

LABORATORY-BASED TASKS IN THE DIAGNOSIS OF ADHD IN ADULTS:

A THEORETICAL AND EMPIRICAL ANALYSIS

by

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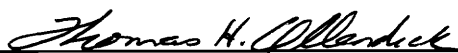
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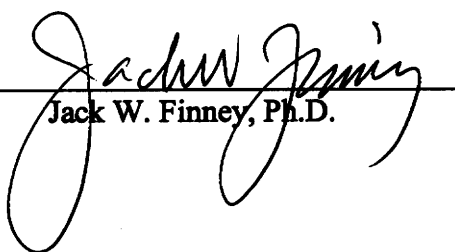
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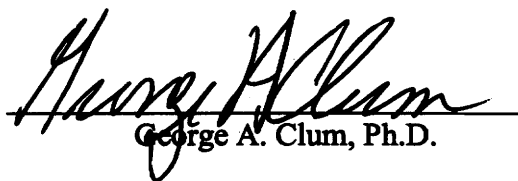
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(Abstract)

The purpose of this study was to empirically evaluate the diagnostic utility of the Conners CPT and the PASAT as a laboratory-based measures of attention, vigilance, working memory, and sustained mental effort in clinic-referred adults with and without ADHD. Moreover, the study was conducted in order to obtain additional evidence in ongoing efforts to clarify the classification and phenomenological status of ADHD in adults. Subjects were adults seeking psychological evaluation for a variety of presenting problems including, emotional, occupational, relational, and/or adjustment, difficulties. Standardized clinical evaluations were conducted and structured clinical interviews were used to determine clinical diagnosis and group membership (ADHD vs. Non-ADHD). It was hypothesized that ADHD adults would exhibit significantly more comorbid psychopathology, learning problems, and verbal memory deficits than non-ADHD adults. It was also hypothesized that the findings from the CPT (Conners, 1992) and PASAT (Gronwall, 1977) would reliably discriminate these groups (ADHD and non-ADHD) of clinic-referred adults. While ADHD adults did not exhibit a higher frequency of learning

disabilities, they did have significantly more comorbid psychopathology and were much more likely to experience clinically impairing deficits in verbal memory functioning. The combined results of the laboratory tasks accurately identified diagnostic group status in over 9 of 10 cases for ADHD adults and in approximately 8 of 10 cases for non-ADHD adults. The relevance of these findings for the psychiatric classification and experiential nature of ADHD in adults, as well as the clinical diagnostic utility of these laboratory measures for adult ADHD is discussed.

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Introduction

The reliability and validity of the diagnosis Attention-Deficit/Hyperactivity Disorder, Residual State (ADHD, RS) in adults is a subject of considerable controversy. The debate primarily concerns issues such as the phenomenological nature of the disorder in adults, the question of the appropriate psychiatric classification for adults who exhibit attention deficit-like symptoms, and the uncertainty surrounding the classification status of the disorder in adults. For example, some researchers and clinicians assert that individuals who appear to have an adult form of ADHD may actually suffer from other psychiatric disorders that also present with inattentiveness, impulsivity, and other cognitive deficits (e.g. problems in information processing). These problematic issues concerning the phenomenological nature, classification status, diagnostic reliability and validity of ADHD in adults necessitate further clarification.

Attention-Deficit/Hyperactivity Disorder in Adults

Before the mid-1960's, most clinicians and researchers held the view that the hyperkinetic syndrome in children dissipated upon the arrival of puberty, and most certainly disappeared by the onset of early adulthood (see Conners & Wells, 1986 for an historical account). These professionals conceptualized the disorder as a developmental malady that was essentially cured with the passage of time and the gradual acquisition of maturity. Similarly, it was widely believed among physicians and psychologists that the positive "paradoxical" effects of stimulant medications in children with the disorder came to an abrupt end in adolescence and that continued psychostimulant treatment with this

population would likely result in “tolerance, addiction, psychomotor acceleration, and euphoria in adolescents who had previously been quieted by these compounds”

(Gittelman & Mannuzza, 1985, p. 237).

There is now considerable evidence that Attention-Deficit/Hyperactivity Disorder (ADHD; the DSM-IV names for diagnostic categories will be used unless otherwise specified) is not a developmental lag in maturation. Carefully controlled follow-up investigations have found that 30-50% of children with ADHD become young adults with ADHD (Gittelman, Mannuzza, Shenker, & Bonagura, 1985; Weiss, Hechtman, Milroy, & Perlman, 1985). Similarly, genetic studies of the prevalence of the disorder in families have found that significantly more parents and adult siblings of children with ADHD meet criteria for the disorder than parents and adult siblings of normal control subjects (Biederman, Faraone, Keenan, & Tsuang, 1989; Biederman, Faraone, Keenan, & Knee, et al., 1990; Faraone, Biederman, Keenan, & Tsuang, 1991). Moreover, Wender and his colleagues have demonstrated repeatedly that many clinic-referred adults who meet criteria for ADHD receive ample benefit from psychostimulant treatment as do many children with the disorder (Wender, Reimherr, & Wood, 1981; Wender, Wood, Reimherr, & Ward, 1983; Wender, Reimherr, Wood, & Ward, 1985).

Estimated prevalence of adult ADHD in psychiatric outpatients. The American Psychiatric Association (1994) notes that data on the prevalence of ADHD in adults is limited. However, well accepted estimates of ADHD in children indicate that three to five percent of all U.S. children may be affected by the disorder (Lambert, 1978).

Follow-up studies indicate that 50-80% of children with ADHD maintain functionally impairing symptoms into adolescence and early adulthood (Cantwell, 1985; Gittelman, 1985; Weiss, 1985). Adolescents and young adults who maintain symptoms of the disorder frequently exhibit poor academic performance, poor occupational adjustment, poor social adjustment and problems in self-esteem (Weiss & Hechtman, 1993).

Moreover, the childhood disorder appears to predispose one to various psychiatric disorders in adulthood, including antisocial personality disorder and anxiety disorder in a significant minority, and to increased symptoms of psychopathology in general (Weiss & Hechtman, 1986). As Biederman et al. (1990) note, ADHD in young adults (an age of high risk for the onset of adult psychiatric conditions) appears to represent a major public health problem for the United States, and the probable magnitude of this problem emphasizes the need to establish reliable and valid means of identifying and diagnosing adults affected with the disorder.

Classification status in DSM-IV. Despite these empirical findings, ADHD, RS remains a controversial diagnosis. The difficulties surrounding ADHD in adults persist because conceptual issues cloud its phenomenology and classification status, and methodological problems hinder the clinical diagnostic process.

A brief history covering the recent evolution of the overall disorder in the official psychiatric nomenclature will benefit the discussion of problems in the classification status and clinical diagnostic process of the adult manifestation of the disorder. The third edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-III; American

Psychiatric Association, 1980) included two separate subtypes of childhood ADHD—Attention-Deficit Disorder with Hyperactivity (ADHD) and Undifferentiated Attention-Deficit Disorder-without hyperactivity (ADDnoH)—and a distinct category for adults with the disorder—Attention Deficit Disorder, Residual Type (ADD, RT). The category ADDnoH was thought to include children who exhibited little hyperactivity but had considerable difficulty maintaining concentration and attention. The category ADD, RT for adults required a past history of ADD and the persistence of clinical impairment in attention and concentration, but not hyperactivity (American Psychiatric Association, 1980). Thus, it was assumed under DSM-III that adults with the disorder lost their debilitating hyperactive symptoms, if they ever had such symptoms, and more closely resembled children diagnosed ADDnoH. When DSM-III was revised in 1987, the no-H subtype of childhood ADD and the adult category ADD, RT were removed due to a lack of empirical support (American Psychiatric Association, 1987). However, since 1987, several studies have supported the existence of an inattentive, non-hyperactive subtype of the disorder (e.g. Barkley, DuPaul, & McMurray, 1990; Goodman & Stevenson, 1989; Halperin, Newcorn, Sharma, Healey, Wolf, Pascualvaca, et al., 1990). For example, Barkley et al. (1990) conducted a study comparing children who would have been diagnosed ADHD and ADDnoH under DSM-III on an extensive battery of interviews, behavior ratings, tests, and direct observations. They found that ADHD children exhibited more comorbid externalizing and internalizing symptoms, performed less well on vigilance testing, and had more substance abuse and aggression among their relatives

than did ADDnoH children. In contrast, ADDnoH children were more day-dreamy and lethargic, were at greater risk for memory retrieval problems, were more likely to exhibit impaired perceptual-motor speed, and had a higher frequency of anxiety disorders among their relatives than ADDH children. Barkley et al. (1990) viewed these findings as support for the notion that ADDH and ADDnoH may be “separate and distinct childhood disorders rather than subtypes of a common attention deficit” (Barkley et al., 1990, p. 775). Findings such as these prompted many researchers and clinicians to assert that the childhood subtype, ADDnoH, and the adult category, ADD, RT, be restored in the upcoming DSM-IV (Shaffer, 1994). The adult oriented clinicians and researchers offered three primary reasons for their assertion: 1) the DSM-III-R criteria for ADHD were worded well for children but not for adults; 2) the mounting empirical evidence that many children who were diagnosed with ADHD remained impaired as adolescents and young adults with symptoms of inattention and impulsivity but without symptoms of hyperactivity; and, 3) the erroneous perception created by the DSM-III-R diagnostic criteria that ADHD is a disorder for children and adolescents leading clinicians to overlook the disorder in adults (Ratey, Greenberg, Bemporad, & Lindem, 1992).

The DSM-IV Task Force for Disorders Usually First Diagnosed During Infancy, Childhood, or Adolescence addressed these concerns in several ways. First, while DSM-IV followed the trend set forth by DSM-III-R and integrated ADDH and ADDnoH into one overarching category (Attention-Deficit/ Hyperactivity Disorder), they also identified three subtypes (Predominantly Inattentive Type, Predominantly Hyperactive-Impulsive

Type, and Combined Type) within the overall category for both children and adults. Moreover, DSM-IV requires the clinician to determine the appropriate subtype based on which of the three symptom patterns have predominated over the previous six months (American Psychiatric Association, 1994). The DSM-IV Work Group concluded on the basis of literature reviews, data reanalyses, and field trial results that “this disorder is best viewed as a unitary disorder with different predominating symptom patterns” (American Psychiatric Association, 1994, p. 775).

Second, the work group addressed the concerns of researchers and clinicians by changing the wording of each criteria so that each criterion could apply to adults as well as children. Third, the DSM principle that age alone is not a sufficient basis for distinguishing between disorders was emphasized. Fourth, the task force concluded that the existing evidence supported the possibility that some children with the disorder would experience “the full compliment of symptoms of Attention-Deficit/Hyperactivity Disorder into mid-adulthood” (American Psychiatric Association, 1994, p. 82). For those adults who still met the full criteria for one of the three subtypes of the disorder, the diagnosis would be Attention-Deficit/Hyperactivity Disorder, Residual State (ADHD, RS) and the subtype would be specified. Fifth, the task force recognized that a group of adults exists who likely met full criteria for the disorder in childhood but who retain only a few cardinal symptoms in adulthood (such as extremely poor concentration or impulsivity but not hyperactivity). Their limited number of symptoms prevents these adults from receiving the standard diagnosis, even though the symptoms they retain may

cause functional impairment. Thus, the task force included a specific category (Attention-Deficit/Hyperactivity Disorder, In Partial Remission) for these adults. Finally, the task force added a completely separate category (Attention-Deficit/Hyperactivity Disorder, Not Otherwise Specified) to cover children who exhibit atypical or subthreshold varieties of the disorder and adults who are functionally impaired by a few cardinal symptoms of the disorder but who probably never met full criteria (American Psychiatric Association, 1994).

Thus, the DSM-IV task force concluded that there is limited support for the notion that adult Attention-Deficit/Hyperactivity Disorder is a valid clinical phenomenon qualitatively similar to, yet in some ways distinct from, the more established childhood version of the disorder. However, as noted above, conceptual issues continue to cloud the classification and phenomenological status of the disorder in adults, and methodological problems hinder its clinical diagnosis.

Conceptual Problems Surrounding ADHD, RS

The major conceptual problems surrounding ADHD, RS concern the issue of psychiatric comorbidity and subsequent issues related to its status as a separate clinical entity. In children, ADHD often co-occurs with anxiety disorders, major depressive disorders, and conduct or oppositional defiant disorder (Biederman, Newcorn, & Sprich, 1991). Moreover, the comorbid presentation of these disorders in childhood (ADHD plus another disorder or combination of disorders) appears to frequently develop into adult psychiatric disorders. For example, ADHD with comorbid Conduct Disorder in children

seems to often lead to Antisocial Personality Disorder in adults (Biederman et al., 1990; Faraone et al., 1991; Mannuzza, Klein, Bessler, Malloy, & LaPadula, 1993; Wilens, Biederman, Spencer, & Frances, 1994). Such high rates of comorbidity in ADHD patients led some researchers to consider whether ADHD may represent a prodrome of other psychiatric disorders rather than a separate disorder in its own right (Biederman et al., 1993; Munir, Biederman, & Knee, 1987). If ADHD in childhood is merely a prodromal manifestation of other psychiatric disorders, then the diagnosis of ADHD in adulthood may not clarify adult psychiatric status; rather, it may hinder efforts to adequately manage the patient's symptoms using other adult psychiatric classifications and treatment schemes.

The issue of the prodromal nature of ADHD in children is as yet unsettled, but existing evidence seems to support its status as a distinct syndrome (Barkley, 1990b). Upon the conclusion of a review of studies evaluating the status of ADHD as a separate syndrome, Barkley (1990) concluded that "despite contradictory evidence for covariation of the symptoms, the disorder meets other important conditions for syndrome definition and should continue to be viewed as such" (p. 343). He also noted that the variability of symptoms across settings and symptom instability in general, may have contributed to the controversy surrounding the disorder's status as a separate entity. In addition, evidence supporting the usefulness of an adult classification of the disorder has been generated from studies showing the similar clinical characteristics of children and adults labeled ADHD (Biederman et al., 1993). Moreover, some researchers find evidence supporting

the usefulness of an adult classification of the disorder in studies showing that adults labeled ADHD frequently respond favorably to psychostimulant medication while normal control adults frequently respond poorly to such treatment (Wender et al., 1985). Thus, while some evidence exists that supports the status of ADHD as a distinct syndrome affecting both children and adults, researchers and clinicians still face considerable difficulty in developing valid and reliable methods of diagnosing ADHD in adults.

Methodological Problems in the Diagnosis of ADHD, RS

ADHD in adults presents the researcher and clinician with numerous diagnostic problems. The most difficult diagnostic issues include a lack of uniform application of the operational criteria for diagnosis, the difficulty establishing a childhood history of the disorder, the problem of psychiatric comorbidity, the problem of similar clinical presentation of ADHD, RS and other disorders, and the absence of empirically validated, objective measures of ADHD in adults.

Lack of uniform interpretation and application of operational criteria. Some research indicates that the controversies surrounding the classification and diagnosis of ADHD, RS may be related to differences in the interpretation and/or application of operational criteria for ADHD, RS in the diagnostic process (Horton & Fiscella, 1986; Mattes, 1985; Wender et al. 1985a; Wender, Reimherr, & Wood, 1985b). For example, Mattes, Boswell, and Oliver (1984) found that stimulant medication was ineffective in relieving the symptoms of ADHD in adults. However, these findings sharply contrast with the findings of Wender et al. (1985a). Upon closer examination, it was revealed that Mattes

et al. (1984) used a less stringent diagnostic criteria for adult ADHD than did Wender et al. (1985a). The mean score on the Wender Parent Rating Scale for ADHD adults in the Mattes et al. study was 10.7. However, Wender and his colleagues restricted the diagnosis of ADHD in adults to those who scored 12 or higher on the Parent Rating Scale (Wender et al., 1985a). If Mattes et al. (1984) had used the stricter criteria on the Parent Rating Scale, then only four subjects would have been left in the original group of 26 adults diagnosed with ADHD, eliminating virtually every medication non-responder from the ADHD group. Thus, differences in the application of operationalized criteria for the diagnosis of adult ADHD led to considerable differences in outcome.

Difficulties in establishing a childhood history of ADHD. Carlson (1993) notes that the validity of adult psychiatric diagnoses requires that one “have comprehensive information about psychopathology at all developmental stages, not just adulthood” (p.1766). However, complete school records of adults who present with symptoms indicative of ADHD are frequently unavailable to the clinician. In the absence of such documentation, it is difficult, and in some cases seemingly impossible, for the clinician to construct an objective detailed history of childhood symptomatology. Thus, the clinician is often forced to rely on patients’ subjective reports of their own childhood history of symptomatology. However, Wender et al. (1981) found that parent reports were a better predictor of response to treatment than patient reports, indicating that clinicians and researchers may be able to obtain a relatively valid measure of the childhood disorder

from parents of patients. Thus, it seems important to obtain parent reports of childhood history of symptomatology in potential ADHD adults whenever possible.

The problem of comorbidity of ADHD, RS and other diagnoses. As noted above, ADHD children often present with comorbid psychopathology (Biederman et al., 1991). Follow-up studies with adults who were diagnosed ADHD as children reveal that these adults often meet criteria for other psychiatric diagnoses as well (Weiss et al., 1985). Most prevalent among these comorbid disorders are antisocial personality disorder and substance use disorders. Comorbidity in adult patients presents difficult problems for clinicians who must decide which of the co-occurring conditions should be the primary diagnosis and the subsequent focus of clinical intervention. If the clinician makes an incorrect decision, then treatment could be ineffective, if not harmful.

The problem of similar clinical presentation of ADHD, RS and other disorders. The problem of symptom overlap between ADHD, RS and mood disorders and some personality disorders (e.g. borderline personality disorder) presents another difficult diagnostic issue for clinicians and researchers (Ward et al., 1993). The Wender Utah criteria help mitigate this diagnostic dilemma by setting up several rule-out criteria that preclude the diagnosis of ADHD, RS in the presence of a mood disorder, a psychotic disorder, or borderline personality disorder. Rule-out criteria for ADHD, RS such as these will likely need to be included in future editions of the DSM. In the meantime, research and clinical intervention seem likely to benefit from an application of the Wender Utah exclusionary criteria in adult ADHD assessments.

Absence of empirically validated, objective measures of adult ADHD. Numerous laboratory or analogue methods of assessing ADHD symptomatology have been developed (see Barkley, 1991 for a review). Clinicians often employ these methods as part of a routine ADHD assessment. However, Barkley (1991) found that the ecological validity of most of these tasks was rather poor and concluded that “future advances in ecological validity are likely to come from...a greater reliance on assessments of the target behaviors in natural settings” (p. 150). The difficulties associated with reliably assessing ADHD, RS symptomatology in natural settings and in the laboratory are considerable. However, laboratory measures that are sensitive to the cardinal symptoms of ADHD, RS (namely, difficulties with sustained attention, impulsivity, and information processing) may be available. However, no laboratory measure has been empirically shown to reliably discriminate between ADHD, RS subjects, other psychiatrically disturbed subjects, and normal control subjects. The identification of laboratory measures that could be empirically validated and shown to reliably discriminate between ADHD, RS adults, other psychiatrically disturbed adults, and normal control adults would likely aid efforts to establish more reliable methods of diagnosing adult ADHD.

Given the difficulties noted above in the diagnosis of ADHD, RS, it seems reasonable that the diagnosis of ADHD, RS should be made using multiple indicators of psychopathology. Thus, the establishment of a standardized approach to the diagnosis of ADHD, RS is sorely needed. It would likely require the following components: 1) operationalized criteria from DSM-IV, as established by a skilled clinician using a semi-

structured interview, should be met; 2) the revised Wender Utah criteria (Ward et al., 1993) as established by client self-report and parent report (when possible) should be met; 3) parent or guardian report concerning history of ADHD symptomatology, as established using the Wender Parent Rating Scale, should be obtained when possible; and, 4) as indicated above, empirically validated laboratory measures that could reliably discriminate between ADHD, RS adults, other psychiatrically disturbed adults, and normal control adults should be developed. It is proposed that the Conners Continuous Performance Test and the Paced Auditory Serial Attention Test will meet these criteria for laboratory-based measures of fundamental behavioral and cognitive deficits associated with ADHD, RS.

Continuous Performance Tasks (CPTs) as Measures of Vigilance and Impulsivity

The Continuous Performance Test (CPT) was first developed by Rosvold, Mirsky, Sarason, Bransome, and Beck (1956) as a means of assessing attention in brain-damaged adults who suffered from petit mal epilepsy. Their task alternatively asked subjects to press a response key when a target letter appeared (e.g., “X” in the X version of the task) or after a sequence of letters appeared (e.g., “AX” in the AX version of the task). It was assumed that in order to perform well, subjects had to constantly pay attention to remain ready to respond when an infrequent target would appear. Rosvold et al. (1956) established specific values for parameters of the test such as the frequency of the target stimuli, the presentation time of each stimuli, the inter-stimulus interval, and the number of trials administered in the test. In the years since Rosvold et al. (1956) first introduced

their versions of the CPT, a wide variety of CPTs have been developed in which some or all of these parameters were manipulated by researchers in order to test hypotheses about attentional performance in specific groups.

These researchers have since demonstrated that the CPT can adequately discriminate various psychiatric groups from normal control groups including, autistic children (Garretson, Fein, & Waterhouse, 1990), ADHD children (Sykes, Douglas, Weiss, & Minde, 1971; O'Dougherty, Neuchterlein, & Drew, 1984), conduct disordered children (Shapiro & Garfinkel, 1986), learning disabled children (Richards, Samuels, Turner, & Ysseldyke, 1990), children at increased risk for the development of schizophrenia (Neuchterlein, 1983), and, schizophrenic adults (Earle-Boyer, Serper, Davidson, & Harvey, 1991). The CPT has also been shown to be useful in separating populations at high risk for schizophrenia into subgroups who are at true risk for the disorder and subgroups who are not at true risk for the disorder (Garver, 1987).

In the previous two decades, the theoretical focus concerning the core deficit in ADHD has shifted from an emphasis on motor restlessness and hyperactivity to an emphasis on inattentiveness and poor concentration (Barkley, 1990a). This recent theoretical shift in the conceptualization of the disorder is reflected in the evolution of its various names. The names for the well-known constellation of symptoms evolved from “Minimal Brain Dysfunction” in the early 1960’s, to “Hyperkinetic Reaction of Childhood” in DSM-II (American Psychiatric Association, 1968), to “Attention Deficit Disorder with or without Hyperactivity” in DSM-III (American Psychiatric Association, 1980), to “Attention-

deficit Hyperactivity Disorder” in DSM-III-R (American Psychiatric Association, 1987), to “Attention-Deficit/Hyperactivity Disorder, inattentive type, hyperactive type, or combined type” in DSM-IV (American Psychiatric Association, 1994). This increasing focus on inattentiveness as a core feature of the disorder has led many clinicians to use standardized measures of impulsivity and vigilance, such as Kagan’s Matching Familiar Figures Test (Kagan, 1966) or variations on the CPT (e.g. Gordon, 1986) in diagnostic evaluations of children suspected of meeting criteria for ADHD (Barkley, 1991). Ostensibly, these tests remained objective and sensitive to vigilance decrement whereas other commonly used methods of assessment (parent reports, teacher reports) were potentially biased (Gordon, 1986).

Most researchers consider the CPT to be a vigilance task because it requires subjects to visually or auditorily monitor a sequence of individually presented stimuli (usually letters or digits) and to respond when a previously designated target is presented. It is thought that CPTs are sensitive to decrement in attention across time because stimuli are presented rapidly for an extended period of time with no means for a subject to compensate for a missed target. Thus, CPTs are considered to capture even brief periods of inattention in subjects. However, as Halperin et al. (1991) note, “the CPT has not been shown to consistently discriminate between patient groups, and no diagnostic group has been shown to consistently perform poorly on the CPT, making its use as a diagnostic tool more controversial” (p. 603).

Measures in a CPT. In the traditional CPT, the stimuli are presented individually on a computer screen. There are two different versions of the traditional CPT. The first is a simultaneous discrimination task, called an “X-task,” in which the designated target is usually a single letter (“X”) and the subject is asked to respond every time the designated target appears. The second version of the traditional CPT is a successive discrimination task, called an “AX-task,” in which the subject is asked to respond to a designated target (“X”) after the occurrence of a specific warning signal (“A”). The successive discrimination task requires a larger memory component, but the warning signal is assumed to help the subject deploy attention so that the target may be processed more quickly and accurately. Reviews comparing these two types of traditional CPTs generated mixed results with some finding that vigilance decrement occurred only on successive discrimination tasks (Parasuraman & Davies, 1984) and others finding vigilance decrements on both types of tasks (Corkum & Siegel, 1993). These versions of the CPT typically provide measures of reaction time (time elapsed between the onset of the stimulus and the subject’s response), errors of omission (failing to “hit,” or respond to, a designated target stimulus), errors of commission (hitting a designated non-target stimulus), correct hits (responding to a designated target), and correct rejections (not responding to a designated non-target). Errors of omission are usually considered a measure of inattention and errors of commission are considered to indicate impulsivity.

Problems in the use of traditional CPTs. Several problematic issues arise in research using traditional versions of the CPT. Traditional forms of the CPT are those versions of

the task that ask the subject to respond to target stimuli that are presented infrequently—often comprising only 20% of the total number of trials (Conners, 1992). While the traditional CPT showed promise in its early years as a measure for evaluating children with attentional and learning problems, many researchers assumed that the task was measuring vigilance decrement (a decline in sustained attention over time). However, research with the traditional CPT revealed that vigilance decrement often did not occur in psychiatric patients taking the CPT. For instance, in an investigation of sustained attention in hyperactive children using a traditional CPT, Schachar, Logan, Wachsmuth, and Chajczyk (1988) found that hyperactive subjects did not perform more poorly over time than normal controls and did not benefit less from a warning to prepare attention for an upcoming target. Thus, their findings did not confirm the hypothesis that children with this disorder have a unique deficit in the ability to sustain attention. Moreover, research with the traditional CPT also revealed that the degree of vigilance decrement often depended on the age of the subjects being evaluated (Seidel & Joschko, 1991; Swanson, 1983). These difficulties with the CPT led some researchers to conclude that the measures of inattention and impulsivity generated by the CPT (e.g. errors of omission, errors of commission) were impure indices of these constructs (Swanson, 1983; O'Dougherty et al., 1984; Tarnowski, Prinz, & Nay, 1986; Nestor, Faux, McCarley, Shenton, & Sands, 1990).

Signal Detection Theory and continuous performance. In order to addresses problems with the CPT, some researchers have applied Signal Detection Theory (Green & Swets,

1966) analyses to CPT data in an attempt to distinguish empirically attentional effects that might contribute to a decrease in sustained attention from non-specific factors such as expectancy, motivation, and fatigue (Nestor et al., 1990; Swanson, 1983). Through an application of Signal Detection Theory analysis to his CPT data, Swanson (1983) found that a putative vigilance decrement in many subjects in his study was not due to a decline in sustained attention over time; rather, the decline in performance over time seemed related to non-specific factors such as changes in response criterion (i.e., subjects became more lax in their subjective decision making process about whether or not to respond to a stimulus). Thus, Swanson's (1983) findings reveal that the results of traditional CPTs may be difficult to interpret accurately where sustained attention or vigilance is concerned. As Conners (1992) explains, "with the passage of time in a boring task, children may become more inefficient because they choose to be less strict in deciding when a signal is a target or not, rather than because their ability to detect the target (sensitivity) has deteriorated" (Conners, 1992, p. 52). Moreover, in a review of several studies using traditional forms of the CPT, Corkum and Siegel (1993) found no consistent evidence from CPT data that a vigilance decrement is a core feature of ADHD. Traditional CPTs often do not provide data that may be subjected to a Signal Detection Theory analysis because too few behavioral responses are obtained when subjects are asked to "hit" a target stimulus that typically appears on only 20% or fewer trials. Thus, the studies reviewed by Corkum and Siegel (1993) using traditional forms of the CPT may have been insensitive to deficits in sustained attention for the reasons suggested by

Conners (1992). Two studies were reviewed that used non-traditional forms of the task in which stimuli were partially degraded to make discrimination more difficult and to thereby increase error rates (Neuchterlein et al., 1983; O'Dougherty et al., 1984).

Conners (1992) noted that the sensitivity of a CPT to vigilance decrement is primarily dependent upon two stimulus parameters of the task: interstimulus interval (ISI) and target event rate. ISI refers to the amount of time that elapses between the presentation of successive stimuli on the CPT. Traditional forms of the CPT typically do not vary ISI in the course of the task. However, it is known that the speed and variability of subjects' reaction times are often significantly influenced by systematically varying the length of the period of uncertainty, or ISI, preceding the onset of the target stimulus (Zahn, Kruesi, & Rapoport, 1991). Moreover, Zahn et al. (1991), and others (Sergeant & Scholten, 1985), found that visual processing in ADHD children was significantly more adversely influenced by variable ISI than in normal children.

Target event rate is another important parameter of the CPT that Conners (1992) noted to be related to the sensitivity of the task to decreases in sustained attention. Target event rate refers to how frequently target stimuli appear in the course of the task. Target event rate in traditional CPTs is typically low, because it is assumed that subjects who are not receiving ongoing visual stimulation from frequent targets will be more likely to experience a decline in sustained attention. However, findings suggest that these tasks may be too easy for patient groups (Schachar, Logan, Wachsmuth, & Chajczyk, 1988) allowing all but the youngest or most seriously impaired to perform normally. Two

major difficulties arise when all but the most seriously impaired or youngest subjects obtain very low numbers of errors on a CPT: 1) subjects who are known to be inattentive appear to perform well because the distribution of error scores lack variability making discrimination between groups impossible (Newcorn, Halperin, Healey, O'Brien, Wolf, et al., 1989); and, 2) the sensitivity of the task to vigilance decrement is low. These difficulties seem likely to have contributed to the lack of sensitivity of the CPT to vigilance decrement in ADHD subjects in the studies reviewed by Corkum and Siegel (1993). Thus, more research with CPTs that use variable ISI, that provide a higher error rate, and that provide data amenable to Signal Detection Theory analysis are needed.

The Conners Continuous Performance Test. The Conners Continuous Performance Test provides several advantages over the traditional CPT. First, the Conners CPT is a “true continuous performance test” in which the subject is responding frequently and occasionally withholding a response to a non-target. For example, the subject is asked to respond to every letter except the “X.” This CPT paradigm obtains a large sample of behavior obtained on trials throughout the task, in contrast to the traditional CPT where the subject provides a small sample of behavior obtained occasionally within the task. This paradigm allows estimates of performance at any stage of the task as well as estimates of sustained attention over time (vigilance). Moreover, the task is divided into six blocks in order to allow statistical analysis of performance on a number of dependent measures at several intervals within the test. Second, since subjects are responding more often, it becomes more difficult for subjects to withhold responses to the “non-target” X.

Thus, even non-attentionally impaired and non-impulsive subjects typically obtain several errors of commission (“hitting” a non-target). Here, subject reaction time becomes a more useful measure of performance, since there are now enough responses to *both* targets and non-targets to obtain stable reaction time means. Third, variability of reaction time becomes a useful measure, because there are now enough responses to obtain error estimates. Fourth, interstimulus interval is systematically varied throughout the task, providing a more sensitive measure of sustained attention by altering the attentional demands placed upon the subject. For example, it is easier to maintain attention to stimuli that appear at a rate of one per second than it is to maintain attention to stimuli that appear at a rate of one every four seconds. Fifth, and perhaps most important, since a large sample of behavior is obtained for both correct hits and errors of commission, the data obtained from the Conners CPT is amenable to Signal Detection Theory analysis.

Signal Detection Theory Concepts. Signal Detection Theory is a mathematical, theoretical system that ultimately grew out of Fechner’s classical psychophysical experiments which originally attempted to determine the nature of sensory thresholds by studying the relationship between the magnitude of a physical stimulus and the magnitude of the sensation of that stimulus that registered in the mind (Fechner, 1966). The early attempts to measure sensory thresholds led to the recognition that subjects were not merely passive receivers of stimuli but were actively engaged in the process of deciding whether they were confident enough to report that a target stimulus had actually

occurred on a given trial. Therefore, early psychophysicists realized that in order to assess sensory capacities accurately, they would need some mechanism whereby subjects' decision-making behavior could be taken into account. Attempts to adequately account for subjects' decision-making biases in sensory threshold experiments did not come to fruition until 1966, when Green and Swets published their now classic book, Signal Detection Theory and Psychophysics. The fundamental concepts of Green and Swets Signal Detection Theory, d' (d-prime) and β (Beta), are best understood in relation to attempts to measure human sensory thresholds. For example, if a subject in a sensory threshold experiment is presented with a series of trials on which the stimuli to be detected are near his/her sensory threshold, and if the target stimulus actually occurs on only one-half of those trials, then the subject will be uncertain whether a target stimulus was present on any given trial. Moreover, given that human sensory nerves are incessantly active, even in the absence of physical stimuli (a phenomenon termed sensory "noise"), a subject may experience difficulty distinguishing sensory "noise" from an actual target on any given trial, especially when stimuli are presented at or near his/her sensory threshold. Moreover, on trials when a target stimulus is presented, the combined "noise" and sensory stimulus may be difficult to distinguish from the "noise" alone, leading the subject to be uncertain about whether to respond 'yes,' a target was present, or 'no,' a target was not present. Given that the level of uncertainty will vary from trial to trial, the subject will need to determine how certain he/she needs to be before responding 'yes,' a target was present. This determination of the degree of certainty needed before

responding 'yes' is termed the subject's "response criterion," or "decision criterion." A subject's response or decision criterion is a subjectively determined, cutoff sensory value above which one is willing to state that a target was present. The cutoff sensory value is determined by one's motives (arising from his/her perceptions regarding the relative risks for the possible types of errors that may be made), and his/her expectations concerning the frequency of the target stimuli. For example, when one is highly invested in not missing the presence of an actual target (e.g., an oncologist reading an x-ray film who wants to minimize the chances of missing a cancerous tumor), or when the probability of an actual target on trials is very high, then one is likely to set a "lax response criterion." Observers with a lax response criterion are more likely to respond 'yes' on any given trial even though they are uncertain, either because the cost of missing an actual target may be very high (e.g., when the oncologist misses a real tumor), or because the subject is convinced that the likelihood of an actual target on any trial is high. When one is highly invested in not falsely reporting that a target is present when in fact the target stimuli is not present (e.g., a radar operator on a battleship who must not mistake a civilian airliner for an enemy military jet), or when the probability of an actual target on trials is very low, then one is likely to set a "strict response criterion." Observers with a strict response criterion are more likely to respond 'no' on any given trial, either because the cost of falsely reporting that a target is present is very high (e.g., when a radar operator on a battleship leads the captain to fire a missile at a civilian airliner), or because the subject is convinced the likelihood of an actual target appearing

on any given trial is very low. The Signal Detection Theory measure for the subject's response or decision criterion is termed Beta (β). Subjects with a low Beta (lax response criterion) will have many "hits" (correctly reporting the presence of an actual target), but they will also have many "false alarms" (incorrectly reporting that a target was present on target-absent trials). Subjects with a high Beta (strict response criterion) will have more "errors of omission" (failing to report the presence of a target on a trial), but they will also have fewer "false alarms" (incorrectly reporting that a target was present on target-absent trials). Subjects will set a strict or lax response criterion depending on the relative consequences of making errors of omission versus errors of commission. While the adoption of a lax or strict subjective response criterion alters the pattern of response, it does not exert any direct influence on the actual sensitivity of the subject to physical stimuli.

In Signal Detection Theory, sensitivity refers to the average amount of sensory activity generated by a given signal compared to the average amount of noise-generated activity. This conceptualization of sensitivity is similar to the way the term sensitivity is typically used. For example, a television antenna that produces a large electrical response that allows a weak television signal to be discerned above the background static (noise) that is constantly present in urban settings is said to be more "sensitive" than an antenna that produces only a small electrical response to a television signal that allows the signal to be partially obscured by the background static. Signal Detection Theory attempts to capture a similar notion of sensitivity in human beings by mathematically generating what

amounts to a perceptual analogue of sensitivity. This perceptual analogue of sensitivity is represented by the distance between the means of the signal-present distribution and the signal-absent distributions of a subject in a detection experiment. This difference between the centers of the signal-present and signal-absent distributions merely reflects the difference in average sensation levels that are required for a subject to perceptually distinguish between trials in which a target stimulus occurred and trials in which a target stimulus did not occur. In Signal Detection Theory, this measure of perceptual sensitivity is termed d-prime (d'). When the signal-present (signal plus noise) and the signal-absent (noise only) distributions are far apart and overlap very little, then d-prime is said to be large and perceptual sensitivity is considered strong. This conceptualization of perceptual sensitivity makes intuitive sense, for in order for these two distributions to be far apart, the subject's responses in a detection experiment indicate that he/she is frequently able to discriminate signal-present (signal plus noise) trials from signal-absent (noise only) trials, resulting in a high number of "hits" and a decreased likelihood of "errors of omission" and "errors of commission." If the subject is frequently able to distinguish between signal-present and signal-absent trials, then he/she exhibits strong perceptual sensitivity. In contrast, when the signal-present (signal plus noise) and the signal-absent (noise only) distributions are close together and show considerable overlap, then d-prime is said to be small and perceptual sensitivity is considered weak. This conceptualization of perceptual sensitivity also makes intuitive sense, for in order for these two distributions to be close together, the subject's responses in a detection experiment indicate that he/she is

frequently unable to discriminate signal-present (signal plus noise) trials from signal-absent (noise only) trials, resulting in a low number of “hits” and an increased likelihood of “errors of omission” and “errors of commission.” If the subject is frequently unable to distinguish between signal-present and signal-absent trials, then he/she exhibits weak perceptual sensitivity. It should be noted that Signal Detection Theory attempts to measure a subject’s sensitivity to a signal independently from his/her response criterion, but the theory also acknowledges that both sensitivity and response criterion may affect actual responses on a detection experiment.

Given that Beta is the subjective criterion for sensation level that separates a “yes” response from a “no” response, it makes sense that Beta would be statistically defined as the ratio of the heights of the respective unit normal curve Y axes for the signal and noise distributions. Therefore, the formula for computing Beta may be written as, $\text{Beta} = Y_h/Y_c$, where Y_c = the height of the normal curve using the proportion of commission errors, and where Y_h = the height of the normal curve using the proportion of hits (McNicol, 1972). Moreover, given that d-prime represents the distance between the means of the signal-present and signal-absent distributions, it makes sense that d-prime would be statistically defined as the distance along the X-axis between the noise and signal distributions in standard score units. The calculation of d-prime requires the use of normal curve deviates expressed in terms of Z scores. Therefore, the formula for d-prime may be written as $d\text{-prime} = Z_c - Z_h$, where Z_c = the normal curve deviate using the proportion of commission errors, and where Z_h = the normal curve deviate using the

proportion of hits (McNicol, 1972). This formula also makes intuitive sense, for when there are relatively more hits than commission errors, the value of d-prime will be higher, representing good perceptual sensitivity.

It should also be noted that Signal Detection Theory applies not only to detection experiments in which a subject attempts to distinguish target-absent from target-present trials. The theory and its indices of d-prime and Beta also apply equally well for detection experiments in which one is asked to distinguish one stimulus from another similar stimulus. The Continuous Performance Test represents the latter form of detection experiment, for in the CPT, subjects are asked to distinguish trials with the target letter from trials with non-target letters. In all forms of the CPT, the subject's own internal distractibility and/or decreasing neural arousal are analogous to the sensory "noise" that creates difficulty in distinguishing signal plus noise trials from noise only trials. In ADHD adults, increasing distractibility and/or decreasing neural arousal may actually raise their detection threshold (decreasing perceptual sensitivity) and hamper their ability to distinguish target-present trials from target-absent trials. Moreover, in ADHD adults, this phenomenon seems likely to become more pronounced over time. In addition, the two signal detection indices, d-prime and Beta are assumed to be related to attention and impulsivity respectively. A Signal Detection Theory analysis of the data in this experiment will aid efforts to determine whether impaired performance reflects a breakdown of specific attentional processes or non-specific factors such as expectancy, motivation, fatigue, and/or response criterion.

The Paced Auditory Serial Attention Test as a Measure of Information Processing

The Paced Auditory Serial Attention Test (PASAT) was developed by Gronwall (1977) as a measure of information processing capacity in patients recovering from concussion. The task requires a subject to listen to a series of single-digit numbers spoken from a tape player. The subject must add every two consecutive numbers, say the sum of those numbers out loud, remember the number that occurred just prior to the spoken sum, add it to the next number spoken from the tape player, say the new sum out loud, and so on. The task is a measure of information processing capacity, working memory capacity, and the ability to maintain mental effort over time under systematically increasing processing demands (i.e. under: 1.Low; 2. Moderate; 3. High; and, 4.Very High, Information Processing Demand Conditions administered sequentially). Moreover, each condition of the task may be broken down into three blocks of 20 trials allowing one to evaluate subjects' information processing performance over time. While the PASAT has been infrequently used in studies with ADHD children and adults, it has commonly been used as a measure of recovery from various types of brain injury in neuropsychological studies (Tannock, Ickowicz, & Schachar, 1995). However, numerous studies suggest that ADHD children and adults may suffer from impaired information processing capacity as do children and adults with specific forms of brain injury (Chelune & Baer, 1986; Loge, Staton, & Beatty, 1990; Roeltgen & Schneider, 1991; Swanson, 1994). Moreover, given that those aspects of information processing that involve the use of working memory capacity and the ability to maintain attention during a cognitively

demanding processing task (e.g. tasks involving simultaneous processing of information) are considered to be particularly well tapped by the PASAT (Tannock et al., 1995), it may serve as a useful laboratory-based measure of these potential specific cognitive deficits in ADHD adults and subsequently aid efforts to improve clinicians' ability to reliably diagnose ADHD in adults.

Working memory is commonly defined as a system of limited memory capacity that allows one to maintain specific information in memory while simultaneously performing some mental manipulation of other information (Swanson, 1994). For example, working memory is required when one attempts to calculate the answer to a word math problem while simultaneously attempting to recall the mathematical rules required to perform the calculation properly. This aspect of cognitive function is particularly relevant to both children and adults with ADHD, because it is widely considered to be required for success in a wide variety of academic and occupational settings (Tannock et al., 1995). Moreover, it is difficult to imagine how one could successfully negotiate the challenges inherent in most language-related tasks (e.g. reading comprehension, written expression, problem solving tasks, etc.) faced in day-to-day experience without adequate working memory functioning. In ADHD adults, compromised cognitive arousal may be related to impaired working memory performance (Swanson, 1994). If ADHD adults experience impaired working memory performance due to decreased cognitive arousal, then one would expect ADHD adults as a group to perform less well than non-ADHD adults on a cognitively demanding information processing task such as the PASAT. Moreover, if

ADHD adults experience difficulty maintaining mental exertion on tasks that are perceived to be cognitively demanding (as indicated by DSM-IV criteria for the Inattentive Subtype of ADHD; American Psychiatric Association, 1994), then one would expect ADHD adults as a group to show greater decline in performance across time on the PASAT than non-ADHD adults.

Purpose of the present study

As is evident from the preceding review, there are several unresolved issues concerning the classification and phenomenological status of ADHD, RS, the diagnosis of ADHD, RS, and the experiential nature of the disorder for the typical patient. The purpose of the present study was to obtain additional evidence in the ongoing effort to clarify the classification and phenomenological status of adult ADHD and to empirically evaluate the diagnostic utility of the Conners CPT and the PASAT as a laboratory-based measures of attention, vigilance, working memory, and sustained mental effort in clinic-referred adults with and without ADHD.

Experimental Hypotheses

Hypothesis related to diagnostic status:

H1 It was hypothesized that the ADHD, RS group (clinic-referred adults diagnosed with ADHD, RS as determined by structured clinical interview) would present with more comorbid psychopathology than the control group (clinic-referred adults without ADHD, RS as determined by structured clinical interview). Based on the literature, more

comorbid anxiety and depressive disorders and more antisocial personality disorder symptomatology would be expected in the ADHD, RS group.

Hypotheses related to the clinical correlates of ADHD, RS:

H2a It was hypothesized that the ADHD, RS group would present with a significantly greater incidence of learning disability (as defined by a significant discrepancy between their IQ estimate and an achievement estimate, i.e. ≥ 15 points) than the control group.

H2b It was also hypothesized that the ADHD, RS group would present with a significantly greater incidence of auditory verbal memory deficit (as defined by a significant discrepancy between the Logical Memory Subtest standard score on the Wechsler Memory Scale-Revised and a verbal IQ estimate, i.e. ≥ 15 points) than the control group.

Hypotheses related to the laboratory tasks:

H3a It was hypothesized that the ADHD, RS group would score (as measured by total number of correct responses) significantly below the control group on an auditory information processing task (PASAT).

H3b It was hypothesized that the ADHD, RS group would show a significantly more rapid decline in performance (as measured by number of correct responses per block) across blocks (i.e., over time) than the non-ADHD group on an auditory information processing task.

H3c It was hypothesized that the ADHD, RS group would perform as well as the control group in the lower information processing demand conditions of the information

processing task but significantly less well than the non-ADHD group in the higher information processing demand conditions of the auditory information processing demand task (as measured by number of correct responses per condition).

H3d It was also hypothesized that the Conners CPT would reliably discriminate subjects clinically diagnosed with ADHD, RS from control subjects. Specifically, both the ADHD, RS group and the non-ADHD control group would show a decline in d-prime across the blocks of the task, but the ADHD, RS group would show significantly lower overall d-prime and a significantly more rapid decline in d-prime across the blocks of the task.

H3e The ADHD, RS group would show significantly greater vigilance decrement (as defined by a decline in d-prime independent of changes in Beta) than the non-ADHD group.

Method

Subjects

Subjects were 35 adults (19 males, 16 females) from the New River Valley area of Virginia and 27 adults (14 males, 13 females) from the Triangle area (Chapel Hill-Raleigh-Durham) of North Carolina, exhibiting learning, occupational, relational, and/or adjustment, difficulties and clinic-referred for psychological evaluation. Upon clinical evaluation (see below), 35 subjects (21 from Virginia, 14 from North Carolina; mean age = 26.03 years; mean highest grade level = 15.32) met DSM-IV diagnostic criteria for ADHD-RS and 27 (14 from Virginia, 13 from North Carolina; mean age = 23.84 years;

mean highest grade level = 15.65) subjects did not meet specific DSM-IV criteria for ADHD-RS (see Table 1). Several chi square analyses were performed to examine the similarity of the groups of subjects from Virginia and North Carolina. To examine the relationship between subject location and gender, a 2 (Location: Virginia, North Carolina) x 2 (Gender) chi square analysis was performed and revealed that the groups were comparable in terms of gender ($\chi^2 (1) = .145, p. = .703$). To examine the relationship between subject location and age, a 2 (Location: Virginia, North Carolina) x 2 (Age: ≤ 22 years, ≥ 23 years) chi square analysis was performed and revealed that the groups were comparable in terms of age ($\chi^2 (1) = 1.693, p. = .193$). To examine the relationship between subject location and diagnostic group membership, a 2 (Location: Virginia, North Carolina) x 2 (Group: ADHD, non-ADHD) chi square analysis was performed and revealed that the groups were comparable in terms of diagnostic status ($\chi^2 (1) = .277, p. = .599$). In addition, a 2 (Location: Virginia, North Carolina) x 3 (estimated FSIQ: IQ ≤ 109 , IQ = 110-119, IQ ≥ 120) chi square analysis was performed to examine the relationship between subject location and estimated Full-Scale IQ (as calculated from the Vocabulary and Block Design Subtests of the Wechsler Adult Intelligence Scale-Revised; Wechsler, 1981) and revealed that the groups were comparable in terms of their cognitive ability scores ($\chi^2 (2) = .953, p. = .621$). Finally, two more chi square analyses were performed to examine the relationship between subject location and level of educational attainment (as determined by Broad Reading and Broad Math Scores from

the Woodcock-Johnson Psychoeducational Battery- Revised; Woodcock & Johnson, 1989). Specifically, a 2 (Location: Virginia, North Carolina) x 2 (Reading Achievement: ≤ 100 , ≥ 100) chi square analysis revealed that the two groups were comparable in terms of their academic achievement in reading ($\chi^2 (1) = .247$, $p = .619$), and a 2 (Location: Virginia, North Carolina) x 3 (Math Achievement: Broad Math ≤ 109 , Broad Math = 110-119, Broad Math ≥ 120) chi square analysis revealed that the two groups were comparable in terms of their academic achievement in math ($\chi^2 (2) = 2.895$, $p = .235$).

A childhood diagnosis of hyperactivity was not sufficient for inclusion in the ADHD, RS group; rather, only those adults who exhibited continuation of symptoms into early adulthood were included in the ADHD, RS group. Moreover, the presence of debilitating symptomatology in childhood and a continuation of those symptoms into early adulthood (as determined by structured interview) was the sine-qua-non of ADHD, RS group membership.

Procedure

Adults who were referred for assessment of academic and/or adjustment problems, or ADHD, were contacted by phone and given a brief description of the study. Near conclusion of the initial phone contact, if the subject indicated a desire for further participation in the study, he/she was given an appointment at the Psychological Services Center at Virginia Tech or the Attention Deficit Disorders Program at Duke University Medical Center for a pre-assessment interview. Upon arrival at either clinic, the adult received a copy of the study consent form that included a written description of the study

(Appendix A) and a release of information form (Appendix B) asking for permission to contact parents by mail. If the client did not wish for his/her parent(s) to be contacted, or if his/her parents were unavailable, he/she was not automatically excluded from the study. (As Carlson, 1993 notes, parent reports are useful in obtaining a more thorough history of symptomatology in young adults and in checking the reliability of retrospective information, but parents reports are not considered an essential component of the retrospective diagnosis of ADHD, RS.) Diagnostic work-ups took place in two sessions lasting approximately three hours each. The first session began with an assessment of the subject's academic and/or work performance using a brief pre-assessment question and answer session. Next, the subject was administered a semi-structured diagnostic interview covering present and childhood psychiatric status on Axis I (American Psychiatric Association, 1994) disorders and present psychiatric status on Axis II disorders (American Psychiatric Association, 1994) by a trained interviewer. The interviews were audio- or video-taped and lasted approximately 90 minutes each. Next, laboratory measures of attention and auditory processing were administered by trained examiners; they lasted approximately 30 minutes each. After the first session and if permission was granted, parent questionnaires covering childhood hyperactivity, a cover letter, and a stamped return envelope were mailed to parents. Session two was scheduled approximately one week later at the Psychological Services Center at Virginia Tech or at the Attention Deficit Disorders Clinic at Duke University Medical Center and consisted of the administration of a modified structured interview specifically probing DSM-IV

ADHD, RS symptomatology (American Psychiatric Association, 1994), laboratory measures of attention (CPT, PASAT), an abbreviated intelligence test, a shortened achievement test, and self-reports of child ADHD symptomatology. The study coordinator assigned subjects to diagnostic groups solely on the basis of the structured clinical interview, for the diagnostic interview served as the “gold standard” for assigning subjects to either the ADHD, RS group or the non-ADHD, RS group. The results of the laboratory tests did not influence the experimental assignment of subjects to diagnostic groups.

Setting and Apparatus

All assessment activities took place at the Psychological Services Center at Virginia Tech or the Attention Deficit Disorders Program at Duke University Medical Center.

Testing rooms were equipped with audio or video taping equipment in order to record the semi-structured interviews for later reliability checks. The attentional and vigilance tasks were administered by computer in one of two testing rooms. One testing room was equipped with a IBM-compatible 486SX computer with super-VGA video display and another with a IBM-compatible Pentium computer with super-VGA video display.

(Note: the software programs for the attention and vigilance task (Conners CPT) required only an IBM PC XT, AT, PS/2, PS/1, 386, 486, or Pentium (or 100% IBM compatible) computer system with at least 512K of RAM and a CGA, EGA, VGA, or Hercules video adapter attached to either a color or monochrome monitor (Conners, 1992). The software required to run the vigilance task was the Conners Continuous Performance Test

Computer Program, published by Multi-health Systems in North Tonawanda, New York and Toronto, Ontario.

Measures

As the American Psychiatric Association (1994) notes, persons with ADHD appear to perform abnormally on tasks that require “effortful mental processing,” but “it is not yet entirely clear what fundamental cognitive deficit is responsible for this” (p. 81).

Therefore, several laboratory tasks tapping different executive functions were utilized in order to explore potential explanations for this generalized cognitive deficit and to further elucidate the experiential nature of the disorder for young adults.

Diagnostic Status of Groups

The structured interview consisted of five parts: A modified version of the Structured Clinical Interview for DSM-III-R that covered DSM-IV diagnostic criteria (Spitzer, Williams, Gibbon, & First, 1990), the ADDH module from the Schedule for Affective Disorders and Schizophrenia for School-Age Children (KIDDIE-SADS; Orvaschel & Puig-Antich, 1987), the Structured Interview for ADD-H Symptoms (Gittleman & Mannuzza, 1985) for use with adolescents and young adults, the Structured Clinical Interview for DSM-III-R-II (SCID-II; Spitzer, Williams, Gibbon, & First, 1990), and the Wender Utah Rating Scale (Ward et al., 1993). This combined structured interview was administered by trained clinicians and reliability checks using the kappa procedure were performed.

The modified SCID-I was used in the current study to determine which subjects met criteria for any DSM-IV Axis I disorder. The results of a SCID are heavily dependent upon the clinical impressions of the interviewer given that it is not a fully-structured interview. Therefore, its reliability is highly dependent upon situational factors such as the level of expertise of the interviewer (Spitzer et al., 1990). However, good reliability has been demonstrated for the majority of disorders covered by previous editions of the SCID, and kappas were found to be similar to those reported for other psychiatric instruments (Spitzer et al., 1990).

The KIDDIE-SADS (Orvaschel & Puig-Antich, 1987), is a semi-structured interview (see Appendix C) covering childhood diagnoses under DSM-III-R (American Psychiatric Association, 1987). The ADDH module of this interview was used to supplement the ADIS-IV, covering symptoms of childhood ADHD. Questions from the ADDH module of the KIDDIE-SADS were worded in the past tense. Following Biederman, Faraone, Spencer, Wilens, Norman, Lapey et al. (1993), if the subject endorsed symptoms on the KIDDIE-SADS to a clinically meaningful degree, then he/she was asked if each individual symptom was still present. This method helped establish that the syndrome reported to have existed in childhood had continuity with the syndrome reported in adulthood.

The Structured Interview for ADD-H Symptoms is a brief semi-structured interview designed by Gittleman and Mannuzza (1985) to cover symptoms necessary to make a DSM-III diagnosis of Attention Deficit Disorder, Residual Type (American Psychiatric

Association, 1980) including inattentiveness, impulsivity, and hyperactivity (see Appendix C). These questions were then tested on normal volunteers. The interview was revised and a final form adopted for purposes of their study of the diagnosis of ADDH or ADDnoH in adolescents. When positive symptoms were reported, the interviewer probed for symptom severity which was rated on a five-point scale. A symptom was considered clinically significant if it received a rating of three or higher. Interrater reliability checks for independent diagnoses on 27 interviews yielded a kappa of .78 (Gittleman & Mannuzza, 1985). This interview seemed appropriate for this study because it followed DSM-III breakdown of the disorder into ADDH and ADDnoH, which more adequately reflects the DSM-IV (American Psychiatric Association, 1994) subtyping of the disorder into inattentive, hyperactive/impulsive, and combined types.

The SCID-II (Spitzer et al., 1990) is a semi-structured interview for eliciting information to aid the diagnosis of DSM-III-R personality disorders in adults (see Appendix C). This interview was used in unmodified form because the DSM-III-R and DSM-IV criteria for most of the personality disorders are similar. Since the SCID-II is not a fully-structured interview and requires clinical judgment of the interviewer, reliability of the SCID-II is a function of the training of the interviewers and the consistency with which these interviewers apply diagnostic criteria (Spitzer et al., 1990). In a reliability study for the SCID-II using 226 subjects, test-retest kappas were similar to those reported for other studies with similar personality assessment instruments, such as the Personality Disorders Examination (PDE; Stangle, Pfohl, & Zimmerman, 1985).

The Wender Utah Rating Scale (WURS; Ward et al., 1993) is a self-report questionnaire that asks the adult about ADHD like symptoms from their childhood (see Appendix C). Subjects were be instructed to rate each item as it described their childhood behavior as very slightly (1), moderately (2), quite a bit (3), or very much (4). A score of 46 places one in the 86th percentile for childhood “hyperactivity” according to Ward et al. (1993) and were used as the cut-off for inclusion in the ADHD, RS group. All subjects completed the WURS, and when available and if permission was granted, their primary caretakers were contacted by mail and asked to complete and return the Wender Parent’s Rating Scale (WPRS). The WPRS (See Appendix C) is a modified version of the Conners Abbreviated Parent Rating Scale (Conners, 1973). It asks parents to rate how much their child was bothered by behavior problems between the ages of six and ten years of age on a scale from (0) not at all, to (2) just a little, to (3) pretty much, to (4) quite a bit. A score of 12 or greater places one in the 95th percentile for childhood “hyperactivity” according to Ward et al. (1993).

Clinical Correlates of ADHD, RS

Standardized assessment instruments and laboratory measures were administered by trained examiners in order to evaluate issues related to the nature of functional impairments in ADHD adults and the subjective experience of ADHD in adults.

The Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) is an almost uncontested measure of adolescent and adult intelligence and were used in this study to assess intellectual level, and to evaluate the potential presence of learning

disability in all subjects. IQs were estimated from the Vocabulary and Block Design subtests. Tests were administered according to instructions in the WAIS-R manual. The WAIS-R is considered to be useful in assessing a variety of neurological impairments including memory impairment, expressive language aphasia, receptive language aphasia, and motor skills deficits (Kaufman, 1990).

The Woodcock-Johnson Psycho-Educational Battery-Revised (WJ-R; Woodcock & Johnson, 1989) is a comprehensive achievement test comprised of a broad range of individually administered tests for evaluating cognitive abilities, scholastic aptitudes, and educational achievement. The Letter-Word Identification and Passage Comprehension subtests were administered in order to obtain a Broad Reading composite score as a measure of reading achievement. The Calculation and Applied Problems subtests were administered in order to obtain a Broad Math composite score as a measure of math achievement. These two composite scores were used as an estimate of overall achievement and were utilized in combination with the estimated IQ scores from the abbreviated WAIS-R in an attempt to obtain an estimated ability-achievement discrepancy. The estimated ability-achievement discrepancy was used to rule upon the presence of a learning disability.

The Logical Memory Subtests of Wechsler Memory Scale-R (WMS-R; Wechsler, 1987) were also administered. Several adults referred for adult ADHD assessment at the Virginia Tech Psychological Services Center, and who presented with “ADHD like” symptoms, appeared to exhibit a deficit in receptive auditory verbal memory in addition

to ADHD, RS. The logical memory subtests of the WMS-R are an excellent measure of receptive verbal memory for complex language and attention span for receptive language (D'Elia, Satz, & Schretlen, 1989). Thus, the Logical Memory Subtest of the WMS-R were used to evaluate deficits in receptive auditory verbal memory in young adults with ADHD, RS.

Laboratory Measures Assessing of Attentional Functioning

The Paced Auditory Serial Addition Test (PASAT) was originally developed by Gronwall (1977) as a measure of information processing capacity to test the rate and degree of progress in patients recovering from closed head injury. During the PASAT, the subject listens to a series of single-digit numbers played on a tape recorder and presented at specified intervals. The task requires the subject to add the numbers according to the following rule: add the first number to the second and speak the answer out loud (the examiner records each answer on the PASAT answer sheet), add the second number to the third number and speak the answer out loud, add the third number to the fourth and give the answer, and so on throughout that block. Before the administration of the test, an untimed practice session was used to ensure that the subject understood and was familiar with the task. The examiner introduced the test to the subject by writing a series of numbers on a sheet of paper and explaining the addition rule. When the addition rule was fully understood, subjects practiced several trials spoken by the examiner at a slow pace. When the untimed practice was completed, the subject performed a slow paced practice session with the tape. During the tape practice, if the subject lost track for

any reason, he/she was encouraged to “pick up and get going again after any two consecutive digits.” After the subject successfully completed ten successive trials with the practice tape, the four blocks of the actual test were administered from the audio-tape. There was a one minute rest between each block. There were 61 digits per condition giving the subject an opportunity to give 60 total responses per condition. The task was made progressively more difficult each block by reducing the fixed time interval between the digits. The interstimulus intervals for the four blocks were 2.4, 2.0, 1.6, and 1.2 seconds respectively. Thus, the information processing load increased with successive blocks because the same number of trials were completed in less time.

The Conners Continuous Performance Test (CPT; Conners, 1992) generates 12 dependent measures, including hit reaction time (Hit RT), standard error of reaction time (SE), percent commissions, percent omissions, variability of SEs, Beta, d-prime, change in RT by block, change in RT by ISI, change in SE by block, and change in SE by ISI. The computer program presents six blocks of approximately 2 1/2 minutes each and presents three different ISI's within each block (1 second ISI, 2 second ISI, and 4 second ISI). The stimulus duration is 200 milliseconds throughout the task. The CPT is known to be a reliable measure of neurocognitive/attentional dysfunction in children and adults with ADHD (Barkley, Grodzinsky, & DuPaul, 1992), in schizophrenic patients (Earle-Boyer et al., 1991), and in autistic children (Garretson et al., 1990). Also, the CPT appears to be the best "biological marker" for detecting subjects at genetic/biological risk for the development of major psychiatric illness (Garver, 1987). Indices of perceptual

sensitivity (d' statistic) and response bias (β) may be obtained when a signal detection theory analysis is applied to CPT data.

Interviews were conducted by two graduate clinicians and three trained, advanced undergraduate psychology students. Prior to performing independent interviews of subjects, the student interviewers received considerable training from the study coordinator that involved introduction to, and extensive review of, DSM-III-R and DSM-IV diagnostic criteria for the disorders covered by the structured clinical interviews. The interviewers also observed trained, graduate clinician interviewers perform interviews of study subjects and rated the observed interviews under the supervision of the study coordinator. The two graduate clinicians performed inter-rater reliability checks on approximately one-half (30 interviews) of the audio- and videotaped interviews. Kappa coefficients of agreement between the student and graduate clinician interviewers were computed. An overall calculation of the level of agreement between the two raters for all possible diagnoses for the 30 interviews checked for reliability resulted in a kappa coefficient of .92. A kappa coefficient of this size is considered highly desirable by Landis & Koch (1977).

Results

To examine the frequency of comorbidity in the ADHD, RS group as compared to the non-ADHD group (Hypothesis 1), a 2 x 2 chi square analysis was performed and revealed that the ADHD group presented with significantly more comorbid psychopathology than the non-ADHD group ($\chi^2 (1) = 4.397, p = .018$). It should be noted that learning

disabilities were not included in these analyses as an Axis I or an Axis II disorder.

Approximately 43 percent of the ADHD group had comorbid psychopathology while slightly less than 15 percent of the non-ADHD group met criteria for two or more Axis I or II diagnoses. Table 2 shows the frequency of comorbidity in the ADHD and non-ADHD groups. It should be noted that all subjects with comorbidity had at least one comorbid Axis I disorder. Therefore, a chi square analysis that examined comorbidity with Axis I disorders only was conducted and found to be identical to the analysis described above. Unfortunately, too few Axis II disorders were present to examine the relationship between the diagnosis of ADHD and comorbid personality disorders.

In order to examine the relationship between adult ADHD and the presence of a learning disability (Hypothesis 2a), a 2 x 2 chi square analysis was performed, revealing that the ADHD group did not present with a significantly greater incidence of learning disabilities than the non-ADHD group ($\chi^2 (1) = .097, p = .755$). In fact, the ADHD adults in the present sample were slightly less likely to present with a learning disability than the non-ADHD adults. Specifically, as shown in Table 3, the ADHD adults had approximately a 1 in 4 chance of presenting with a comorbid learning disability, whereas the non-ADHD adults had slightly less than a 1 in 3 chance of meeting criteria for a learning disability.

Similarly, a 2 x 2 chi square analysis was conducted to examine the relationship between group status and the presence of an auditory verbal memory deficit (Hypothesis 2b). As predicted, the ADHD adults were significantly more likely to exhibit an auditory

verbal memory deficit than the non-ADHD adults ($\chi^2 (1) = 9.135, p = .0015$). While 60 percent of the ADHD group exhibited a significant discrepancy between their estimated Full-Scale IQ from the WAIS-R and their Verbal Memory Index Score from the WMS-R, only 19 percent of the non-ADHD group exhibited such a significant discrepancy (see Table 4).

Hypotheses 3a, 3b, and 3c were tested via a 2 (Group: ADHD vs. non-ADHD) x 3 (Block: 1 vs. 2 vs. 3) x 4 (Cognitive Demand Condition: low vs. moderate vs. high vs. very high) repeated measures ANOVA computed on subjects' correct responses on the PASAT. Contrary to what was predicted, a significant main effect for group was not found, ($F (1, 60) = 3.93, p = .0520$); however, as is apparent, marginally significant effect was noted ($p = .0520$). However, as predicted, a significant group x block interaction was found ($F (2, 120) = 5.67, p = .0045$), as was a significant group x condition interaction ($F (3, 180) = 20.20, p = .0001$). A simple effects analysis was conducted to evaluate each group's performance across the 3 blocks of the PASAT (see Figure 1). For the non-ADHD group, a one-way ANOVA revealed a significant effect for block ($F (2, 186) = 23.12, p = .0001$). A subsequent Fisher's LSD indicated that the non-ADHD group performed significantly less well in the third block than in the first and second blocks ($p < .05$). However, no differences were revealed between the first and second blocks. Similarly, a one-way ANOVA conducted for the ADHD group revealed a significant effect for block ($F (2, 242) = 33.87, p = .0001$). A subsequent Fisher's LSD

indicated that the ADHD group performed significantly less well in each successive block ($p. < .05$) of the test (i.e., the ADHD subjects performed significantly more poorly in the second block than in the first block, and significantly more poorly in the third block than in the second block). Additional simple effects tests were conducted for between group effects. Specifically, t-tests comparing groups at each block (see Table 5) revealed no significant difference at block 1, but the groups were significantly different on blocks 2 and 3 ($p. < .05$).

Simple effects analyses were also conducted to evaluate each group's performance across the 4 conditions of the PASAT (see Figure 2). For the non-ADHD group, a one-way ANOVA revealed a significant effect for condition ($F(3, 104) = 7.55, p. = .0001$). A subsequent Fisher's LSD indicated that the non-ADHD group performed significantly better in conditions 1 and 2 than in conditions 3 and 4 ($p. < .05$). However, no differences were revealed between the first and second conditions, and no differences were revealed between the third and fourth conditions. Similarly, a one-way ANOVA conducted for the ADHD group revealed a significant effect for condition ($F(3, 136) = 52.91, p. = .0001$). A subsequent Fisher's LSD indicated that the ADHD group performed significantly less well in each successive condition ($p. < .05$) of the test (i.e., the ADHD subjects performed significantly more poorly in the second condition than in the first condition, significantly more poorly in the third condition than in the second condition, and significantly more poorly in the fourth condition than in the third condition). Additional simple effects tests were conducted for between group effects. Specifically, t-

tests comparing groups at each condition revealed no significant differences in performance in conditions 1, 2, or 3, but the groups were significantly different in condition 4 ($p < .05$). Means and standard deviations for these analyses are presented in Table 6.

Hypotheses 3d was tested using a 2 (Group: ADHD vs. non-ADHD) x 5 (Block: 1 vs. 2 vs. 3 vs. 4 vs. 5) repeated measures ANOVA on the CPT measure d-prime, using block as a repeated measure. While the Conners CPT contains 6 blocks, block 1 was considered a practice block, and therefore, it was not included in this analysis.

The ANOVA revealed a significant group effect ($F(1, 60) = 13.42, p = .0005$), a non-significant but marginal block effect ($F(4, 240) = 2.32, p = .0576$), and a significant group x block interaction ($F(4, 240) = 4.82, p = .0009$). The ADHD group obtained a lower mean d-prime than the non-ADHD group, supporting Hypothesis 3d. To explore the group x block interaction effect, a follow-up simple effects analysis was conducted to evaluate the performance of each group across the 5 blocks of the CPT. For the non-ADHD group, a one-way ANOVA did not reveal a significant effect for block ($F(4, 130) = .46, p = .7614$). A subsequent Fisher's LSD confirmed that the performance of the non-ADHD group did not vary significantly across blocks. Similarly, a one-way ANOVA conducted for the ADHD group did not reveal a significant effect for block ($F(4, 170) = 1.69, p = .1535$). However, a subsequent Fisher's LSD indicated that the ADHD group performed significantly less well in the fourth and fifth blocks (which were

not significantly different from each other) than in the first, second, and third blocks (which were not significantly different from each other) ($p < .05$). Further, simple effects tests were conducted for between group effects at each of the blocks. Specifically, t-tests comparing groups at each block revealed no significant difference at block 1, but the groups were significantly different on blocks 2, 3, 4, and 5 ($p < .05$). Means and standard deviations for these analyses are presented in Table 7. The table reveals that the ADHD group showed a greater decline in d-prime across the blocks of the task than the non-ADHD group as predicted in Hypothesis 3d. Moreover, the ADHD group exhibited a steady decline in perceptual sensitivity (d-prime) across blocks of the CPT whereas the non-ADHD group exhibited relatively stable perceptual sensitivity (d-prime) over time. Figure 3 reveals the differential levels of perceptual sensitivity over time for the two groups.

In order to evaluate Hypothesis 3e, a group x block ANCOVA on d-prime, with Beta serving as the covariate was conducted and revealed that changes in d-prime were independent of changes of Beta and were significant only in the ADHD group. Thus, this analysis indicated that the ADHD group showed significantly greater vigilance decrement (as defined by a decline in d-prime independent of Beta) than the non-ADHD group.

To further explore the diagnostic utility of the two laboratory measures of attentional and information processing functioning, the data from the two laboratory measures (CPT and PASAT) were subjected to multivariate statistical analyses. First, in order to determine the diagnostic classificatory power of the CPT alone, an exploratory stepwise

discriminant function analysis was performed using the 12 dependent measures from the CPT. The 12 dependent measures from the CPT included, hit reaction time (Hit RT), standard error of reaction time (SE), percent commission errors, percent omission errors, variability of standard error across blocks, total Beta (i.e., the mean overall Beta for each group across all blocks), total d-prime (the mean overall d-prime for each group across all blocks), change in hit reaction time across blocks, change in reaction time by inter-stimulus interval, change in standard error by block, change in standard error by inter-stimulus interval, and variability in standard error. On the basis of the stepwise selection procedure, 2 variables from the CPT were selected for entry into the canonical and classification discriminant function analyses. The variables selected in decreasing order discriminative power were, d-prime total and standard error inter-stimulus interval change. Using these 2 discriminating variables from the CPT, the classificatory discriminant function analysis correctly classified 82.86 percent of the ADHD, RS subjects and 74.07 percent of the non-ADHD, RS subjects into their respective diagnostic categories (see Table 8).

In order to determine the diagnostic classificatory power of the PASAT alone, a second exploratory stepwise discriminant function analysis was performed using the 8 dependent measures from the PASAT. The 8 dependent measures from the PASAT included, hits (correct responses) in blocks 1-3, hits in conditions 1-4, and total hits. On the basis of the stepwise selection procedure, 2 variables from the PASAT were selected for entry into the canonical and classification discriminant function analyses. The

variables selected in decreasing order of discriminative power were hits in condition 4 and hits in block 1. Using these 2 discriminating variables from the PASAT, the classificatory discriminant function analysis correctly classified 80.00 percent of the ADHD, RS subjects and 74.07 percent of the non-ADHD, RS subjects into their respective diagnostic categories (see Table 9).

Third, a discriminant analysis entering all dependent measures from the CPT and the PASAT was performed. On the basis of the stepwise selection procedure, 6 variables from the two laboratory measures of attention were selected for entry into the canonical and classification discriminant function analyses. The variables selected in decreasing order of discriminative power were, hits condition 4 from the PASAT, d-prime total from the CPT, hits condition 3 from the PASAT, variability in standard error from the CPT, hit reaction time change across blocks from the CPT, and change in hit reaction time across blocks from the CPT. Using these discriminating variables from the two laboratory-based measures, the classificatory discriminant function analysis correctly classified 91.43 percent of the ADHD, RS subjects and 88.89 percent of the non-ADHD, RS subjects into their respective diagnostic categories (see Table 10).

Discussion

Diagnostic Status

The first hypothesis was derived from the work of Joseph Biederman and his colleagues (e.g. Biederman et al., 1993). In their work, these researchers have emphasized that even though ADHD is widely accepted as a valid clinical entity, or

syndrome, in children, the status of the disorder in adults remains unclear. As noted in the introduction, a primary reason for the uncertainty surrounding the category of adult ADHD is the high degree of comorbidity with other psychiatric disorders exhibited by ADHD adults (see Biederman et al., 1991; Biederman et al., 1993; Mannuzza et al., 1993; Wilens et al., 1994). The consistently high level of psychiatric comorbidity in adults diagnosed with ADHD has led some researchers to speculate whether the adult form of the disorder might represent little more than either an artifact of overlapping symptoms from other adult psychiatric disorders or a prodrome of other adult psychiatric disorders (Biederman et al., 1993; Munir et al., 1987). However, previous research showing the continuity of clinical symptomatology from ADHD in childhood to ADHD in adulthood supports the usefulness of the adult classification of the disorder (Biederman et al., 1993). In this study, we attempted to generate further evidence to substantiate these earlier findings. The results of this study corroborated the findings of Biederman and colleagues by showing that while clinic-referred adults with ADHD did present with more comorbid psychopathology than non-ADHD clinic-referred adults (confirming Hypothesis 1), they also exhibited symptomatology that was quite similar to the attentional and cognitive impairments known to be associated with the childhood disorder (e.g. impaired vigilance performance as revealed by the findings from the CPT, poorer information processing performance as revealed by the PASAT, weaker memory performance as revealed by the WMS-R). As was found previously (Biederman et al., 1993), the ADHD adults in this study consistently performed at a lower level on attentional and cognitive tasks than did

non-ADHD clinic-referred adults who exhibited various other forms of psychiatric disturbance. This finding replicates, in a sample of ADHD and non-ADHD adults, the findings of numerous child studies comparing attentional and cognitive functioning in ADHD and non-ADHD children. This replication lends more support to the notion that ADHD in adults likely represents a separate clinical entity, or syndrome, with specific patterns of attentional and cognitive impairment that transcend other patterns of psychiatric comorbidity in adulthood. Therefore, these results suggest that ADHD in adults represents a valid clinical diagnosis that, far from obscuring adult psychiatric status and treatment schemes, may help clarify adult psychiatric status and lead clinicians to select more appropriate intervention strategies. Finally, it should be noted that the use of the ADHD section of the KIDDIE-SADS, administered retrospectively in past tense, revealed a remarkable degree of continuity in subjects' reports of ADHD symptomatology from childhood to adulthood. Again, this method lends anecdotal confirmation to earlier findings (Biederman et al., 1993), providing further evidence that the experiential nature of the syndrome recalled from childhood appears to bear a high degree of consistency with the syndrome experienced in adulthood.

Clinical Correlates of ADHD in Adults

The hypotheses related to the clinical correlates of ADHD, RS were based on numerous subjective reports made by ADHD adults who had been assessed by the study coordinator at both the Psychological Services Center at Virginia Tech and the Attention Deficit Disorders Program at Duke University Medical Center in the three years prior to

the start of the present study. In addition, clinical observations of these same adults during the assessment process tended to confirm frequent subjective reports by clients of considerable difficulty remembering verbal information and sustaining mental exertion on complex or boring tasks. For example, several adults referred for ADHD assessment at the Virginia Tech and Duke University clinics, and who presented with clinical or sub-clinical ADHD symptoms, appeared to exhibit a deficit in receptive auditory verbal memory. However, as noted in the introduction, it was frequently difficult to determine whether the apparent deficits in auditory verbal memory were a direct result of ADHD symptomatology (e.g. as a byproduct of the distractibility ADHD adults frequently exhibit) and therefore a clinical correlate of the disorder in adults, or whether adults with clinically significant deficits in auditory verbal memory were referred for ADHD assessment because their receptive verbal memory difficulties caused them to exhibit “ADHD-like” symptoms but without having the disorder at all. The clinician who evaluates adults presenting for ADHD assessment and who appear to exhibit an auditory verbal memory deficit (AVMD) must decide between three possible alternatives, including: 1) the apparent AVMD is not a verbal memory problem at all but merely a result of other ADHD symptomatology such as distractibility, and the subject should be treated for ADHD; 2) the apparent ADHD symptomatology (inattentiveness, difficulty listening, etc.) is not the result of ADHD at all but merely a result of an AVMD that causes one to appear to suffer from ADHD; and 3) AVMD is present along with ADHD. We attempted to generate evidence in this study that would help clarify the nature of the

auditory verbal memory problems exhibited by many adults who are referred for ADHD evaluation. The Logical Memory and Verbal Paired Associates subtests of the Wechsler Memory Scale-R (WMS-R; Wechsler, 1987) were used because they are considered good standardized measures of receptive verbal memory for complex language and attention span for receptive language (D'Elia, Satz, & Schretlen, 1989). We determined that an auditory verbal memory deficit was present if a subject exhibited a 15 standard score point discrepancy between his/her estimated Full-Scale IQ from the WAIS-R and his/her Verbal Memory Index Score from the WMS-R. When this criterion was used for the presence of AVMD, it was found that a significantly greater proportion of adults diagnosed with ADHD using a structured clinical interview exhibited clinically meaningful verbal memory problems than adults not diagnosed with ADHD. As noted in Table 4, 60% of the ADHD adults exhibited AVMD while only 19% of the non-ADHD adults showed AVMD. These results support the notion that AVMD is a relatively frequently occurring clinical correlate of ADHD in adults, suggesting that option 3 listed above may often be the best way for clinicians to conceptualize apparent AVMD in adults referred for ADHD assessment. However, the results do not unequivocally rule-out the possibility that a phenomenon such as that listed in option 1 above was at work in this study whereby ADHD symptomatology (e.g. distractibility, inattentiveness) in adults with the disorder in our sample caused them to perform poorly on the verbal sections of the WMS-R. If this phenomenon did occur in our sample of ADHD adults, then the WMS-R did not measure auditory verbal memory functioning but rather served as

another measure of ADHD symptomatology. In future studies, a better measure of auditory verbal memory functioning in ADHD adults may be obtained if ADHD adults were divided into a psychostimulant treatment group and a no treatment group before being tested. Psychostimulant treatment would presumably mitigate the impairing effects of inattention and distractibility and allow the WMS-R to provide a more adequate measure of auditory verbal memory functioning in adults with ADHD.

The non-significant relationship between the diagnosis of ADHD and the occurrence of a learning disability (LD) may be a result of the way the sample was obtained, and thus, may reflect the nature of the sample in this study rather than a lack of relationship between these two diagnostic groups in general (i.e. between ADHD and LD groups). For instance, the fact that many subjects were referred by academic deans at nearby universities due to difficulties in college course work may have inflated the number of subjects in both diagnostic groups who ultimately met criteria for a specific learning disability, causing LD to be over-represented in our sample.

Laboratory Measures of Attentional and Information Processing Functioning

One of the primary diagnostic dilemmas confronting researchers and clinicians who investigate and treat ADHD in adults is the lack of empirically validated, objective measures of ADHD symptomatology in adults. As Barkley (1991) notes, this problem facing professionals who work with ADHD in adults likely arises from the considerable difficulties associated with establishing measures that reliably assess ADHD, RS symptomatology in natural and laboratory settings. Nevertheless, the need for

empirically validated, reliable, objective measures of ADHD symptoms in adults is also considerable.

Given that no laboratory measures have been empirically shown to reliably discriminate between ADHD, RS subjects and other psychiatrically disturbed subjects, and given that laboratory measures were available that seemed to hold promise for this purpose (PASAT, Conners CPT), we attempted to determine whether these measures were sensitive to the primary impairing symptomatology considered to be associated with ADHD in adults.

We first predicted that the PASAT would adequately discriminate clinic-referred adults who met diagnostic criteria for ADHD from clinic-referred adults who did not meet criteria for ADHD in terms of: 1) a global measure of working memory capacity (i.e., total number of correct responses); 2) working memory capacity over time (i.e., number of correct responses across blocks); and 3) working memory capacity by level of cognitive demand (i.e., number of correct responses across information processing demand conditions).

The results revealed that the PASAT did not discriminate ADHD adults from non-ADHD adults at a statistically significant level in terms of the global measure of working memory capacity as measured by total number of correct responses. However, this global measure was nearly significant and suggested that ADHD adults experienced what likely should be considered a clinically meaningful deficit in overall working memory functioning as compared to non-ADHD subjects. This impairment in working memory

capacity was evident (although not statistically significantly so) in ADHD adults even though this generalized measure of working memory functioning did not take into account the variables of time and cognitive demand—variables directly related to the fundamental functionally impairing symptoms of ADHD in children and adults, namely, vigilance and sustained mental effort respectively. That is, ADHD adults in this sample exhibited a generalized deficit in working memory functioning.

However, the results did reveal that when working memory capacity over time (i.e., number of correct responses across blocks) was evaluated, the PASAT discriminated ADHD adults from non-ADHD adults at a statistically significant level. Figure 1 reveals that while both groups showed a performance decrement over time, the ADHD group evidenced a more rapid decline such that by the second block of the test the groups were significantly discrepant and remained so for the remainder of the test. These results support the traditional notion that ADHD subjects experience a decline in vigilance more rapidly than non-ADHD subjects, and that this notion holds true for adults with ADHD as it does for children with ADHD. (Note: Tannock et al., 1995 obtained similar results with ADHD children using the CHIPASAT, a child version of the PASAT.) However, caution should be exercised in making this interpretation, since the vigilance construct may be confounded with information processing constructs, such as working memory, and may be due to other cognitive variables that have been previously found to distinguish ADHD and non-ADHD children and adults (e.g., intellectual capacity and level of educational achievement). However, as reported above, the ADHD and non-

ADHD groups in this study did not differ in terms of estimated cognitive capacity or level of academic achievement, and therefore, it seems unlikely that these variables could account for the differential decline over time in the working memory functioning of these groups. Moreover, as we shall see below in the discussion of the Conners CPT results, the construct of vigilance may well provide considerable explanatory power in attempts to account for the differential levels of performance of these diagnostic groups.

The results for the PASAT also revealed that when working memory capacity by level of cognitive demand (i.e., number of correct responses across information processing demand conditions) was evaluated, the PASAT discriminated ADHD adults from non-ADHD adults at a statistically significant level. Figure 2 reveals that while both groups showed a performance decrement as the task became more demanding, the ADHD group evidenced greater decline in the successively more cognitively demanding conditions in that the ADHD adults performed significantly less well in each successive condition of the test. However, it is interesting to note that the groups did not become significantly discrepant from each other until the fourth and most demanding condition of the test. Table 6 and Figure 2 reveal that within the fourth condition, the ADHD subjects generated approximately 40% fewer correct responses than they did in the previous condition, and 44% fewer correct responses than the non-ADHD group did in condition 4. These findings suggest that the ADHD adults were able to maintain adequate levels of mental exertion so long as the task demands remained below a certain threshold of perceived cognitive demand. However, once the threshold was crossed at which the

ADHD subjects as a group felt mentally-overmatched by the task, as apparently occurred in condition 4, the group as a whole experienced cognitive or mental “shut-down.” This dramatic change in cognitive effort applied to the task was clearly evident from clinicians’ behavioral observations of many subjects from the ADHD group. These clinical observations revealed that numerous ADHD adults were simply unable to continue to engage in the task at condition 4, as evidenced by long stretches of time in which many ADHD adults generated few, if any, correct responses. Moreover, this difficulty re-engaging the task continued even after prompts designed to alert subjects and help them re-engage, such as “pick back up,” were given by the examiners. This phenomenon of cognitive shut-down simply did not occur in the non-ADHD subjects.

These findings imply that the PASAT captured not only the phenomenon described by the DSM-IV symptom from the Predominately Inattentive Type of ADHD that states that ADHD patients “often avoid, dislike, or are reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework)” (American Psychiatric Association, 1994, p. 84), but it also generated evidence addressing why ADHD patients may exhibit such reluctance. That is, these findings from the PASAT suggest that when ADHD adults perceive that their information processing resources are being overwhelmed by a task, they experience an almost involuntary tendency to mentally disengage from that task, as well as considerable difficulty voluntarily re-engaging that task (as evidenced by their inability to re-engage the PASAT after alerting prompts from the examiners in condition 4 to do so).

These findings from the PASAT also provide evidence concerning the experiential nature of ADHD in adults. For example, the findings corroborate subjective reports from adults in this study that they experience considerable difficulty remaining mentally engaged in tasks that they perceive to be intellectually demanding (e.g. reading for courses in college; mentally adding the cost of a few items while standing in the checkout line at the grocery store; memorizing a set of instructions to perform some novel task at work; etc.). Moreover, while many adults who do not have ADHD may experience difficulty remaining engaged in tasks that they perceive to be mentally demanding, the findings from the PASAT suggest that ADHD adults likely experience considerably more difficulty doing so, even when compared to other clinic-referred adults (the majority of whom were diagnosed with either a learning disability, an affective disorder, or an anxiety disorder, all of which may impact one's working memory functioning). In addition, these ADHD adults seem likely to frequently find themselves in school or occupational settings in which their peers appear considerably more capable of adequately managing tasks that place a heavy load on one's information processing resources. Indeed, one cognitively gifted ADHD adult (as indicated by estimated Full-Scale IQ) in this study seemed to speak for the group as a whole when he reported that he has never felt like he was "on a level playing field" with his peers at school or work, because he frequently found that he simply could not force himself to remain mentally engaged in intellectually challenging activities, even if he perceived those activities to be enjoyable.

As we did with the PASAT, we predicted that the Conners CPT would adequately discriminate clinic-referred adults who met diagnostic criteria for ADHD from clinic-referred adults who did not meet criteria for ADHD in terms of a global measure of perceptual sensitivity (i.e., overall d-prime from the CPT) and perceptual sensitivity over time (i.e., value for d-prime across blocks).

The results revealed that the CPT did discriminate ADHD adults from non-ADHD adults at a statistically significant level in terms of the global measure of perceptual sensitivity as measured by overall d-prime. However, this finding suggests that ADHD adults experience deficits in perceptual sensitivity irrespective of variables such as the passage of time or cognitive demand. It should be noted that the Conners CPT is not considered to be a cognitively demanding attentional task in that it does not place heavy demands on one's information processing resources. Rather, this task taxes one's ability to maintain adequate levels of attentional arousal when engaged in a boring task that lasts a relatively long period of time. The fact that the ADHD group was significantly discrepant and below the non-ADHD group on the overall measure of perceptual sensitivity generated by the CPT suggests that ADHD adults came to the task with lower levels of sensitivity (i.e., the deficit in perceptual sensitivity did not emerge only after the passage of time, for it was also evident at the beginning of the task). This finding was corroborated by the differential performance of the diagnostic groups during the practice block of the test. During the practice block, the ADHD group generated a considerably lower d-prime score for that block than did the non-ADHD group. However, as can be

seen in Figure 3, by the first test block the ADHD group was not significantly discrepant from the non-ADHD group in terms of perceptual sensitivity. Thus, ADHD adults approached the task with lower levels of perceptual sensitivity than non-ADHD adults did, and they took longer to become fully engaged in the task than non-ADHD adults did as evidenced by the fact that by the end of the practice block, ADHD adults performed at a level commensurate with the non-ADHD adults. As was the case with the findings concerning overall working memory from the PASAT, the findings concerning overall perceptual sensitivity from the CPT reveal that ADHD adults in this sample exhibited a generalized deficit in perceptual sensitivity.

However, the results revealed that when perceptual sensitivity over time (i.e., value of d -prime across blocks) was evaluated, the CPT discriminated ADHD adults from non-ADHD adults at a statistically significant level. Figure 3 reveals that only the ADHD group showed a decrease in perceptual sensitivity over time. Moreover, the ADHD group evidenced a rapid decline as well in that by the second block of the test, the groups were significantly discrepant and remained so for the remainder of the test. However, it should be noted that the groups were significantly discrepant by block 2, partially because the non-ADHD adults actually increased in perceptual sensitivity between the first and second blocks, but the values for perceptual sensitivity for the non-ADHD adults leveled-off and did not reveal a noteworthy decline for the remainder of the test. Figure 3 shows the consistently widening gap in perceptual sensitivity between the ADHD and non-ADHD groups from block 2 through block 5.

However, as reviewed above, Signal Detection Theory posits that decreasing perceptual sensitivity over time means little, for it may merely reflect changes in response criterion, or Beta, rather than true decreases in perceptual sensitivity or in vigilance. For instance, if one started the test with a moderately strict response criterion, making several hits and few errors of commission but became increasingly lax in response criterion as the test continued, resulting in many hits but also resulting in many more errors of commission, then perceptual sensitivity would appear to decrease. However, in this case, perceptual sensitivity did not decrease, but rather, the subject simply altered his/her response criterion. For this reason, Signal Detection Theorists (e.g. Parasuraman, 1984) assert that sustained attention, or vigilance, is most rigorously defined by decreases in d' independent of changes in Beta (i.e. decreases in perceptual sensitivity that occur while Beta remains relatively constant). The results of the ANCOVA on d' , with Beta serving as the covariate, supported the traditional notion that ADHD subjects experienced a decline in sustained attention, or vigilance, whereas the non-ADHD subjects exhibited no such decline. This finding from the Conners CPT with ADHD adults corroborates findings with children with ADHD on the Conners CPT (Conners, 1992). In addition, this finding from the Conners CPT suggests that decreases in vigilance in ADHD adults occur not only on tasks that these adults perceive to be cognitively demanding, such as the PASAT, but also on low-demand information processing tasks that tax one's ability to maintain attentional focus on tasks that are long and boring. Again, while most adults may experience difficulty maintaining vigilance on

tasks that are long and boring, the results from the Conners CPT with this sample suggest that ADHD adults experience considerably more difficulty maintaining adequate levels of vigilance, even when compared to other clinic-referred adults with various other forms of psychiatric disturbance.

In order to further explore the diagnostic utility of these two laboratory measures of ADHD symptomatology, we next explored the possibility that the dependent measures generated by the PASAT would reliably discriminate ADHD adults from non-ADHD adults when the variables from the test were subjected to multivariate, descriptive stepwise discriminate function analysis and predictive classificatory discriminate function analysis. As was presented in Table 10, the PASAT correctly classified 80% of the ADHD subjects and 74% of the non-ADHD subjects.

We next explored the possibility that the dependent measures generated by the CPT would reliably discriminate ADHD adults from non-ADHD adults when the variables from the test were subjected to multivariate, descriptive stepwise discriminate function analysis and predictive classificatory discriminate function analysis. As was presented in Table 9, the CPT variables correctly classified approximately 83% of the ADHD subjects and 74% of the non-ADHD subjects.

Finally, we explored the possibility that the dependent measures generated by the CPT and the PASAT would reliably, and more accurately, discriminate ADHD adults from non-ADHD adults when the variables from these two laboratory measures were combined and subjected to multivariate, descriptive stepwise discriminate function analysis and

predictive classificatory discriminate function analysis. As was presented in Table 8, the combined CPT and PASAT variables correctly classified approximately 91% of the ADHD subjects and 89% of the non-ADHD subjects. These findings revealed that the combined Conners CPT and PASAT variables accurately classified considerably more ADHD and non-ADHD subjects than did the widely used Gordon Diagnostic System (Gordon, 1986) which correctly classified approximately 75% of ADHD and non-ADHD children. However, given the relatively small ratio of number of subjects ($n = 62$) to number of variables (6) in the classificatory discriminant analysis in the current study, the rate of successful classification in this sample may be misleadingly high. Therefore, these results need to be replicated in additional samples of clinic-referred adults before the discriminant functions identified in this sample may be assumed sufficiently accurate for use in clinical diagnostic classification.

In this study, clinic-referred adults were assigned to diagnostic groups on the basis of a state-of-the-art semi-structured clinical interview, and high levels of inter-rater reliability were obtained among raters using the semi-structured interviews. Moreover, the diagnostic groups were not discrepant on variables such as gender, cognitive ability, academic achievement, and highest grade level passed. In addition, the combined variables from the two laboratory measures correctly classified slightly over 9 of 10 ADHD adults and slightly under 9 of 10 non-ADHD adults in this study. Therefore, it seems reasonable to conclude that the Conners CPT and the PASAT may well be found (upon replication of these results with other samples) to fulfill the need for objective,

empirically validated, laboratory measures of ADHD symptomatology that reliably discriminate ADHD adults from other clinic-referred adults. Moreover, the fact that these measures correctly classified subjects to diagnostic groups with such high degrees of accuracy using this sample is especially important, given that it is presumably much more difficult to distinguish between ADHD adults and other psychiatrically disturbed adults (whose symptom pictures overlap considerably with adult ADHD) than it is to distinguish between ADHD adults and normal control adults with no psychiatric disturbance. Therefore, these findings provide strong evidence that laboratory measures such as the Conners CPT and the PASAT will make important contributions to ongoing efforts to establish more reliable methods of diagnosing adult ADHD.

Conclusions

As noted above, the American Psychiatric Association (1994) asserts that children and adults with ADHD appear to perform abnormally on tasks that require “effortful mental processing ... yet [it is not] entirely clear what fundamental cognitive deficit is responsible for this” (p. 81). The current study contributed to ongoing efforts to clarify the nature of the fundamental cognitive deficits experienced by adults with ADHD, as well as ongoing efforts to clarify the classification and phenomenological status of ADHD in adults, by generating additional evidence that clinic-referred adults with ADHD are at significantly greater risk for psychiatric comorbidity than non-ADHD clinic-referred adults. Moreover, this study further elucidated the phenomenological status and experiential nature of ADHD in adults by showing that clinic-referred adults

with ADHD exhibited several specific cognitive deficits including, poorer auditory short-term verbal memory functioning, weaker working memory performance, lower perceptual sensitivity, and greater difficulty maintaining mental effort over time when cognitive tasks were demanding. The present study further helped clarify the issue of the phenomenology and typical experience of the disorder in adults by confirming previous findings that these adults demonstrate swifter decrements in vigilance, even on a low information processing demand task that does not tax brain centers responsible for higher cognitive operations or executive control functions. Moreover, previous findings that ADHD adults exhibit poorer sustained attention, in general, irrespective of the effects of non-specific factors such as expectancy, motivation, and fatigue were confirmed.

Taken together, these findings suggest that the functioning of several separate brain centers governing theoretically distinct functions, such as short-term verbal memory and verbal working memory, and brain centers governing broader abilities, such as perceptual sensitivity and continued mental effort on cognitively challenging tasks, are involved in the emergence of the constellation of deficits typical of adult ADHD. The likely involvement of several areas of brain function in the characteristic symptom picture of ADHD in adults supports the notion the disorder may be better characterized as a widespread deficit in the neuronal functioning of the brain rather than primarily a skills deficit, a motivational deficit, or a deficit in behavioral inhibition or regulation. Rather, an adequate theory of adult ADHD must account for the broad deficits in sustained mental exertion and general perceptual sensitivity as well as the more specific deficits in

short-term memory and working memory exhibited by these adults. Theories that account for possible deficits in global cerebral arousal or general weaknesses in the alerting functions of the human attentional system seem likely to make important contributions to our understanding of the phenomenology of adult ADHD, as seen in this study, by expanding upon theories that exclusively emphasize deficits in behavioral regulation or sustained attention as core deficits. Further exploration of such potential deficits in overall brain function, with particular emphasis on generating theoretical explanations for the possible etiology of multiple cognitive deficits across separate brain systems, is critical if we are to gain further understanding of the typical cognitive deficits that characterize adult ADHD.

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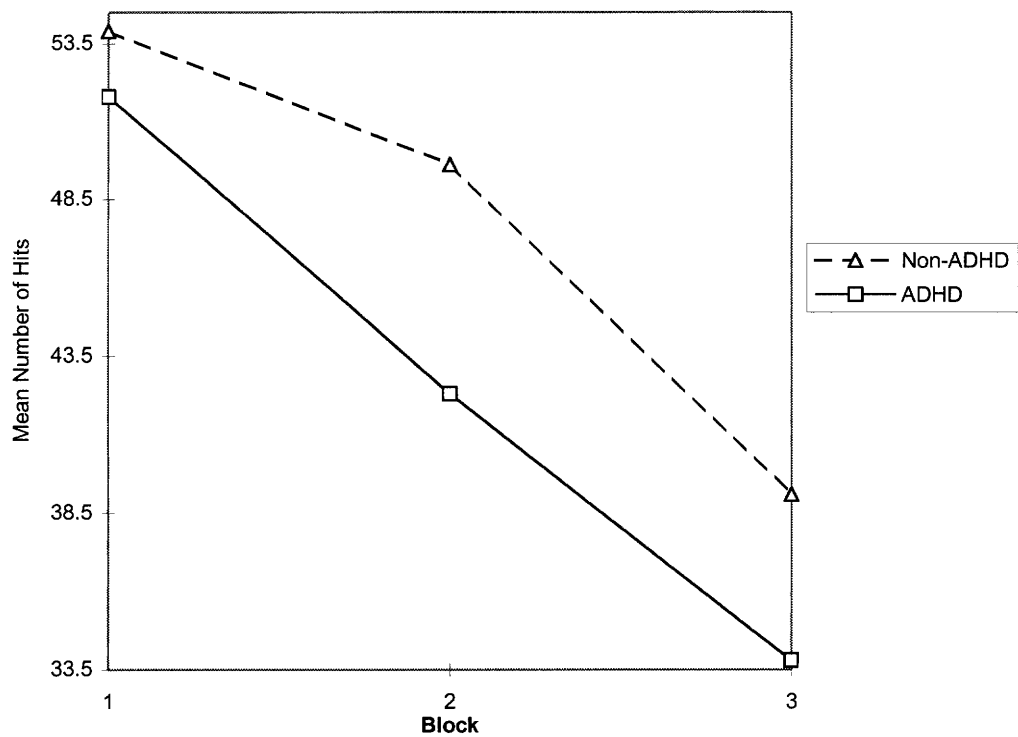


Figure 1
Mean Values for Hits for ADHD and non-ADHD Adults
for Consecutive Blocks of the PASAT

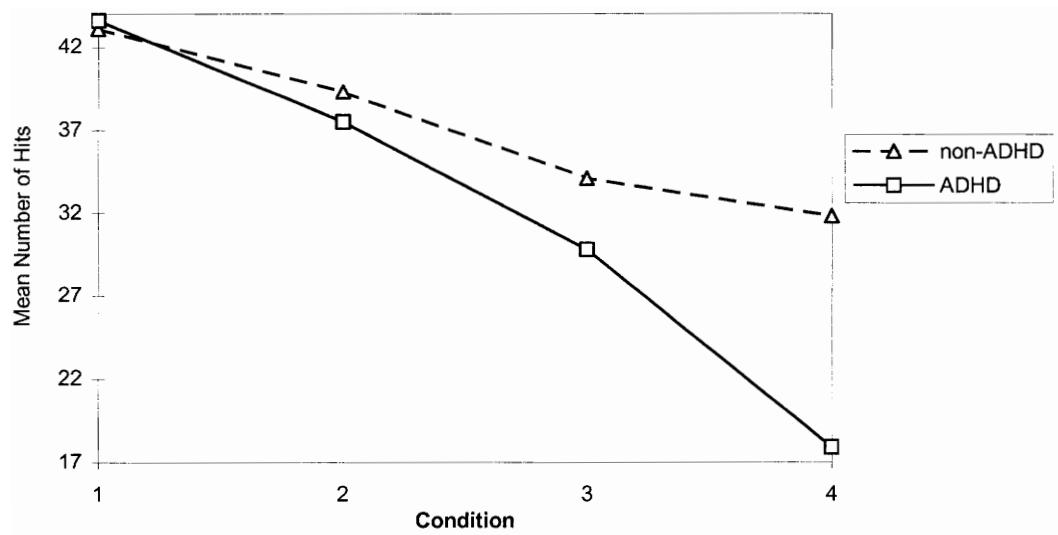


Figure 2
Mean Number of Hits on the PASAT for
ADHD and non-ADHD Adults on Each Information
Processing Demand Condition

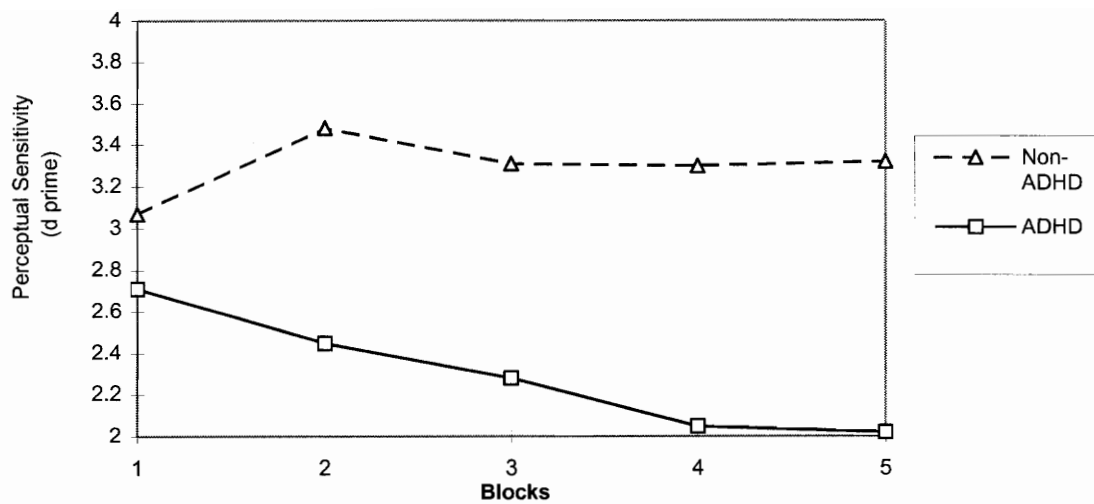


Figure 3
Mean Values of Perceptual Sensitivity for ADHD
and non-ADHD Adults for Consecutive Blocks of the CPT

Table 1

Location, Gender, and Number of ADHD and Non-ADHD Subjects

ADHD				Non-ADHD			
Virginia		North Carolina		Virginia		North Carolina	
M	F	M	F	M	F	M	F
12	9	9	5	7	7	5	8
21		14		14		13	
Total ADHD = 35				Total Non-ADHD = 27			

Table 2

Number and Proportion of Subjects with Comorbidity
in the ADHD and Non-ADHD Groups

	ADHD (n=35)	Non-ADHD (n=27)
Comorbid	15 (42.86%)	4 (14.81%)
Not Comorbid	20 (57.14%)	23 (85.19%)

Table 3

Number and Proportion of Subjects with a Learning Disability
in the ADHD and Non-ADHD Groups

	ADHD (n=35)	Non-ADHD (n=27)
Learning Disabled	8 (22.86%)	8 (29.63%)
Not Learning Disabled	27 (77.14%)	19 (70.37%)

Table 4

Number and Proportion of Subjects
with Auditory Verbal Memory Deficit
in the ADHD and Non-ADHD Groups

	ADHD (n=35)	Non-ADHD (n=27)
Auditory Verbal Memory Deficit	21 (60.00%)	5 (18.52%)
No Auditory Verbal Memory Deficit	14 (40.00%)	22 (81.48%)

Table 5

Means and Standard Deviations for Number of Correct Responses for
ADHD and Non-ADHD Adults on Each Block of the PASAT

<u>Group</u>	<u>PASAT Block</u>		
	1	2	3
ADHD	51.80 (10.64)	42.31 (10.75)	33.76 (13.01)
Non-ADHD	53.94 (11.11)	49.63 (12.47)	39.13 (11.78)

Table 6

Means and Standard Deviations for Number of Correct Responses for
ADHD and Non-ADHD Adults on Each Condition of the PASAT

<u>Group</u>	<u>PASAT Condition</u>			
	1	2	3	4
ADHD	43.57 (8.94)	37.49 (9.25)	29.78 (8.57)	17.94 (9.18)
Non-ADHD	43.11 (7.77)	39.26 (9.09)	34.11 (10.35)	31.78 (11.04)

Table 7

Mean Values and Standard Deviations for Perceptual Sensitivity for
ADHD and Non-ADHD Adults for Consecutive Blocks of the CPT

<u>Group</u>	<u>CPT Block</u>				
	1	2	3	4	5
ADHD	2.71 (1.06)	2.45 (1.18)	2.28 (1.19)	2.05 (1.56)	2.03 (1.4)
Non-ADHD	3.07 (.98)	3.48 (1.07)	3.31 (1.34)	3.30 (1.11)	3.32 (1.67)

Table 8

Number and Proportion of Subjects Correctly Classified into
Diagnostic Group from CPT Measures of Attentional Functioning

Actual Group	Predicted Group Membership		
	non-ADHD	ADHD	Proportion Total Number
non-ADHD	74.07% (n=20)	25.93% (n=7)	100% (n=27)
ADHD	17.14% (n=6)	82.86% (n=29)	100% (n=35)
Total	41.94% (n=26)	58.06% (n=36)	100% (n=62)

Table 9

Number and Proportion of Subjects Correctly Classified into
Diagnostic Group from PASAT Measures of Attentional Functioning

Actual Group	Predicted Group Membership		
	non-ADHD	ADHD	Proportion Total Number
non-ADHD	74.07% (n=20)	25.93% (n=7)	100% (n=27)
ADHD	20.00% (n=7)	80.00% (n=28)	100% (n=35)
Total	43.55% (n=27)	56.45% (n=35)	100% (n=62)

Table 10

Number and Proportion of Subjects Correctly Classified into Diagnostic Group
from the Combined CPT and PASAT Measures of Attentional Functioning

Actual Group	Predicted Group Membership		
	non-ADHD	ADHD	Proportion Total Number
non-ADHD	88.89% (n=24)	11.11% (n=3)	100% (n=27)
ADHD	8.57% (n=3)	91.43% (n=32)	100% (n=35)
Total	43.55% (n=27)	56.45% (n=35)	100% (n=62)

Appendix A

Official Consent Form

Title: The Conners Continuous Performance Test: An Objective Measure to Inform the Diagnosis of Attention-Deficit/Hyperactivity Disorder in Young Adults

Experiment Number:

Principal Investigator: A. Timothy Butcher

Purpose of the Study

The purpose of this study is to investigate attention problems in college students. Specifically, we are interested in identifying more efficient and accurate ways to evaluate the possible presence of attentional difficulties in college students and their potential impact on academic and cognitive functioning.

Procedures

Your involvement in this study will include participation in a two session assessment with each session lasting approximately two-three hours. Specifically, you will be 1) completing an extensive psychological evaluation in the form of an interview in which you will be asked questions about depression, anxiety, attention difficulties, and various psychological problems that you may be experiencing now or may have experienced as a child, 2) completing a questionnaire that asks you to recall behavioral difficulties you may have experienced as a child, 3) performing computerized and laboratory tests of attention, and, 4) completing a brief battery of tests in order to provide estimates of intellectual, academic, and memory functioning. Further, we will be asking your permission to contact your parents by mail so that we may ask them to complete a questionnaire concerning attentional problems you may have experienced as a child. However, you are under no obligation to allow us to contact your parents to receive this information, and your participation in the study is in no way contingent upon giving permission to contact your parents.

Discomforts/Risks from Participating in this Study

Your participation in this study may involve the potential risk of discomfort or embarrassment associated with answering questions about past and present attention problems, possible difficulties with anxiety, depression, substance abuse, relationship problems with family and friends, and other psychological problems college students sometimes experience. If you experience distress as a result of this study, and wish to terminate participation, you may discontinue at any time and an appropriate referral will

be offered. Further, a graduate student trained in clinical psychology will be available throughout the study in case you have any questions or concerns. Dr. Thomas Ollendick, faculty supervisor and a licensed clinical psychologist, will also be available for this purpose, and the phone number for the RAFT Community Crisis Center is provided below.

Expected Benefits

Through your participation in this study, you will receive a free, comprehensive assessment of the problems for which you were referred to the Psychological Services Center. Moreover, within two weeks of the completion of your assessment, you will be provided with a face-to-face feedback session with the principal investigator in order to discuss your assessment results and to give you an opportunity to ask any questions you may have. You will also receive a written report of your assessment results at the feedback session. The report you receive will be written by the principle investigator and will be approved and signed by Dr. Thomas Ollendick, faculty supervisor and a licensed clinical psychologist. Copies of your report may be sent to other parties upon your written request and an appropriate referral will be provided upon your request.

In addition, your participation in this study may help us identify more efficient and accurate ways to evaluate the possible presence of attentional difficulties in college students, and increase our understanding of the potential impact of attention problems on academic, cognitive, and memory functioning in college students.

Freedom to Withdraw

You are free to withdraw from participation in this study at any time, without penalty. You also have the option to not answer any question(s) at any time during the study.

Anonymity of Subjects and Confidentiality of Results

The results of this study will be kept strictly confidential. Researchers will not release your results to anyone except in the case where you have indicated that you may hurt yourself or someone else. The information you provide will have your name removed and only a subject number will identify you during analyses and any write-up of the research.

The interviews will be audio-taped. However, only qualified project staff (graduate & undergraduate psychology students) will listen to these tapes. All tapes will be stored in a locked file cabinet in a locked room at the Center. If any member of the project staff knows you or your family, he/she will eliminate him/herself from your assessment and will not be permitted to listen to your audio tape. All tapes will be erased upon the completion of the project.

Use of Research Data

The information from this research project may be used for education and scientific purposes. It may be presented at scientific meetings and/or published and reproduced in professional journals or books, or used for any other purpose that the Virginia Tech Department of Psychology considers proper in the interest of education, knowledge, or research.

Approval of Research

This research project has been approved by the Human Subjects Committee (HSC) of the Department of Psychology and by the Institutional Review Board (IRB) of Virginia Tech, as is required of all research projects conducted at Virginia Tech.

Subject's Permission

I have read the above description of the study. I have had an opportunity to ask questions and have them answered. I hereby acknowledge the above and give my voluntary consent for participation in this study.

I further understand that if I participate I may withdraw at any time without penalty.

I understand that should I have any questions regarding this research and its conduct, I should contact any of the persons named below:

A. Timothy Butcher, Principal Investigator	231-6914
Dr. Thomas H. Ollendick, Faculty Advisor	231-6451
Dr. Richard Eisler, Chair, HSC	231-7001
Dr. Ernest Stout, Chair, IRB	231-9359
RAFT Community Crisis Center	382-1738

Signature

Date

Name (Please Print)

Appendix B

Release of Information Form

I, _____, give my consent to allow Tim Butcher or other qualified project staff to contact the person(s) listed below by mail for the purposes of obtaining information for the project on attentional functioning in college students. I understand that this contact will involve a brief letter of explanation and a brief questionnaire about my behavior as a child. I have reviewed this letter and have read the questionnaire. I understand that this permission to contact my parent(s)/guardian will terminate upon the completion of this study.

Parent/Guardian Name and Address:

Signature: _____

Date: _____

Witness: _____

Date: _____

Appendix C

List of Measures

- I. Structured Clinical Interview for DSM-III-R
Copyrighted material, available from:
American Psychiatric Press
1400 K Street, N.W.
Washington, D.C. 20005
- II. KIDDIE-SADS
Copyrighted material, available from:
Center for Psychological Study
Nova University
3301 College Ave.
Ft. Lauderdale, FL 33314
- III. Structured Interview for ADD-H Symptoms
Copyrighted material, available in:
Gittleman, R., & Mannuzza, S. (1985). Diagnosing ADD-H in adolescents. Psychopharmacology Bulletin, 21, 237-242.
- IV. Structured Clinical Interview for DSM-III-R-II
Copyrighted material, available from:
American Psychiatric Press
1400 K Street, N.W.
Washington, D.C. 20005
- V. Wender Utah Rating Scale
Wender Parent's Rating Scale
Copyrighted material, available in:
Ward, M. F., Wender, M. F., & Reimherr, F. W. (1993). The Wender Utah rating Scale: An aid in the retrospective diagnosis of childhood attention deficit hyperactivity disorder. American Journal of Psychiatry, 150, 885-890.

CURRICULUM VITAE

Andrew Timothy Butcher
2933 Cara Court
Blacksburg, Virginia 24060
(540) 961-3578

PERSONAL

Born: January 27, 1962
Corpus Christi, Texas
Married: To Lydia Chu Butcher, BSN
Children: Rachel Erin Butcher (October 19, 1990)
Lauren Ashley Butcher (October 15, 1992)

EDUCATION

Candidate, Master of Science
Clinical Psychology
Virginia Polytechnic Institute and State University

Master of Divinity, May 1989
Southern Theological Seminary
Louisville, Kentucky

Bachelor of Arts, May 1985
Baylor University
Waco, Texas

EXPERIENCE

Clinical

Graduate Clinician - August 1993 - Present
Psychological Services Center and Child Study Center
Virginia Polytechnic Institute and State University
3110 Prices Fork Road
Blacksburg, Virginia 24060
(540) 231-6914
Supervisor:
August 1996 - Present George A. Clum, Ph.D.

Supervisor:
August 1995 - May 1996 Thomas H. Ollendick, Ph.D.

Supervisors:
August 1994 - May 1995 Richard Eisler, Ph.D.
Ellie T. Sturgis, Ph.D.

Supervisor:
May 1994 - August 1994 Richard Eisler, Ph.D.

Supervisors:
August 1993 - May 1994 Robert S. Stephens, Ph.D.
Jack Finney, Ph.D.

Duties include outpatient psychotherapy and assessment, psychological testing, participation on practicum teams, and weekly supervision.

Graduate Assistant - January 1994 - Present

Psychological Services Center and Child Assessment Clinic
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24060

Supervisor: Thomas H. Ollendick, Ph.D.

Duties include co-leading Child Assessment Clinic with faculty supervisor, co-supervising graduate clinicians, psychological testing with children, adults, and families, outpatient psychotherapy, parent training, school visitation, report writing, and data management.

Psychotherapy Extern - September 1994 - September 1996

Center for Psychological and Family Services
Chapel Hill, North Carolina 27514

Supervisor: Stephen D. Bennett, Ph.D.

Duties included outpatient psychotherapy and assessment with couples, families, children and adults, psychological testing, weekly supervision, and bookkeeping.

Graduate Psychology Extern - May - August 1996

Duke University Medical Center
Durham, North Carolina 27710

Supervisor: C. Keith Connors, Ph.D.

Duties included psychological testing with children and adults, report writing, parent training, outpatient psychotherapy, data management, and weekly supervision.

Research Assistant - May 1990 - October 1993

Duke University Medical Center

Supervisor: C. Keith Connors, Ph.D.

Clinical duties included administration of a large variety of psychological tests to children and adults, co-leading social skills groups for children with disruptive behavior disorders, and co-leading parent-training groups.

Research Assistant - January 1990 - May 1990

Lennox-Baker Children's Hospital
Duke University Medical Center

Supervisor: Mary Luckhardt, Ph.D.

Duties included administration of psychological testing protocol as part of a research study evaluating the impact of a child's chronic illness on parental functioning.

Chaplain Intern - May 1989 - May 1990

Duke University Medical Center

Supervisors: James Travis, Ph.D.
James Rawlings, M.Div.

Duties included performing all aspects of pastoral care including, crisis intervention (e.g., in emergency room), supportive grief counseling (e.g., for terminally ill patients and their families), and administration of Church sacraments (e.g., baptism, wedding, etc.). Duties also included participation on weekly interdisciplinary team meetings on assigned hospital units as well as weekly individual and group supervision.

Activities Therapy Volunteer - May 1987 - May 1988

Baptist East Hospital

Louisville, Kentucky

Supervisor: James A. Pollard, Ph.D.

Duties included supervising recreational and therapeutic activities for suicidal, depressed, and/or substance abusing adolescents and adults on lock-down units. Additional duties included assisting in group therapy meetings, teaching values clarification classes, and attending bi-weekly group supervision meetings and weekly staff meetings.

Student Counselor - May 1984 - May 1985

McClennen County Juvenile Detention Center

Waco, Texas

Supervisor: John Moser, Ph.D.

Duties included coordinating, supervising recreational and therapeutic activities for juvenile delinquents.

Teaching

Graduate Teaching Assistant - August 1993 - December 1993

Michael Casey, M.S.

Department of Psychology

Virginia Polytechnic Institute and State University

Blacksburg, Virginia 24060

Duties involved teaching a laboratory section associated with an undergraduate introductory psychology class, writing and administering exams, grading essays, and providing individual assistance to students.

Research

Graduate Research Assistant - September 1995 - Present

Department of Psychology

Virginia Polytechnic Institute and State University

Supervisor: Thomas H. Ollendick, Ph.D.

Assisted in data management, data analysis, and write-up of a study using DSM-IV field trial data investigating the impact of comorbid anxiety on the severity of Conduct Disorder in incarcerated juvenile delinquents.

Graduate Psychology Extern - May - August 1996

Attention Deficit Disorders Program

Duke University Medical Center

Durham, North Carolina 27710

Supervisor: C. Keith Conners, Ph.D.

Conducted psychological testing with children and adults, assisted in report writing and providing feedback for clients, and managed data for a variety of ongoing studies.

Thesis Research - January 1995 - May 1996

Department of Psychology

Virginia Polytechnic Institute and State University

Blacksburg, Virginia 24060

(540) 231-6914

Chairperson: Thomas H. Ollendick, Ph.D.

Designed and conducted a study investigating the accuracy with which specific laboratory measures of working memory and attentional functioning classified clinic-referred adults to ADHD and non-ADHD categories.

Graduate Research Assistant - February 1994 - October 1995

Department of Psychology

Virginia Polytechnic Institute and State University

Supervisor: Russell T. Jones, Ph.D.

Assisted in data management, data analysis, and write-up of a study investigating the impact of wildfire on children's and their mother's emotional adjustment and psychological functioning.

Research Assistant - May 1990 - December 1994

Attention Deficit Disorders Program

Duke University Medical Center

Supervisor: C. Keith Conners, Ph.D.

Assisted in data management, data analysis, and write-up of a variety of studies investigating ADHD assessment, neurological functioning in ADHD, and treatments of ADHD.

Research Assistant - February 1990 - December 1992

University Counseling and Psychological Services Center

Duke University

Supervisor: Joseph E. Talley, Ph.D.

Assisted in data management, data analysis, and write-up of a study evaluating the efficacy of very brief psychotherapy for college students.

PROFESSIONAL ORGANIZATIONS AND ACTIVITIES

Student Affiliate, American Psychological Association
Student Member, Association for the Advancement of Behavior Therapy

POSTER PRESENTATIONS

- Conners, C.K., March, J.M., Fiore, C., & Butcher, A.T. (1993, October). Information processing deficits in ADHD: Effect of stimulus rates and methylphenidate. Poster session presented at the annual meeting of the ACNP in Honolulu, Hawaii.
- Butcher, A.T., Yang, B., & Ollendick, T.H. (1994, November). Social adjustment in children: Convergent validity of teacher nominations, sociometric ratings, and children's self-reports. Poster session presented at the annual meeting of the Association for the Advancement of Behavior Therapy, San Diego, CA.
- Jones, R. T., Butcher, T., Ribbe, D.P., Cunningham, P.B., & Weddle, J.D. (1995, October). Fire Disaster: Psychological Impact on Children and Their Parents. Poster presented at the annual meeting of the Virginia Beach Symposium for Child and Adolescent Psychopathology, Virginia Beach, VA.
- Seligman, L.D., Butcher, A.T., and Ollendick, T.H. (1995, November). Relationship Among Anxiety, Depression, and Conduct Disturbance in Incarcerated Delinquents: A Test of Gray's Theory. Poster session presented at the annual meeting of the Association for the Advancement of Behavior Therapy, Washington D.C.

SYMPOSIUM PRESENTATIONS

- Butcher, A.T. & Ollendick, T.H. (1995, October). Differential sequelae of childhood ADHD in early adulthood: The moderating effects of anxiety and depression. Symposium presentation at the annual meeting of the Virginia Beach Symposium for Child and Adolescent Psychopathology, Virginia Beach, VA.
- Butcher, A.T., Seligman, L.D., & Ollendick, T.H. (1996, October). The Mitigating Effects of Anxiety on Severe Conduct Disorder: Preliminary Findings. Symposium presentation at the annual meeting of the Virginia Beach Symposium for Child and Adolescent Psychopathology, Virginia Beach, VA.

WORKSHOPS

- Conners, C.K., Wells, K., March, J., Fiore, C., Osborne, S., Schulte, A., Butcher, T., & Stoughton, C. (1993). Attention Deficit Hyperactivity Disorder (ADHD): Assessment and Treatment for Children and Adolescents. Workshop series conducted by C. Keith Conners, Ph.D. through Duke University Medical Center, Durham, NC.
- Butcher, A.T. & Ollendick, T.H. (1995, March). The ADHD Child/Adolescent: Practical Applications and Management. Workshop presented to the Lynchburg Mental Health Association in Lynchburg, Virginia.

MANUSCRIPTS

- Butcher, A.T., Ollendick, T.H., Conners, C.K., & Seligman, L.S. (Manuscript in preparation). Laboratory-based tasks in the diagnosis of ADHD in adults: A theoretical and empirical analysis.

Talley, J.E., & Butcher, A.T. (1993). The effects of very brief psychotherapy on self-reported symptoms of depression and anxiety in university students: A short-term outcome study. Unpublished manuscript, Duke University, Durham, NC.

JOURNAL REVIEWS

- 1995 Guest Review - Journal of Clinical Child Psychology
- 1996 Guest Review - Journal of Clinical Child Psychology
- 1996 Goza, A.B. & Butcher, A.T. (1996) Review of Professional Behavior Evaluation System (Ricketts). Journal of Behavioral Education, 6, 239-243.

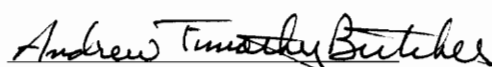
PUBLICATIONS

- Talley, J.E., Butcher, A.T., Maguire, M.A., & Pinkerton, R.S. (1992). The effects of very brief psychotherapy on symptoms of dysphoria. In J.E. Talley (Ed.), The predictors of successful very brief psychotherapy: A study of differences by gender, age, and treatment variables (pp. 12-45). Springfield, IL: Charles C. Thomas.
- Talley, J.E., Butcher, A.T., & Moorman, J.C. (1992). Client satisfaction with very brief psychotherapy. In J.E. Talley (Ed.), The predictors of successful very brief psychotherapy: A study of differences by gender, age, and treatment variables (pp. 46-84). Springfield, IL: Charles C. Thomas.
- Conners, C. K., Wells, K., Erhardt, D., March, J., Schulte, A., Osborne, S., Fiore, C., & Butcher, T. (1994). Multimodality therapies: Methodologic issues in research and practice. Child and Adolescent Psychiatric Clinics of North America, 3(2), 361-378.
- Conners, C. K., March, J. S., Erhardt, D., Butcher, T., & Epstein, J. (1995). Assessment of Attention Deficit Disorders (ADHD): Conceptual Issues and Future Trends. Journal of Psychoeducational Assessment, Monograph Series: Assessment of Attention-Deficit/Hyperactivity Disorders, 185-204.

NON-REFEREED PUBLICATIONS

- Butcher, A.T. (1995). Profiling the Neurologist. (Training module written for Health Sciences Consortium, 201 Silver Cedar Court, Chapel Hill, NC 27514)
- Butcher, A.T. (1996). Pivotal studies of Depakote: Its use as monotherapy and adjunct therapy for complex partial seizures. (Training module written for Health Sciences Consortium, 201 Silver Cedar Court, Chapel Hill, NC 27514)

REFERENCES Available upon request.


Andrew Timothy Butcher