pattern was that the "pure" ADHD group performed poorer than the ADHD/LD and Clinical groups for both VIQ and PIQ. No significant differences were revealed for VIQ in any of the group comparisons.

The factor based indexes (VC, PO, FD, PS) were analyzed using the one-way ANOVAs and the Tukey-HSD test with a .05 significant level. The results of the analyses only partially supported the predicted outcomes set in Hypothesis 1 (Table 3). First, the Control group obtained the highest means for only the VC Index and FD Index with the ADHD/LD unexpectedly obtaining the highest mean on the PO Index in comparison to the "pure" ADHD, Clinical and Control groups. Second, the "pure" ADHD obtained the lowest means for the VC Index, PO Index, and PS Index with the ADHD/LD unexpectedly obtaining the lowest FD Index mean in comparison to the four groups in the study.

Although a specific pattern distinguishing the groups did not emerge, significant differences were revealed for some of the groups on the four indexes.

The "pure" ADHD group VC Index mean was significantly lower than the Control group mean. For the PO Index, the "pure" ADHD group mean was significantly lower than the means for the ADHD/LD group and Control group. The FD Index means for the Control group and the Clinical group were significantly higher than the means for the "pure" ADHD group and ADHD/LD group. The PS Index mean for the Clinical group was significantly higher than the ADHD/LD group and "pure" ADHD.

Table 3

Group Means and Standard Deviations for WISC-III IQ's, Factor Based Indexes, and Subtests

	ADHD		ADHD/LD		Clinical		Control	
	M	SD	M	SD	M	SD	M	SD
IQs								
FSIQ	98.26*	12.49	104.38	9.21	105.48	12.17	110.24**	10.36
VIQ	100.48*	13.18	101.90*	10.08	105.24	11.45	111.85**	10.99
PIQ	96.30*	12.05	106.57**	9.89	105.96*	12.67	107.10**	11.19
Factor Based								
VC Index	101.96*	13.41	104.38	9.21	105.48	12.17	110.24**	10.36
PO Index	98.39*	11.20	110.14**	9.24	105.12	12.89	108.10**	11.90
FD Index	95.00*	12.51	94.52*	9.72	107.84**	15.02	108.33**	12.60
PS Index	96.70	12.43	96.81	11.90	106.76**	12.83	105.05	12.60
Subtests								
Pic. Compl.	9.91	2.48	12.14**	1.93	11.04	2.82	10.86	2.99
Information	9.21*	3.93	10.48	2.96	10.36	3.05	11.86**	2.74
Coding	8.39*	2.54	8.57*	3.19	11.16	3.30	10.10**	2.81
Similarities	9.78	2.47	11.90	7.31	11.36	3.21	12.14	2.59
Pic. Arrange.	8.57*	3.01	11.29	2.74	10.96	3.28	10.05**	2.82
Arithmetic	8.91*	2.61	8.27*	2.10	10.80	2.83	11.38**	2.75
Block Design	10.17	3.07	11.48	3.01	10.20	3.11	12.38	2.26
Vocabulary	10.74	3.22	10.10	2.40	10.76	3.23	11.71	2.26
Obj. Assembly	9.78*	2.24	11.67**	1.32	10.84	2.51	11.62**	2.04
Compreh.	10.61	3.38	11.38	2.51	10.88	2.27	12.71	2.87
Symbol Search	9.91	2.89	10.05	2.22	11.04	3.02	11.48	2.73
Digit Span	9.04*	2.55	9.48	2.54	11.08**	4.11	11.24**	2.88
Mazes	8.87	2.74	8.48	3.53	10.76	4.71	11.29	2.61

* = significantly poorer performance than the Control group at the .05 level

** = significantly better performance than the ADHD group at the .05 level

The second hypothesis stated that the "pure" ADHD group would demonstrate a performance pattern on the WCST that would distinguish it from the ADHD/LD, Clinical, and Control groups. It was expected that the "pure" ADHD group would demonstrate lower scores for Percent Correct and Categories Achieved and higher scores for Perseveration Errors in comparison to the Control group. Also, the four diagnostic groups ("pure" ADHD, ADHD/LD, Clinical, and Control) were expected to demonstrate maturational gains with the "pure" ADHD group exhibiting maturational gains lower than the ADHD/LD, Clinical, and Control groups. It was posited that the majority of the ADHD/LD groups ADHD symptoms would be associated with impaired functioning, but would be a secondary symptom resulting from coping with the specific learning disability.

Examination of group means presented in Table 4 demonstrate that the "pure" ADHD group performed poorer than the ADHD/LD, Clinical and Control groups on Percent Correct, Categories Achieved and Perseveration Errors as predicted by Hypothesis 2. However, further statistical analyses only partially supported the prediction that a distinct pattern of performance would distinguish the "pure" ADHD from the other three groups in the study.

Table 4

Group Means and Standard Deviations for the WCST

	ADHD		ADHD/LD		CLINICAL		CONTROL	
	M	SD	M	SD	M	SD	M	SD
% Correct	44.14	14.79	49.60	19.38	49.10	18.06	59.70	17.56
Categories Achieved	1.91	1.56	3.23	2.05	2.96	2.22	3.90	1.86
Perseveration Responses	39.30	18.29	32.66	29.49	34.96	16.32	30.71	26.59
Perseveration Errors	34.70	14.50	28.95	21.81	31.84	14.09	25.38	19.89
% Perseveration Errors	27.11	11.31	24.47	16.22	25.42	10.35	20.73	14.88
Nonperserv. Errors	36.78	20.54	32.67	26.37	31.92	15.81	24.29	16.91
Trials for 1st Category	12.82	9.59	16.19	17.63	33.68	81.39	15.00	2.16
% Conceptual Level Responses	29.63	17.69	36.81	21.30	31.87	21.52	48.69	21.97
Failure to Maintain Set	1.22	1.59	.76	1.13	.76	1.52	1.29	1.52

A 3 (Age) x 4 (Group) Analysis of Variance (ANOVA) was run on each measure of the WCST test. Variable x Group x Age ANOVAs revealed significant results for Categories Achieved, Percent Correct, Perseveration Errors. Significant Group main effects were revealed for Percent Correct, $F(3,78) = 4.776$, $p < .004$, and Categories Achieved, $F(3,78) = 6.436$, $p < .001$. Significant Age main effects were revealed for Percent Correct, $F(2,78) = 16.055$, $p < .000$, Categories Achieved, $F(2,78) = 4.776$, $p < .004$, and Perseveration Errors, $F(2,78) = 6.086$, $p < .003$. Group by Age interactions were revealed for Percent Correct, $F(6,78) = 2.980$, $p < .011$, Categories Achieved, $F(6,78) = 2.868$, $p < .014$, and Perseveration Errors, $F(6,78) = 2.238$, $p < .048$.

Simple Effects analyzes were used to explore the Group x Age interactions. The difference between the four diagnostic groups for the three age classifications was examined for each group using one-way ANOVAs with the Tukey follow-up test (Figures 1, 2, and 3). No significant differences between the 6-7 year olds and 10-12 year olds were found for Percent Correct, Categories Achieved, and Perseveration Errors. However, significant differences between the four diagnostic groups were revealed for the 8-9 year olds. For Percent Correct the "pure" ADHD and ADHD/LD performed significantly poorer than the Control group. For Categories Achieved the "pure" ADHD performed significantly poorer than the Clinical and Control groups with the ADHD/LD also showing significantly poor performance than the Control group. Finally, for Perseveration Errors both the "pure" ADHD and the ADHD/LD groups performed significantly poorer than the Control group.

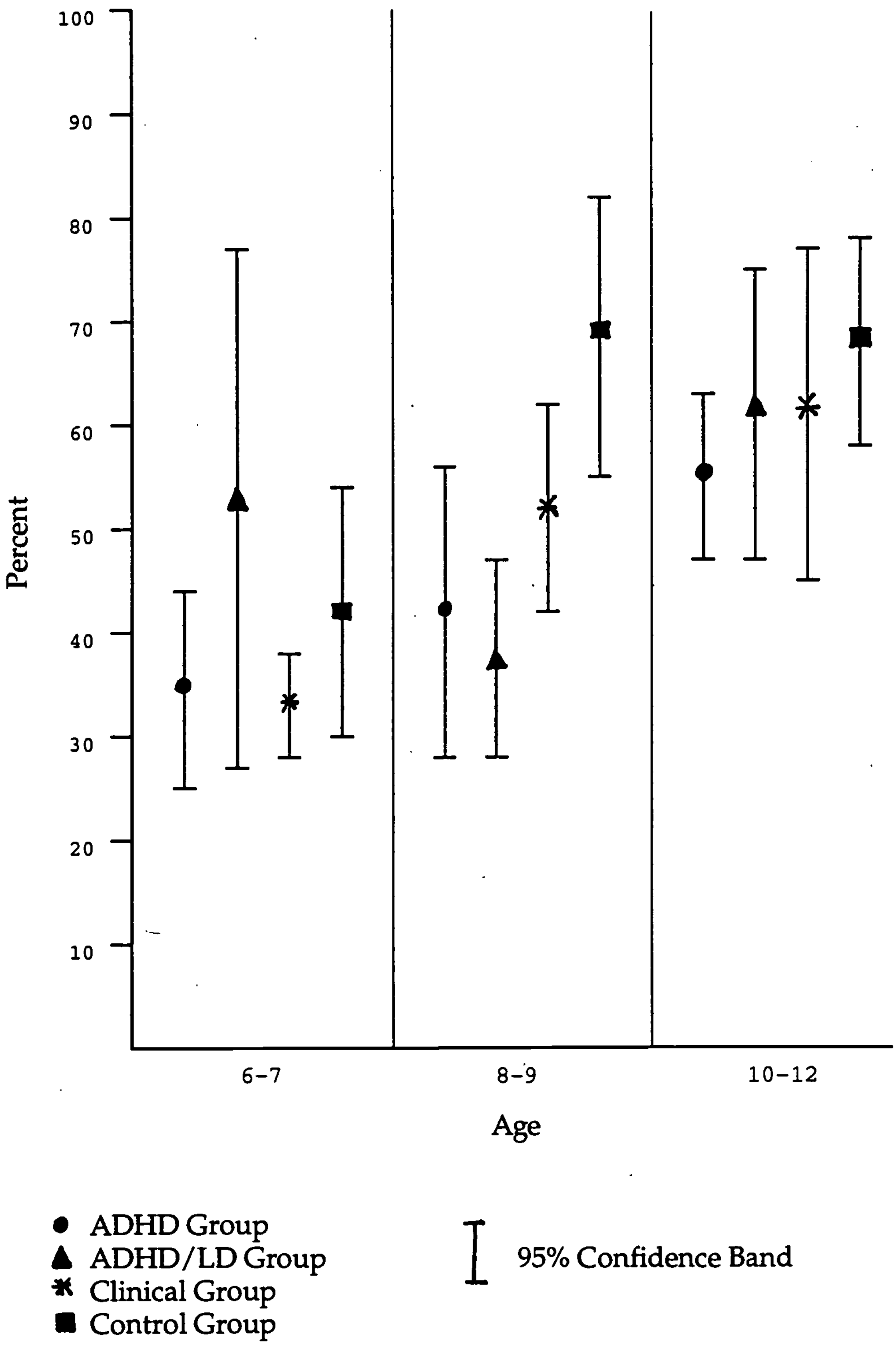

Figure 1. Simple Effects Comparison for WCST of the Four Diagnostic Groups for Each Age Classification: Percent Correct

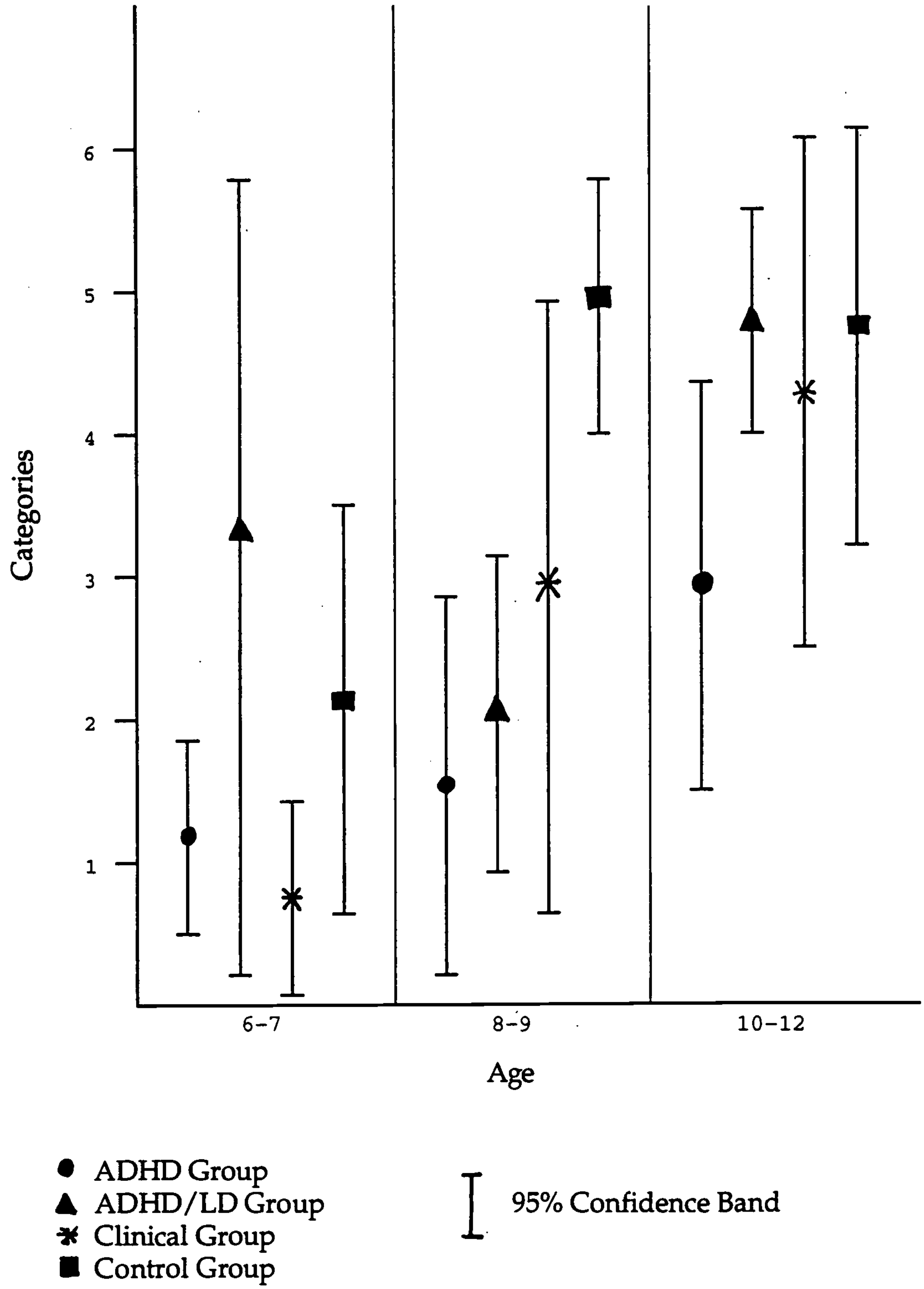

Figure 2. Simple Effects Comparison for WCST of the Four Diagnostic Groups for Each Age Classification: Categories Achieved

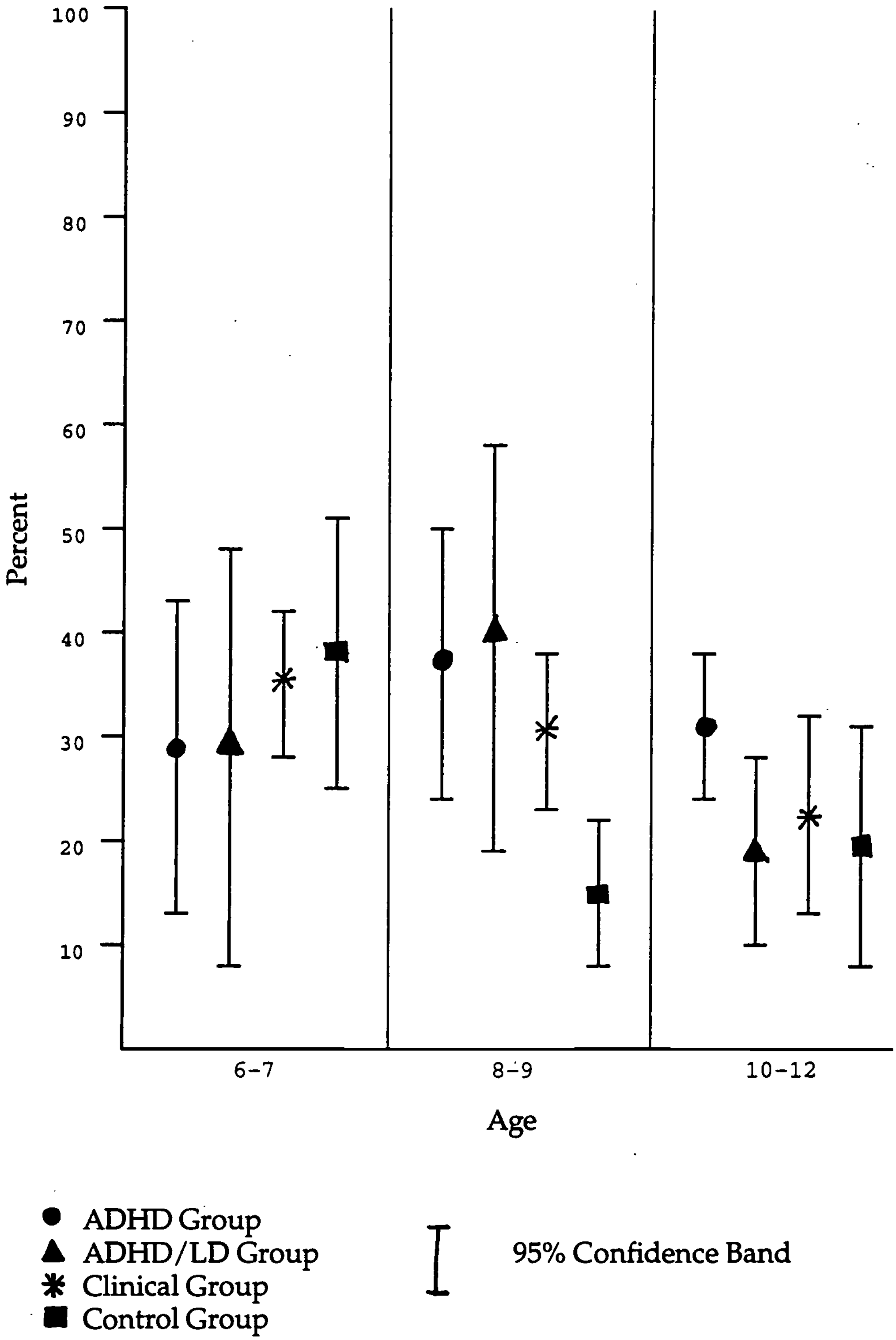

Figure 3. Simple Effects Comparison for WCST of the Four Diagnostic Groups for Each Age Classification: Perseveration Errors

A one-way ANOVA with a Tukey follow-up test was run for each diagnostic group to examine age differences for Percent Correct, Categories Achieved, and Perseveration Errors. The results gave partial support to the Hypothesis 2 prediction that maturational gains would be demonstrated by all the groups (Figures 3, 4 and 5). The "pure" ADHD group's 10-12 year olds performed significantly better than the 6-7 year olds for Percent Correct with no significant age differences revealed for Categories Achieved or Perseveration Errors.

The ADHD/LD group's 10-12 year olds performed significantly better than the 8-9 year olds on Percent Correct and Categories Achieved. No significant age difference were revealed for Perseveration Errors. In both the Clinical group and the Control group, the 6-7 year olds performed significantly poorer than the 8-9 year olds and 10-12 year olds for all Percent Correct, Categories Achieved and Perseveration Errors.

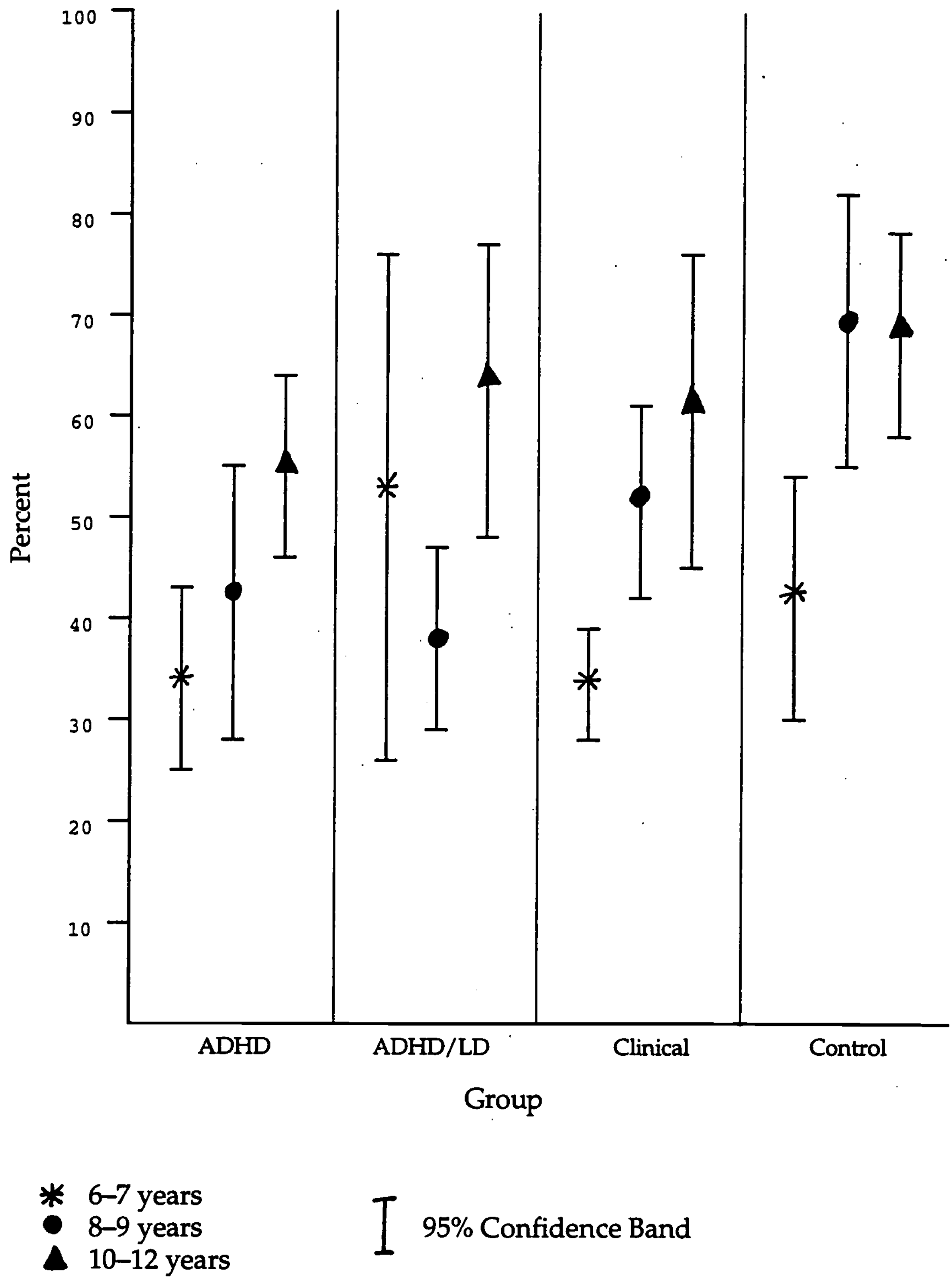

Figure 4. Simple Effects Comparison for WCST of the Three Age Classifications for Each Diagnostic Group: Percent Correct

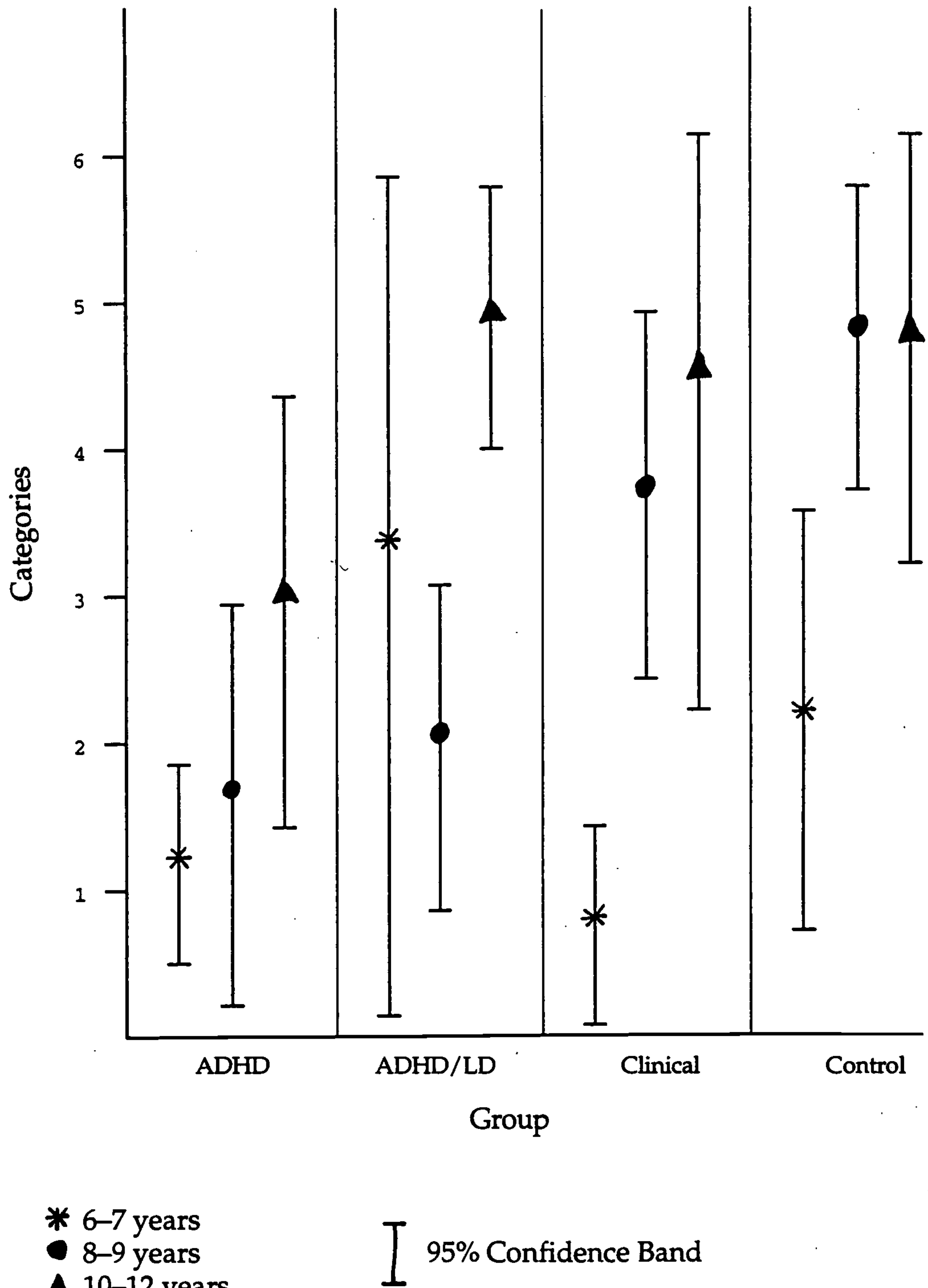

Figure 5. Simple Effects Comparison for WCST of the Three Age Classifications for Each Diagnostic Group: Categories Achieved

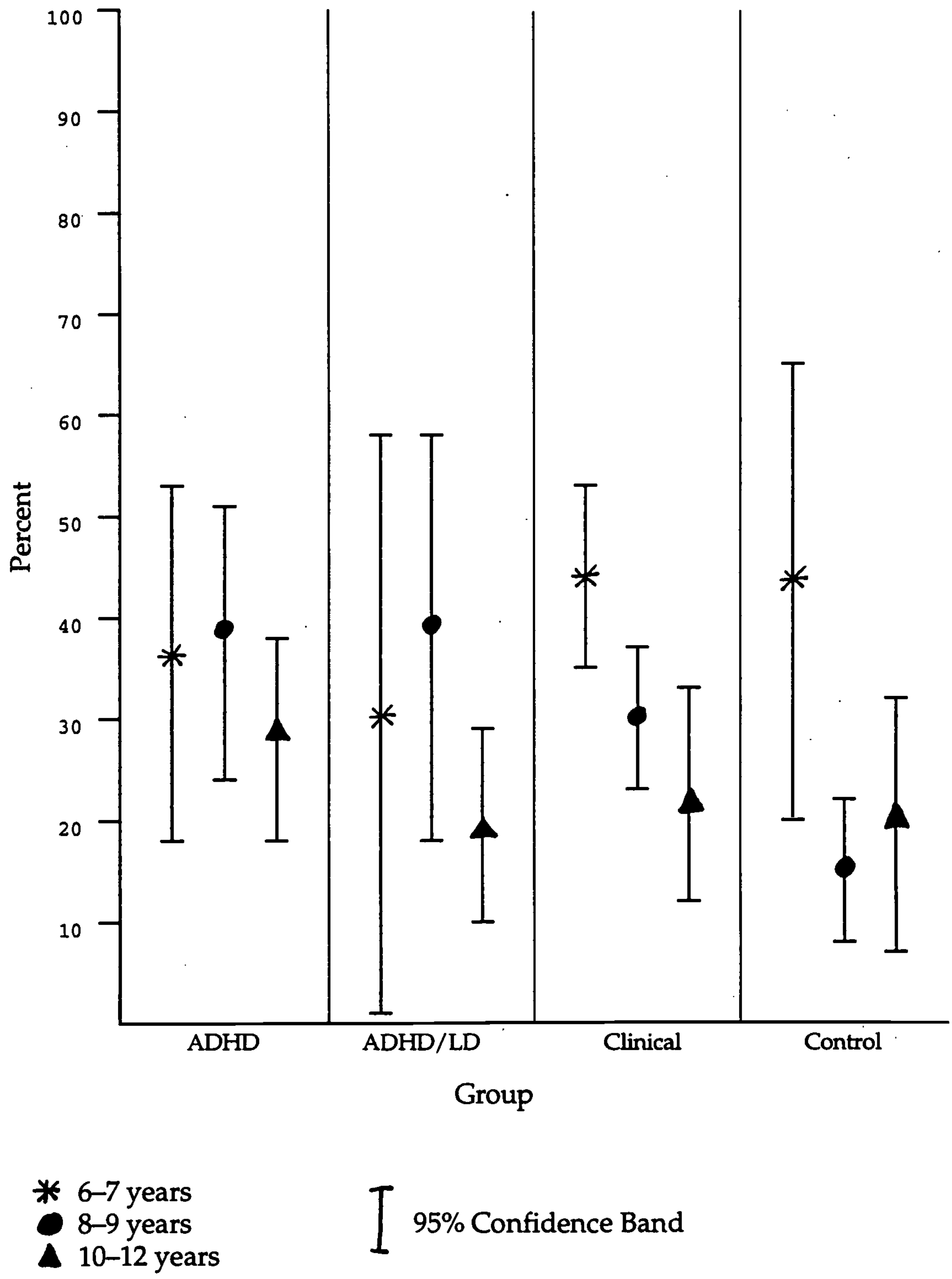

Figure 6. Simple Effects Comparison for WCST of the Three Age Classifications for Each Diagnostic Group: Perseveration Errors

Table 5 shows the cell means for the "pure" ADHD and ADHD/LD groups related Percent Correct, Categories Achieved, and Perseveration Errors. Examination of the means indicated that with the exception of the 8-9 year olds ADHD/LD poorer performance on Percent Correct and Perseveration Errors, the "pure" ADHD performed poor than the ADHD/ LD group at all age levels of Percent Correct, Categories Achieved, and Perseveration Errors. This gives minimal support to Hypothesis 2 which posited that some of the ADHD/LD group's ADHD symptoms could be a secondary symptom resulting from coping with the specific learning disability rather than related to impaired frontal lobe functioning.

Table 5

Means of WCST Components for Group by Age Conditions

	Age		
Group	6 -7 years	8-9 years	10-12 years
		Percent Correct	
ADHD	34.88	41.48	54.90
ADHD/LD	51.49	37.05	62.32
		Categories Achieved	
ADHD	1.14	1.63	2.88
ADHD/LD	3.00	2.00	4.86
		Perseveration Errors	
ADHD	35.57	37.50	31.13
ADHD/LD	28.17	38.00	19.29

Additional analyses were carried out on a component of the WCST not directly related to this study. Unexpectedly, the Group x Age ANOVA for Percent of Conceptual Level Responses revealed significant results. A significant Group main effect, $F(3, 78) = 6.181$, $p < .001$, a significant Age main effect, $F(2,78) = 17.253$, p .001, and a Group x Age interaction, $F(6,78) = 3.410$, $p < .005$, were revealed for Percent of Conceptual Level Responses. Group x AGE cell means are shown on Table 6. Simple Effects were run on the Group x Age interactions. A one-way ANOVA was run for each of the three age levels to determine if any two groups differed significantly from each other (Figure 7). The Tukey follow-up test revealed that no groups differed significantly at the 10-12 year old level. However, the Clinical groups performed significantly poorer than the ADHD/LD group at the 6-7 year old level. The "pure" ADHD and ADHD/LD performed poorer than the Clinical group at the 8-9 year old level with the ADHD/LD obtaining the lowest percentage level.

A one-way ANOVA was run for each of the four groups to determine if the subjects' performance within each age level of a particular group differed significantly (Figure 8). For the "pure" ADHD group, the 6-7 year olds obtained significantly fewer conceptual level responses than the 10-12 year olds. For the ADHD/LD group, the 8-9 year olds obtained significantly fewer conceptual level responses than the 10-12 year olds. For the Clinical group and the Control Group, the 6-7 year olds obtained significantly fewer conceptual level responses than both the 8-9 year olds and 10-12 year olds.

Table 6

Means of Percent of Conceptual Level Responses for Group by AGE Conditions

	Age		
Group	6-7 years	8-9 years	10-12 years
ADHD	18.53	27.24	41.71
ADHD/LD	39.36	22.76	50.69

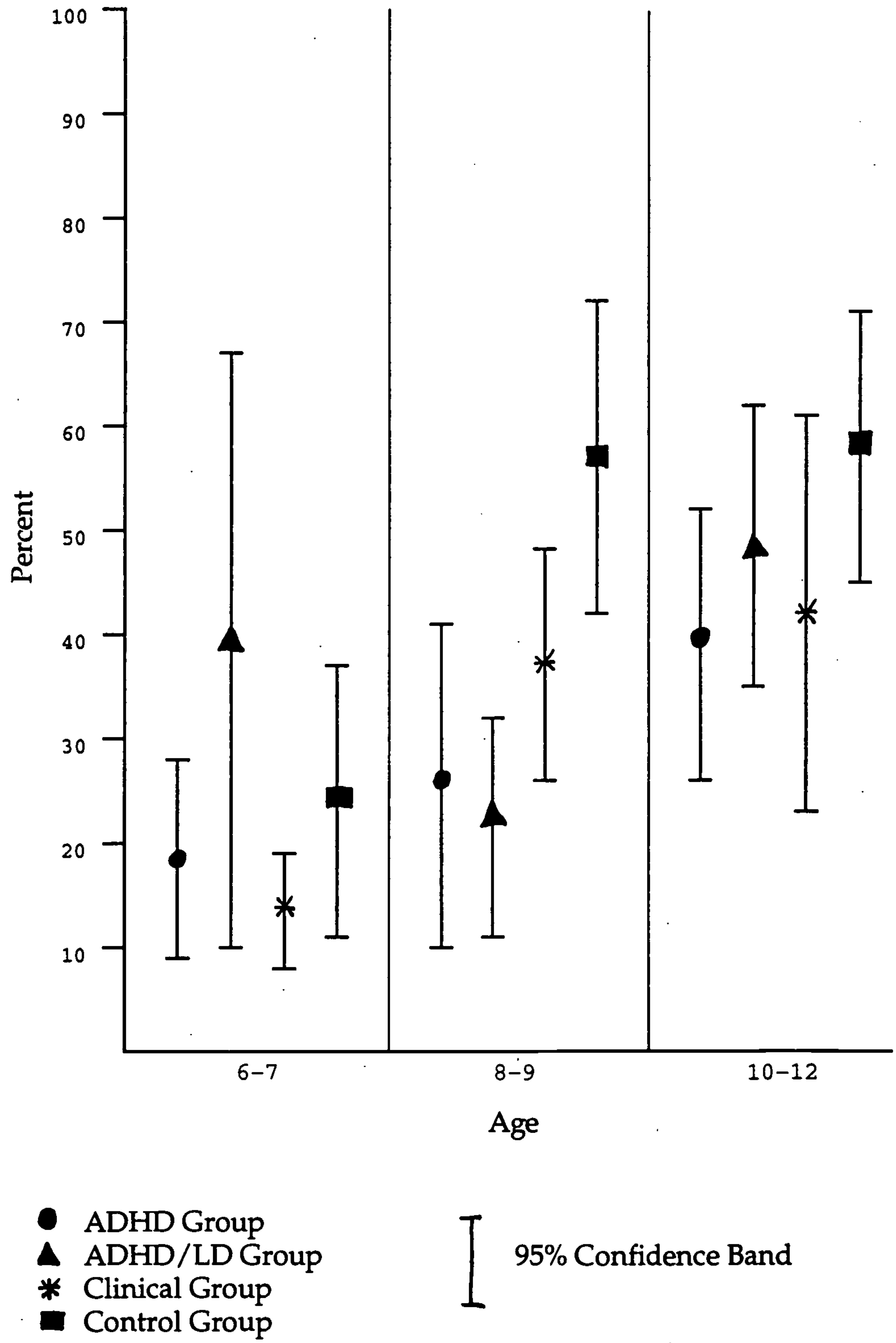

Figure 7. Simple Effects Comparison for WCST of the Four Diagnostic Groups for Each Age Classification: Percent of Conceptual Level Responses

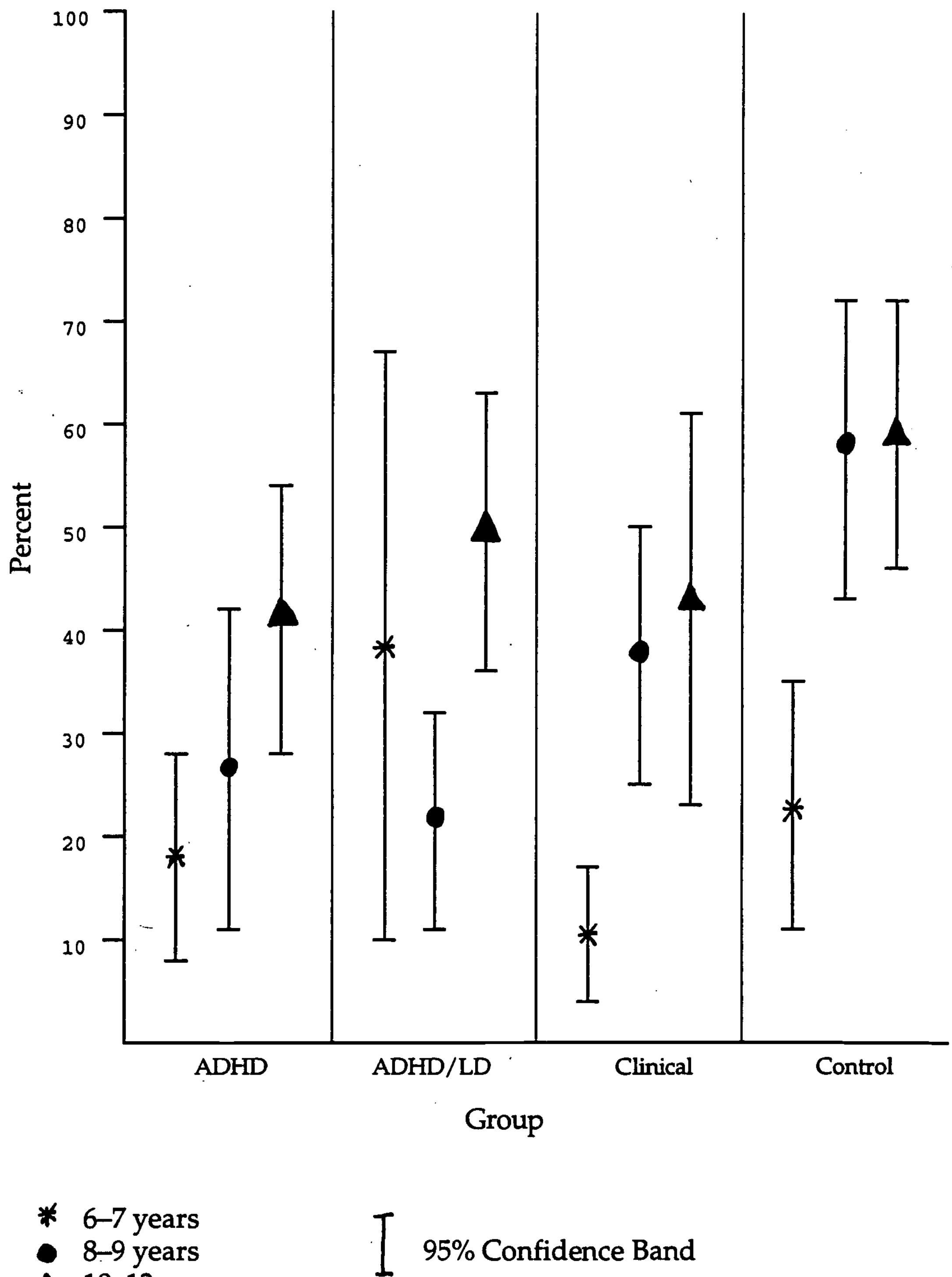

Figure 8. Simple Effects Comparison for WCST of the Three Age Classifications for Each Diagnostic Group: Percent of Conceptual Level Responses

CHAPTER 4

DISCUSSION

The present study explored the assessment and diagnosis of ADHD within a neuropsychological framework. The theoretical foundation for the evaluation was based on the premise that frontal lobe disinhibition can produce difficulties with impulsivity, inattention, and hyperactivity which are the hallmark symptoms of ADHD. Frontal lobe dysfunction has also been linked to executive functioning deficits in the areas of organizational skills, planning, future-oriented behavior, set maintenance, self regulation, selective attention, vigilance, and response regulation and inhibition. It was hoped that the separate information provided by the WISC-III and WCST would produce a pattern of results that would distinguish the "pure" ADHD group from the ADHD/LD, Clinical, and Control groups.

Analyses run on the WISC-III gave only partial support to Hypothesis 1. As expected, a pattern of poor performance was demonstrated by the "pure" ADHD group in comparison to the Control group for the three IQ scores (FSIQ, VIQ, PIQ), the four factor based scores (VCI, POI, FDI, PSI), and the 12 subtests. However, the prediction of a specific pattern of performance based on significant results was not obtained for the factor based score of PSI and the following subtests: Similarities, Picture Completion, Block Design, Vocabulary, Symbol Search Comprehension, and Mazes. This pattern of significant and nonsignificant subtest performances is thought to be the result of random variability with no strength of diagnostic predictibility present. Additionally, these findings challenge the practice of using Block Design and Vocabulary subtests in the estimation of a Full Scale IQ (Grodzinsky & Diamond, 1992; Kusché, Cook, & Greenberg, 1993) for the purpose of matching subjects according to intellectual functioning. This study would have obtained difference FSIQ results using the modified method. Skewed results would have emerged since a significant discrepancy was obtained between the "pure" ADHD group and the Control group for the WISC-III FSIQ with no significant differences obtained at the subtest level for Block Design and Vocabulary.

As predicted, the Control group obtained the highest FSIQ, VIQ, and PIQ in comparison to the "pure" ADHD, ADHD/LD, and Clinical groups with the "pure" ADHD demonstrating the poorest performance. Additionally, as predicted, no systematic pattern of performance emerged to distinguish the "pure" ADHD group, ADHD/LD group, or Clinical group. No significant differences between the three groups were demonstrated for VIQ. Interestingly for the PIQ, the Control, ADHD/LD, and Clinical groups, respectively, performed significantly better than the "pure" ADHD group. This result may lend support to the recent conceptualization that an executive functioning deficit or self-regulatory deficit underlies ADHD (Barkley, 1990; Douglas, 1988; Pennington, 1991). Douglas (1988) views ADHD as a self-regulatory deficit across visual, auditory, motor, and perceptual-motor modalities which affects organized information processing, effective attending throughout the processing of information, and the inhibition of inappropriate responding. The PIQ gives a measure of non-verbal mental processing. It is comprised of the PO factor which taps the child's ability to integrate and organize perceived material within a time limit and the PS factor which requires a high degree of attention and concentration in the process of rapidly scanning an array (Sattler, 1992). These required skills appear to relate directly to Diamond's views linking the symptoms of ADHD with a self-regulatory deficit model.

The predictions related to the factor based scores were only partially supported. As expected, the "pure" ADHD received the lowest scores in comparison to the other three diagnostic groups for the VCI and POI. Although the "pure" ADHD obtained lower scores for the FDI and PSI in comparison to the Clinical and Control groups, the "pure" ADHD group and ADHD/LD had comparable performances on FDI and PSI. The Control group performed significantly better than the other three groups for only VCI and FDI. Although no significant differences were revealed, in comparison to the Control group, the Clinical group performed better on PSI with the ADHD/LD group demonstrating a better performance for POI. After the Coding subtest score and the Symbol Search subtest score were removed from the PIQ, the ADHD/LD was shown to have even stronger perceptual organization skills according to the POI score.

Halperin, Gittelman, Klien, and Rudel (1984) found that a group of reading disabled/hyperactive children performed significantly better on PIQ than a group of hyperactive children with no learning disability. These researchers noted that past studies have suggested that reading disabled children may have superior configural spatial skills relative to normal children. Levin (1990), investigated the organizational abilities of dyslexic children on language and visuospatial tasks and concluded that primary frontal lobe dysfunction may be associated with executing effective problem-solving strategies related to the reading process. These findings may suggest that in relation to the visual modality, the ADHD/LD does not appear to have frontal lobe dysfunction.

Although this study incorporated a heterogeneous ADHD/LD group, some of the variance could be attributed to superior visuospatial skills or simply related to artifactual elements.

Both the Clinical and Control groups performed significantly better than the "pure" ADHD and ADHD/LD for PSI and FDI suggesting that the latter two groups may have weaknesses related to attention, concentration, or short-term memory. Although the factor based scores can be used to develop hypothesis about the child's strength and weakness (Sattler, 1988, 1992), specific comments about the etiology of the apparent attention, concentration, and memory issues cannot be made.

In a study using the WCST and WISC-R to compare the performance of Externalizers, Internalizers, and Controls, Matson and Fischer (1991) found that the WISC-R factor scores of VC, PO, FFD added discriminant power to a psychoneurological evaluation. However, the factor structure of the WISC-III has changed by altering the WISC-R FFD factor by taking out the Coding subtest and developing a PS factor which incorporates Coding. Sattler (1992) and Kamphaus and others (1994) argue that the WISC-III FDI should not be interpreted until further research demonstrates that it is a robust factor.

The WCST results only partially supported the Hypothesis 2 predictions. As expected, the "pure" ADHD demonstrated the poorest performance in comparison to the ADHD/LD, Clinical and Control groups for Percent Correct, Categories Achieved and Perseveration Errors. According to Chelune and others (1986), this performance pattern would indicate that the "pure" ADHD group had more difficulties with concept formation, cognitive flexibility, and the use of environmental feedback to regulated goal-directed behavior. Again, these are behaviors assumed to be negatively affected by frontal lobe disinhibition or executive functioning deficits.

Further analyses revealed Group x Age interactions from which some confusing and nonspecific patterns of performance emerged. For example, significant differences between the four diagnostic groups were only revealed for the 8-9 year olds. At this age classification, the "pure" ADHD and ADHD/LD performed significantly poorer than the Control group for Percent Correct, Categories Achieved, and Perseveration Errors with the ADHD/LD performing significantly lower than the Clinical group on Categories Achieved. Although mixed results exist, the ability of the WCST to discriminate between Controls and ADHD or ADD has been documented by different studies (Barkley et al., 1992; Chelune et al., 1986). Additionally, Chelune and Thompson, (1987) noted that their findings indicated even though the WCST performance may be age dependent, differences in levels of skills at younger and older age levels can be detected. However, Loge, Staton, & Beatty (1990) did not obtain any group differences on the WCST when comparing an ADHD group and Control group of normals using 6-12 year olds.

This study gave partial support to the other studies, but no specific pattern of findings was revealed. Developmental issues, other possible confounding issues associated with using four diagnostic groups, and variance due to random sampling are thought to have negatively impacted the ability of the WCST to discriminate between the four diagnostic groups at the 6-7 year old level and the 10-12 year old level.

Developmental issues related to the 6-7 year olds' performance on the WCST can be explained from different points of view. According to Piaget, the 6-7 year olds' cognitive development is characterized by slow, concrete, and restricted thought processes (Wadsworth, 1971). These restricted thought processes would make it difficult for the young child to plan and organize at any level that would approximate WCST requirements. Also, anatomical issues related to the laying down of myelin (Benson, 1991), suggest that the 6-7 year olds' brains are not matured or developed enough to perform the adult tasks required on the WCST.

For both nonverbal and verbal executive functions, a maturational spurt appears to take place between the ages of 6-8 (Becker, Isaac, & Hynd, 1987; Passler et al., 1985; Welsh et al., 1991). Additionally, Chelune and Baer (1986) noted that on the WCST a plateau appeared for eight year olds on the WCST. Feducia and O'Leary (1990) also noted a plateau at this age with a range of executive functions maturing at different times between the ages of 8-12. The maturational spurts and plateaus coupled with individual differences may explain the sensitivity of the WCST in some discriminating among the groups at the 8-9 year old level.

Gnys and Willis (1991) argued that tests developed for adults do not necessarily measure the same abilities in children. According to Welsh and Pennington (1988), most of these measures have not been designed with consideration given to the child's developmental level, nor developmental norms established. Developmental norms have been established for the WCST, but questions still arise as to whether the frontal lobe functions tapped by the WCST are developmentally appropriate for different ages of children. For example, Pennington (1991) noted that a younger child who does not have number concepts in place will be handicapped on the WCST. The utility of the WCST as a tool in the measurement of the executive functioning of children must be questioned since the children's developmental acquisition of executive functions is being measured in comparison to adult acquired functions.

Chelune et al. (1986) observed that ADD children make appropriate maturational gains on the WCST, but at a level approximately two years behind their matched cohorts. With the exception of the ADHD/LD group's 8-9 year olds' performance on Percent Correct and Perseveration Errors, it appears that gains were made between the 6-7 and 8-9 year olds and the 8-9 and 10-12 year olds across each diagnostic group. However, this study did not find a consistent pattern of growth across all groups for Percent Correct, Categories Achieved, and Perseveration Errors when the results were statistically analyzed. Again developmental issues, confounds from having four diagnostic groups, and variability from random sampling may have prevented the emergence of significant results.

Adding a heterogeneous ADHD/LD group and Clinical group to this study created confounding issues related to uncontrolled SES, sex and environmental factors which apparently prevented consistent discrimination between the groups on the WCST. The Clinical group may have performed better than expected on the WCST since these subjects were allowed to remain on antidepressant and anxiety medications which apparently allowed them to attend and process more effectively. Interestingly, recent research has suggested that not only are executive functioning deficits or frontal lobe dysfunction associated with ADHD, but also with psychopathology (Kusché et al., 1993) and dyslexia (Levin, 1990). Kusché et al. (1993) suggested that executive dysfunction or weakness might result in difficulties with controlling or ameliorating strong affect of any kind emanating from the limbic region. Levin (1990) posited that frontal lobe dysfunction may cause some dyslexic children to give irrelevant responses and make verbal intrusions because of poor organizational skills and deficit problem-solving abilities.

Very preliminary findings suggest that some of the ADHD/LD group's ADHD symptoms may be related to secondary symptoms of coping with the learning disability rather than associated with impaired functioning. Minimal support is given to this Hypothesis 2 notion when cell means for Percent Correct, Categories Achieved, and Perseveration Errors are compared for ADHD group and the ADHD/LD. With the exception of the performance of the 8-9 year olds in the ADHD/LD group on Percent Correct and Perseveration Errors, the "pure" ADHD group performed poorer than the ADHD/LD group at all levels of Percent Correct, Categories Achieved, and Perseveration Errors. However, this notion must be supported by strong statistical findings before accurate statements can be made.

Pennington (1991) found that a comorbid (ADHD/dyslexia) group's neuropsychological profile was identical to the pure dyslexia group's profile. These findings were posited to give converging evidence for the hypothesis that ADHD in dyslexia is usually a secondary symptom. McGee and Share (1988) supported this view by suggesting that many of the children labeled as ADHD really have attentional problems which are secondary consequences of their primary learning disability. More research needs to be conducted comparing groups with different "pure" learning disabilities, comorbid groups of ADHD/LD, and pure ADHD groups on instruments sensitive to frontal lobe functioning, attentional issues, memory issues and executive functioning issues.

Unexpectedly, the Group x Age ANOVA for Percent of Conceptual Level Responses revealed significant results. As with Percent Correct, Categories Achieved, and Perseveration Errors, no distinguishing pattern of performance emerged. However, this WCST component could add more information related to the development of concept formation should other studies find it a useful WCST component to investigate.

This study demonstrated that the WISC-III and the WCST are most valuable in distinguishing a "pure" ADHD group from a Control group of normals. Unfortunately, the two tests were not able to effectively distinguish between the "pure" ADHD, ADHD/LD and Clinical groups. Nevertheless, the WISC-III complemented the WCST results by giving information related to intellectual functioning, while also providing information to make some clinical hypotheses related to memory, attention, concentration, processing speed, verbal abilities and nonverbal abilities. Since it appears that frontal lobe functioning interfaces with all sensory input and output modalities, the versatility of the WISC-III in providing information about certain cognitive strengths and weaknesses could enhance the diagnostic and remedial process. Additionally, no support for the existence of a distinct pattern of test results which will distinguish groups was evidenced. These diverse test results also challenge the utility of the WCST as an appropriate measure for examining executive functioning in children.

The results of this study cannot be generalized because of the small size on which some of the findings were based. Since the subjects were only matched by age possible confounding issues related to SES, sex, and intellectual functioning may also have been present. Additionally, having an ADHD/LD group with subjects who had different learning disabilities and a heterogeneous Clinical group who remained on prescribed antidepressants and antianxiety medication introduced confounding issues that may have clouded the diagnostic picture.

Regardless, this study demonstrated that there are many unaddressed issues surrounding the diagnosis of ADHD using a neuropsychological framework.

More research is needed to identify executive functioning issues related to ADHD, psychopathology, and learning disabilities in children. Studies need to compare the performance of "purer" groups of children with one specific learning disability or one specific clinical diagnosis or ADHD. Comparison of "pure" ADHD groups and Clinical groups on and off medication would help identify the effects of medication on the child's performance on different tests. Additionally, research needs to continue to examine the neurological connections related to the frontal lobes and the implications of frontal lobe dysfunction on the different modalities using developmentally appropriate measures. Overall, it appears that researchers need to take the time to develop larger sample sizes with better defined groups so that findings can be generalized.

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Appendix A

Consent Form

University

INFORMED CONSENT TO ACT AS A HUMAN RESEARCH SUBJECT

"Usefulness of the Wechsler Intelligence Scale for Children-Third Edition and the Wisconsin Card Sorting Test for the Diagnosis of ADHD"

Investigator
Committee Chairperson

"Use of the Wechsler Intelligence Scale Children-Third Edition amd the Wechsler Individual Achievement Test in the Diagnosing of Learning Disabilities in an ADHD Referred Population"

Investigator
Committee Chairperson

University
Phone Number

Committee Member
University
Phone Number

NAME OF THE SUBJECT: ______________________________

PURPOSE OF THE STUDY

My child has been asked to participate in a research study examining frontal functioning in the diagnosis of children with and without Attention-Deficit Hyperactivity Disorder (ADHD) and the comorbidity of ADHD with learning disabilities.

PROCEDURES

Prior to participating, if my child is on stimulant medications, I will be asked to remove my child from the medication (circled): (a) Ritalin; (b) Cylert; (c) Dexadrine, for a period of 16 hours before testing. Full permission from my child's attending physician will be required to grant permission to have medication removed for 16 hours.

Attending Physician's name:______________________

After I fill out some questionaires and complete a short structured interview with the investigator, my child will be asked to perform up to two to three (2-3) hours of testing at the specified Loma Linda University clinic: ______________________.
During that period, my child will be asked to do the following procedures: (1) Intelligence testing; (2) A test of academic achievement; (3) A task involving the sorting of cards. I will also be asked to give written permission to have a questionaire sent to my child's classroom teacher.

RISKS

I understand that no invasive procedures will be used in this study. I understand that it is normal for testing to cause some degree of frustration. Hopwever, I understand that standard procedures such as breaks or discontinuing testing will be used to deal with frustration.

BENEFITS

I have been told that specific benefits cannot be guaranteed. However, it is hoped that the information learned from this study regarding attention deficit/hyperactive children may help in the diagnosis and treatment of children diagnosed as ADHD. It is also hoped that more can be found about some children who appear to have attentional problems that are really not related to ADHD.

PARTICIPANT'S RIGHTS

I have been told that my child's participation in the study is entirely voluntary. I may refuse to participate or withdraw him/her from participation at any time without jeopardy to future medical care, student status, or other entitlements. I have also been told that XXXXX will withdraw my child from the study at her professional discretion.

CONFIDENTIALITY

I have been told that at the completion of the study, the study results can be reviewed and shared with me and my child if I request it. Also upon request, an interpretation of the study results will be provided to other professionals or agencies (school, physician, psychologist). I understand that all research data will be stored in accordance with the routine of the clinic. Research data that is not routinely kept in the clinic's chart will be stored in a locked file in the investigator's research office and will be accessible to research staff only. Additionally, I have been told that any published accounts (as part of the study) will omit any identifying information.

COST/COMPENSATIONS

I have been told that testing utilized in the study will be considered part of the total clinical assessment of my child. However, no additional charges will be attached to the testing procedures associated with the study. If my child has already been assessed and diagnosed at one of the XXXX University clinics, the testing for the study will be offerred at no additional cost.

IMPARTIAL THIRD PARTY CONTACT

I have been told that if I wish to contact an impartial third party not associated with the study, I may contact XXXX, Patient Representative, XXXX, phone XXXX for information and assistance.

INFORMED CONSENT STATEMENT

I have read the contents of the consent form and have listened to the verbal explanation given by the investigator. My questions about this study have been answered to my satisfaction. I hereby give voluntary consent for my child to participate in this study. Signing the consent does not waive my rights nor does it release the investigators, institution or sponsors from their responsibilities. I may leave a message for contact with XXXX should I have additional questions or concerns.

VERIFICATION OF RECEIPT OF DOCUMENTS

(Please initial each statement to indicate receipt of documents)

I have been given a copy of this consent form. _______

I have received a copy of of the California Experimental Subject's Bill of Rights and have had the rights explained to me. _______

SIGNATURES

1. Children seven years and older.

The study has been explained to me. I understand it and I wish to participate in the study.

_______________________________ Signature of the child

_______________ Witness

This protocol has been explained to my child at a level that he/she can comprehend.

_______________________________ Signature of the parent or guardian

__________ Date

2. Children six years old

The subject is unable to sign because___________________________________.

_______________________________ Authorized Signature

_______________ Relationship

__________ Date

I have reviewed the contents of the consent form and the California Experiemental Subject's Bill of Rights with the person(s) signing above. I have explained potential risks and benefits of the study.

Signature of the investigator　　　　Phone number　　　　Date

CALIFORNIA EXPERIMENTAL SUBJECT'S BILL OF RIGHTS

You have been asked to participate as a subject in an experimental clinical procedure. Before you decide whether you want to participate in the experimental procedure, you have the right to:

1. Be informed of the nature and purpose of the experiment;

2. Be given an explanation of the procedures to be followed in the medical experiment, and any drug or device utilized;

3. Be given a description of any attendant discomforts and risks reasonably to be expected from your participation in the experiment;

4. Be given an explanation of any benefits reasonably to be expected from your participation in the experiment;

5. Be given a disclosure of any appropriate alternative procedures, drugs, or devices that might be advantageous to you and their relative risks and benefits;

6. Be informed of the avenues of medical treatment, if any, available to you after the experimental procedure if complications should arise;

7. Be given an opportunity to ask any questions concerning the medical experiment or the procedures involved;

8. Be instructed that consent to participate in the experimental procedure may be withdrawn at anytime and that you may discontinue participation in the medical experiment without prejudice;

9. Be given a copy of this form and the signed and dated written consent form; and

10. Be given the opportunity to decide to consent or not to consent to the medical experiment without the intervention of any element of force, fraud, deceit, duress, coercion, or undue influence to your decision.

I have carefully read the information contained in the "Californial Experimental Subject's Bill of Rights" and I understand fully my rights as a potential subject in a medical experiment involving people as subjects.

______________ ______________________________________

Date Patient

______________ ______________________________________

Time Parent/Legal Guardian

If signed by other than the patient, indicate the relationship:

______________________________ ______________________

Witness

Appendix B

Manuscript Suitable for Publication

The Usefulness of The Wechsler Intelligence Scale For Children–Third Edition and the Wisconsin Card Sorting Test in the Diagnosis of Attention-Deficit Hyperactivity Disorder

Elleen A. Hooper,

William M. McQueen, William G. Britt, Paul L. Poelstra

Rosemead School of Psychology

Biola University

Running Head: WISC-III AND WCST

Abstract

Using a neuropsychological framework, this study explored the usefulness of the Weschler Intelligence Scale for Children–Third Edition and Wisconsin Card Sorting Test in the diagnosis of Attention-Deficit Hyperactivity Disorder. A sample of 90 children ages 6-12 (mean age = 8.53) were divided into four diagnostic groups: (a) pure ADHD, (b) ADHD with a learning disability (ADHD/Learning Disability), (c) clinical group with a diagnosis other than ADHD and/or learning disability, and (d) control group of normals. Utilizing a 4 x 3 factorial design, Group x Age comparisons were made to determine if a specific pattern of performance on the WISC-III and WCST would differentiate the ADHD group from the ADHD/LD, Clinical, and Control groups. On the WISC-III, no specific pattern of significant differences emerged to distinguish the ADHD group from the ADHD/LD or Clinical group. However, the ADHD group did demonstrate the poorest performance in comparison to the ADHD/LD and Clinical groups of the Full Scale IQ, Verbal IQ, Performance IQ, Verbal Comprehension Index and Perceptual Organization Index. Significant group main effects for the WCST were revealed for Percent Correct and Categories Achieved. Significant Age main effects and Group x Age interactions were revealed for Percent Correct, Categories Achieved, Perseveration Errors, and unexpectantly for Percent of Conceptual Level Responses. Significant group differences were only revealed for the 8-9 year olds with no specific pattern emerging. Some significant maturational gains were demonstrated, but the results varied for the different diagnositic groups with no consistent pattern of gains noted.

The Usefulness of The Wechsler Intelligence Scale For Children–Third Edition and the Wisconsin Card Sorting Test in the Diagnosis of Attention-Deficit Hyperactivity Disorder

Attention-deficit Disorder (ADHD), (American Psychiatric Association (APA), 1987) is the most prevelant of the childhood behavioral disorders with approximately 3 to 5% of the childhood population having the disorder depending on the definition chosen. This disorder appears to exist across cultures with some fluctuation related to national/ethnic groups (Ross & Ross, 1982). Barkley (1990) estimated that on the average a 6:1 male to female ratio was cited in most studies for clinic-referred samples of children with a range of ratio from 2:1 to 10:1.

Despite the prevelance of Attention-Deficit Hyperactivity Disorder (ADHD) and the amount of research focused on the disorder, it remains misunderstood due to its heterogeneous qualities, associated issues of comorbidity, and numerous etiological questions. It is this controversy related to etiology and problems of comorbidity that has led to problems in the conceptualization of ADHD as a distinct disorder. Barkley (1990) posits that with the development of consensus criteria for clinical diagnosis or for research, and with greater attention to the study of "pure" cases of ADHD, a better and more critical test of the notion of ADHD as a distinct disorder can be addressed.

Research examining the link between symptoms of ADHD and frontal lobe dysfunction has attempted to bring more understanding to the neuroanatomical and/or neurophysiological underpinnings of the disorder. Findings of some of the studies have indicated that dysfunctioning in the prefrontal/frontal lobes can result in the symptoms of impulsivity, poor attention, hyperactivity and poor response regulation and inhibition which are hallmark characteristics of ADHD (Chelune et al, 1986; Hynd et al., 1990). Specifically, the executive functions of the frontal lobe which involve strategic planning, impulse control, organized search, and flexibility in thought and actions appear to be negatively affected (Welsh, Pennington, and Grossier, 1991). However, no consensus has been reached on a cognitive taxonomy of executive functions or on a neuropsychological theory of how and where these executive functions are localized within the prefrontal areas (Pennington, 1991). Although a hypothesis purposing frontal lobe dysfunction does not provide a complete explanation for the etiology of ADHD, it does provide a framework for the explanation of many of the symptoms associated with the disorder.

The evaluation of frontal lobe functioning in children has been subject to controversy related to the absence of neurological tests that are standardized on children and address developmental issues (Welsh and Pennington, 1988). Welsh, Pennington and Grossier (1991) noted that attempts to operationalize prefrontal and frontal functioning in children has concentrated on adult neuropsychological measures with little adaption for the child's developmental level. Nevertheless, the study conducted by Chelune and Baer (1986) laid a beginning foundation for the establishment of children's norms on one adult test sensitive to frontal lobe functioning.

Using the standardized form of the Wisconsin Card Sorting Test (WCST) (Heaton, 1981) and attempting to maintain a developmental perspective of frontal lobe functioning, Chelune and Baer (1986) conducted a study for the purpose of developing norms for children. Supported by other research (Passler, Issac, and

Hynd, 1985), Chelune and Baer (1986) demonstrated that those behaviors presumed to be dependent on frontal lobe functioning, develop rapidly from the age of 6 and essentially reach adult levels of functioning by age 10. Since the Chelune and Baer (1986) study, research utilizing the WCST has revealed mixed findings as to the sensitivity and appropriateness of this instrucment in measuring frontal lobe functioning in children and adolescents with and without a clinical diagnosis (Barkley, Grodzinsky, & DuPaul, 1992).

This present study will be based on the research developed by Chelune, Ferguson, Koon, and Dickey (1986) where the neuropsychological performance of children with ADD was compared with matched controls using a battery of tests which included the WCST. In the study by Chelune et al. (1986), no significant differences between the ADD and Control group were found on most measures of general intelligence and mental processing. However, in regards to the WCST, the ADD group performed signifcantly poorer than the Control group by making more perseveration errors, sorting fewer categories, and obtaining a lower percentage correct.

For this study, a neuropsychological framework will be used to explore the assessment and diagnosis of ADHD using the WCST (Heaton, 1981; Heaton et al., 1983) and the Wechsler Intelligence Scale for Children–Third Edition (WISC-III), (Wechsler, 1992). Using children ages 6-12, this study will compare the performance of a "pure" ADHD group, an ADHD and learning disability (ADHD/LD) group, a clinical group of children not diagnosed with ADHD or a learning disability, and a control group of "normal" children.

Method

<u>Subjects</u>

The testing population consisted of 90 school-aged children between the ages of 6-12 years (mean age = 8.53) from clinics and private schools in Southern California. After a battery of test was administered, the children were divided into four diagnositic groups: "pure" ADHD (16 males, 7 females), ADHD/LD (14 males, 7 females), Clinical (16 males, 9 females), and Control (11 males, 10 females). The four diagnostic groups were also divided into three age categories: 6-7 years, 8-9 years, and 10-12 years. The battery of tests consisted of the WISC-III, Wechsler Individual Achievement Test (Psychological Corporation, 1992), Conners Teacher and Parent Rating Scales (Conners, 1969, 1970, 1989), and the Home and School Situation Questionaire-Revised (DuPaul, 1990). Parents also completed an interview which followed the ADHD Parent Interview Form (Barkley, 1990). All children obtained an 85 IQ on the WISC-III Full Scale IQ, Verbal IQ, or Performance IQ. The "pure" ADHD group met the minimal requirements for the DSM-IIIR diagnosis (APA, 1987) and satisfied standardized criteria suggested by Barkley (1990). The ADHD/LD met the "pure" ADHD criteria and the criteria for diagnosis of a learning disability using a 20 point discrepancy model. The Clinical group had a clinical diagnosis other than ADHD, learning diability, or psychosis. The control group consisted of children exclusively from the private schools who did not meet the criteria for ADHD or learning disability and had no identified clinical diagnosis.

<u>Tests</u>

For the purpose of this study, the evaluation of test results was limited to the WSCT and WISC-III. The children were free of Cylert, Ritalin, or Dexadrine

16 hours before testing. However, the Clinical group remained on any prescribed antidepressant or antianxiety medication.

The Wisconsin Card Sorting Test (WCST) is a measure of perseverative thinking, concept formation, and problem solving which has been shown to discriminate between frontal and nonfrontal brain lesions in adults (Heaton, 1981). The WCST utilizes stiumlus and response cards which have figures varying in form, color, and number. After instructions are given, the subject is to sort a deck of response cards to match the stimulus cards. After each response, the subject is told whether or not the card is correctly sorted. The task is to sort 10 cards to color, 10 cards to form, and 10 cards to number. Some of the scores derived on the WCST are: Total Percent Correct, Categories Achieved, Perseveration Errors Perseverative Responses, Percent of Perseveration Errors, Percent of Conceptual Level Responses and Failure to Maintain Set.

The WISC-III evaluates the mental processing of children ages 6 through 16. The WISC-III contains 13 subtests, 6 in the Verbal Scale and 7 in the Performance Scale. Five subtests in each scale are designated as standard tests and combine to give a measure of general intelligences as measured by the Full Scale IQ. The Verbal Scale subtests include Information, Similarities, Vocabulary, Comprehension, and Arithmetic. The Performance Scale contains Picture Completion, Block Design, Picture Arrangement, Coding and Object Assembly subtests. The remaining subtests of Digit Span in the Verbal Scale and Symbol Search and Mazes in the Performance Scale are supplemental. Symbol Search and Coding combine to give a measure of Processing Speed. Arithmetic and Digit Span combine to produce a measure labelled Freedom from Distractibility. Picture Completion, Picture Arrangement, Block Design, and Object Assembly give a measure labelled Perceptual Organization. Comprehension, Vocabulary, Similarities, and Information give a measure labelled Verbal Comprehension.

Results

A 3 (Age) x 4 (Group) Analysis of Variance (ANOVA) performed for each of the three WISC III IQ scores (FSIQ, VIQ, PIQ) and the four factor based indexes (VCI, POI, FDI, PSI) revealed significant Group main effects for the three WISC-III IQ scores and four factor based scores. Significant Group main effects for the WISC-III IQ scores were as follows: FSIQ, F (3, 78) = 4.567, $p < .005$; VIQ, F (3,78) = 4.356, $p < .007$; and PIQ, F (3, 78) = 3.176, $p < .005$. The following significant Group main effects were noted for the factor based scores: VC, F (3, 78) = 3.176, $p < .029$; PO, F (3, 78) = 4.604, $p < .005$; FD, F (3, 78) = 8.197, $p < .000$; and PS, F (3,78) = 4.149, $p < .009$. No Age main effects or Group x Age interactions were revealed.

The significant group main effects were further analyzed using one-way ANOVAs with follow-up multiple range Tukey-HSD tests to determine specifically which groups differed significantly for the WISC-III IQ scores and factor based indexes. In Table B-1, the means and standard deviations of the WISC-III IQ scores, factor based indexes, and subtests are presented with indication of significant group differences at the .05 level.

A significant difference at the .05 level was demonstrated between the "pure" ADHD group and the Control group for the WISC-III IQ scores (FSIQ, VIQ, PIQ) and for three of the four factor based indexes (VC, PO FD). Although the "pure" ADHD performed poorer than the Control group on all the subtests, a significant difference at the .05 level was only demonstrated by Information, Comprehension, Coding, Picture Arrangement, Arithmetic, Object Assembly, and Digit Span.

Additionally, the Control group demonstrated the highest FSIQ, VIQ, and PIQ means in comparison to the "pure" ADHD group, ADHD/LD group, and Clinical group with the "pure" ADHD obtaining the lowest IQ means of all the groups (Table B-1). Although the Control group performed better than the other groups, a specific pattern was not supported by the statistical analyses. The Control group performed significally better than the "pure" ADHD group for the FSIQ, VIQ, and PIQ and the ADHD/LD group for VIQ. The "pure" ADHD group demonstrated the poorest performance for the FSIQ, VIQ, and PIQ in comparison to the ADHD/LD, Clinical, and Control groups (Table B-1). No systematic pattern of performance for the VIQ and PIQ emerged among "pure" ADHD, ADHD/LD, and Clinical groups. In fact, the only suggested pattern was that the "pure" ADHD group performed poorer than the ADHD/LD and Clinical groups for both VIQ and PIQ. No significant differences were revealed for VIQ in any of the group comparisons.

The analyses for the factor based indexes (VCI, POI, FDI, PSI) revealed no consistent pattern of performance that would distinguish the groups. Although a specific pattern distinguishing the groups did not emerge, significant differences were revealed for some of the groups on the four indexes. The "pure" ADHD group VC Index mean was significantly lower than the Control group mean. For the PO Index, the "pure" ADHD group mean was significantly lower than the means for the ADHD/LD group and Control group. The FD Index means for the Control group and the Clinical group were significantly higher than the means for the "pure" ADHD group and ADHD/LD group. The PS Index mean for the

Clinical group was significantly higher than the ADHD/LD group and "pure" ADHD.

Insert Table B-1 about here

A 3 (Age) x 4 (Group) Analysis of Variance (ANOVA) was run on each measure of the WCST test. Variable x Group x Age ANOVAs revealed significant results for Categories Achieved, Percent Correct, Perseveration Errors, and unexpectantly for Percent of Conceptual Level Responses. Significant Group main effects were revealed for Percent Correct, F (3,78) = 4.78, $p < .004$, Categories Achieved, F (3,78) = 6.44, $p < .001$, and Percent of Conceptual Level Responses, F (3, 78) = 6.18, $p < .001$. Significant Age main effects were revealed for Percent Correct, F (2,78) = 16.06, $p < .000$, Categories Achieved, F (2,78) = 4.78, $p < .004$, Perseveration Errors, F (2, 78) = 6.09, $p < .003$, and Percent of Conceptual Level Responses, F (2,78) = 17.25, p .001. Group by Age interactions were revealed for Percent Correct, F (6,78) = 2.98, $p < .011$, Categories Achieved F (6,78) = 2.87, $p < .014$, Perseveration Errors, F (6,78) = 2.24, $p < .048$, and Percent of Conceptual Level Responses, F (6,78) = 3.41, $p < .005$.

Simple Effects analyses were used to explore the Group x Age interactions. The difference between the four diagnostic groups for each age classification was examined using one-way ANOVAs with the Tukey follow-up test (Table B-2). No significant differences between the groups was found for 6-7 year olds and then for the 10-12 year olds for Percent Correct, Categories Achieved, and Perseveration Errors. However, for Percent of Conceptual Level

Responses the Clincial group performed significantly poorer than the ADHD/LD group at the 6-7 ear old level. Significant differences between the four diagnostic groups were revealed for the 8-9 year olds. For Percent Correct the "pure" ADHD and ADHD/LD performed significantly poorer than the Control group. For Categories Achieved the "pure" ADHD performed significantly poorer than the Clinical and Control groups with the ADHD/LD also showing significantly poor performance than the Control group. For Perseveration Errors both the "pure" ADHD and the ADHD/LD groups performed significantly poorer than the Control group. Finally, for Percent of Conceptual Level Responses the "pure" ADHD and ADHD/LD groups performed poorer than the Clinical group.

Insert Table B-2 about here

A one-way ANOVA with a Tukey follow-up test was run for each diagnostic group to examine age differences for Percent Correct, Categories Achieved, Perseveration Errors, and Percent of Conceptual Level Responses (Table B-3). The "pure" ADHD group's 10-12 year olds performed significantly better than the 6-7 year olds for Percent Correct and Conceptual Level Responses with no significant age differences revealed for Categories Achieved or Perseveration Errors.

The ADHD/LD group's 10-12 year olds performed significantly better than the 8-9 year olds on Percent Correct, Categories Achieved and Conceptual Levle Responses. No significant age differences were revealed for Perseveration

Errors. In both the Clinical group and the Control group, the 6-7 year olds performed significantly poorer than the 8-9 year olds and 10-12 year olds for Percent Correct, Categories Achieved, Perseveration Errors and Percent of Conceptual Level Responses.

Insert Table B-3 about here

Discussion

The present study explored the assessment and diagnosis of ADHD within a neuropsychological framework. The theoretical foundation for the evaluation was based on the premise that frontal lobe disinhibition can produce difficulties with impulsivity, inattention, and hyperactivity which are the hallmark symptoms of ADHD. Frontal lobe dysfunction has also been linked to executive functioning deficitis in the areas of organizational skills, planning, future-oriented behavior, set maintenance, self regulation, selective attention, vigilance, and response regulation and inhibition. It was hoped that the separate information provided by the WISC-III and WCST would produce a pattern of results that would distinguish the "pure" ADHD group from the ADHD/LD, Clinical, and Control groups.

This study demonstrated that the WISC-III and the WCST are most valuable in distinguishing a "pure" ADHD group from a Control group of normals. Unfortunately, the two tests were not able to effectively distinguish between the "pure" ADHD, ADHD/LD and Clincial groups. Nevertheless, the WISC-III complemented the WCST results by giving information related to intellectual functioning, while also providing information to make some clinical hypotheses related to memory, attention, concentration, processing speed, verbal abilities and nonverbal abilities. Since it appears that frontal lobe functioning interfaces with all sensory input and output modalities, the versatility of the WISC-III in providing information about certain cognitive strengths and weaknesses could enhance the diagnostic and remedial process. Additionally, no support for the existence of a distinct pattern of test results which will distinguish groups was evidenced.

The pattern of significant and nonsignificant WISC-III subtest performances is thought to be the result of random variability with no strength of diagnostic predictibility present. Additionally, these findings challenge the practice of using Block Design and Vocabulary subtests in the estimation of a Full Scale IQ (Grodzinsky & Diamond, 1992; Kusché et al., 1993;) for the purpose of matching subjects according to intellectual functioning. This study would have obtained difference FSIQ results using the modified method. Skewed results would have emerged since a significant discrepancy was obtained between the "pure" ADHD group and the Control group for the WISC-III FSIQ with no significant differences obtained at the subtest level for Block Design and Vocabulary.

Interestingly for the PIQ, the Control, ADHD/LD, and Clinical groups, respectively, performed significantly better than the "pure" ADHD group. This result may lend support to the recent conceptualization that an executive functioning deficit or self-regulatory deficit underlies ADHD (Barkley, 1990; Douglas, 1988; Pennington, 1991). Douglas (1988) views ADHD as a self-regulatory deficit across visual, auditory, motor, and perceptual-motor modalities which affects organized information processing, effective attending throughout the processing of information, and the inhibition of inappropriate responding. The PIQ gives a measure of non-verbal mental processing. It is comprised of the PO factor which taps the child's ability to integrate and organize perceived material within a time limit and the PS factor which requires a high degree of attention and concentration in the process of rapidly scanning an array (Sattler, 1992). These required skills appear to relate directly to Diamond's views linking the symptoms of ADHD with a self-regulatory deficit model.

In a study using the WCST and WISC-R to compare the performance of Externalizers, Internalizers, and Controls, Matson and Fischer (1991) found that the WISC-R factor scores of VC, PO, FFD added discriminant power to a psychoneurological evaluation. However, the factor structure of the WISC-III has changed by altering the WISC-R FFD factor by taking out the Coding subtest and developing a PS factor which incorporates Coding. Sattler (1992) argues that the WISC-III FDI should not be interpreted until further research demonstrates that it is a robust factor.

The WCST Group x AGE interactions produced some confusing and nonspecific patterns of performance which only partially supported the study by Chelune et al. (1986). Developmental issues, other possible confounding issues associated with using four diagnostic groups, and variance due to random sampling are thought to have negatively impacted the ability of the WCST to discriminated between the four diagnostic groups at the 6-7 year old level and the 10-12 year old level.

Developmental issues related to the 6-7 year olds' performance on the WCST can be explained from different points of view. According to Piaget, the 6-7 year olds' cognitive development is characterized by by slow, concrete, and restricted thought processes (Wadsworth, 1971). These restricted thought processes would make it difficult for the young child to plan and organize at any level that would approximate WCST requirements. Also, anatomical issues related to the laying down of myelin (Benson, 1991), suggest that the 6-7 year olds' brains are not matured or developed enough to perform the adult tasks required on the WCST.

For both verbal and nonverbal executive functions, a maturational spurt appears to take place between the ages of 6-8 (Becker et al, 1987; Passler et al., 1985; Welsh et al., 1991). Additionally, Chelune and Baer (1986), noted a plateau appeared for eight year olds on the WCST. The maturational spurts and plateaus coupled with individual differences may explain the sensitivity of the WCST to have some discrimination among the groups at the 8-9 year old level.

Gnys and Willis (1991) argued that tests developed for adults do not necessarily measure the same abilities in children. According to Welsh and Pennington (1988), most of these measures have not been designed with consideration given to the child's developmental level, nor developmental norms established. Developmental norms have been established for the WCST, but questions still arise as to whether the frontal lobe functions tapped by the WCST are developmentally appropriate for different ages of children. For example, Pennington (1991) noted that a younger child who does not number concepts in place will be handicapped on the WCST. The utility of the WCST as a tool in the measurement of the executive functioning of children must be questioned since the children's developmental acquistion of executive functioning is being measured in comparison to adult acquired functioning.

Interestingly, recent research has suggested that not only are executive functioning deficits or frontal lobe dysfunction associated with ADHD, but also with psychopathology (Kusche et al., 1993) and dyslexia (Levin, 1990). Kusché et al. (1993) suggested that executive dysfunction or weakness might result in difficulties with controlling or ameliorating strong affect of any kind emanating from the limbic region. Levin posited that frontal lobe dysfunction may cause some dyslexic children to give irrelevant responses and make verbal intrusions because of poor organizational skills and deficit problem-solving abilities. Adding the ADHD/LD and Clincial groups to the study created confoundign issues which apparently prevented consistent discrimination between the ADHD, ADHD/LD and Clincal groups.

The results of this study cannot be generalized because of the small cell means on which some of the findings were based. Since the subjects were only matched by age possible confounding issues related to SES, sex, and intellectual functioning may also have been present. Additionally, having an ADHD/LD group with subject diagnosed with different learning disabilities and a heterogeneous Clinical group who remained on antidepressant and antianxiety medication introduced confounding issues that may have clouded the diagnostic picture. Regardless, this study demonstrated that there are many unaddressed issues surrounding the diagnosis of ADHD using a neuropsycholgical framework.

More research is needed to identify executive functioning issues related to ADHD, psychopathology, and learning disabilities in children. Studies need to compare the performance of "pure" groups of children with one specific learning disability or one specific clincial diagnosis or well defined ADHD. Comparison of "pure" ADHD groups and Clinical groups on and off all medication would help identify the effects of medication on the child's performance on different tests. Additionally, research needs to continue to examine the neurological connections related to the frontal lobes and the implications of frontal lobe dysfuction on the different modalities using developmentally appropriate measures. Overall, it appears that the researchers need to take time to develop larger sample sizes with better defined groups so that findings can be generalized and more definitive statements can be made regarding findings.

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Table B-1

Group Means and Standard Deviations for WISC-III IQ's, Factor Based Indexes, and Subtests

	ADHD		ADHD/LD		Clinical		Control	
	M	SD	M	SD	M	SD	M	SD
IQs								
FSIQ	98.26*	12.49	104.38	9.21	105.48	12.17	110.24**	10.36
VIQ	100.48*	13.18	101.90*	10.08	105.24	11.45	111.85**	10.99
PIQ	96.30*	12.05	106.57**	9.89	105.96*	12.67	107.10**	11.19
Factor Based								
VC Index	101.96*	13.41	104.38	9.21	105.48	12.17	110.24**	10.36
PO Index	98.39*	11.20	110.14**	9.24	105.12	12.89	108.10**	11.90
FD Index	95.00*	12.51	94.52*	9.72	107.84**	15.02	108.33**	12.60
PS Index	96.70	12.43	96.81	11.90	106.76**	12.83	105.05	12.60
Subtests								
Pic. Compl.	9.91	2.48	12.14**	1.93	11.04	2.82	10.86	2.99
Information	9.21*	3.93	10.48	2.96	10.36	3.05	11.86**	2.74
Coding	8.39*	2.54	8.57*	3.19	11.16	3.30	10.10**	2.81
Similarities	9.78	2.47	11.90	7.31	11.36	3.21	12.14	2.59
Pic. Arrange.	8.57*	3.01	11.29	2.74	10.96	3.28	10.05**	2.82
Arithmetic	8.91*	2.61	8.27*	2.10	10.80	2.83	11.38**	2.75
Block Design	10.17	3.07	11.48	3.01	10.20	3.11	12.38	2.26
Vocabulary	10.74	3.22	10.10	2.40	10.76	3.23	11.71	2.26
Obj. Assembly	9.78*	2.24	11.67**	1.32	10.84	2.51	11.62**	2.04
Compreh.	10.61	3.38	11.38	2.51	10.88	2.27	12.71	2.87
Symbol Search	9.91	2.89	10.05	2.22	11.04	3.02	11.48	2.73
Digit Span	9.04*	2.55	9.48	2.54	11.08**	4.11	11.24**	2.88
Mazes	8.87	2.74	8.48	3.53	10.76	4.71	11.29	2.61

* = significantly poorer performance than the Control group at the .05 level
** = significantly better performance than the ADHD group at the .05 level

Table B-2

Examination of Differences Between the Four Diagnostic Groups for a Given Age Classification on a Specific WCST Component

	Age by Group			
	ADHD	ADHD/LD	Clinical	Control
Percent Correct				
6-7	34.88	51.49	32.66	42.23
8-9	41.48 a	37.05 a	52.63	68.45
10-12	54.90	62.32	60.56	68.41
Categories Achieved				
6-7	1.14	3.00	.75	2.14
8-9	1.63 a, b	2.00 a	3.75	4.75
10-12	2.88	4.86	4.22	4.83
Perseveration Errors				
6-7	35.57	28.17	44.63	42.71
8-9	37.50 a	38.00 a	29.75	14.88
10-12	31.13	19.29	22.33	19.17
Percent of Conceptual Level Responses				
6-7	18.53	39.36	11.86 c	25.34
8-9	27.24 b	22.76 b	38.27	59.81
10-12	41.71	50.69	43.97	61.10

a = significantly poorer performance than the Control group (.05 level)
b = singificantly poorer performance than the Clinical group (.05 level)
c = significantly poorer performance than the ADHD/LD group (.05 level)

Table B-3

Examination of Differences Between the Three Age Classifications for a Given Diagnostic Group on a Specific WCST Component

	Group by Age		
	6-7 years	8-9 years	10-12 years
Percent Correct			
ADHD	34.88	41.48	54.90 d
ADHD/LD	51.49	37.05	62.32 e
Clinical	32.66	52.63 d	60.56 d
Control	42.23	68.45 d	68.41 d
Categories Achieved			
ADHD	1.14	1.6	2.88
ADHD/LD	3.00	2.00	4.86 e
Clinical	.75	3.75 d	4.22 d
Control	2.14	4.75 d	4.83 d
Perseveration Errors			
ADHD	35.57	37.50	31.13
ADHD/LD	28.17	38.00	19.29
Clinical	44.63	29.75 d	22.33 d
Control	42.71	14.88 d	19.17 d
Percent of Conceptual Level Responses			
ADHD	18.53	27.24	41.71 d
ADHD/LD	39.36	22.76	50.69 e
Clinical	11.86	38.27 d	43.97 d
Control	25.34	59.81 d	61.10 d

d = significantly better performance than the 6-7 year olds (.05 level)
e = significantly better performance than the 8-9 year olds (.05 level)

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