

SYMPTOM DIMENSIONS AND NEUROCOGNITIVE FUNCTIONING
IN ADULT ADHD

by

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(Abstract)

Ongoing controversies regarding the clinical and nosological status of ADHD in adults emphasize the need for studies examining whether *DSM-IV* ADHD symptom dimensions and subtypes identified in research with children are valid for adults. Firm symptom criteria validated by data from adult samples have not been developed. Moreover, many clinic-referred adults present with attentional complaints and exhibit symptoms, neurocognitive weaknesses, and secondary problems similar to those seen in ADHD. However, data are mixed regarding the profile of neurocognitive deficits involved in adult expressions of ADHD, and it is unknown whether patterns of weakness in neurocognitive performance can be identified that reliably discriminate adults with ADHD from those with other neurobehavioral disorders (e.g., learning disabilities, LD). The purpose of this study was to further (a) evaluate the discriminant validity of *DSM-IV* ADHD in adults, (b) examine the nature and severity of neurocognitive deficits in adult ADHD, and (c) clarify the diagnostic utility of executive functioning measures among clinic-referred adults.

Overall, results supported the discriminant validity of adult ADHD, but little support emerged for the existence of separate *DSM-IV* subtypes. Importantly, symptom ratings supported the existence of two broad symptom domains consistent with those delineated in *DSM-IV*. Moreover, principal components analysis of neuropsychological data identified three dimensions of neurocognitive executive functioning (EF; verbal working memory; sustained *intention*; and effortful learning) in which ADHD adults (n=35) performed

significantly less well than those who received an LD diagnosis (n=24) or no diagnosis (n=21). Furthermore, composite scores in these EF domains generated correct classifications that were significantly better than chance when classifying adults that (a) did and did not meet criteria for ADHD, (b) met criteria for ADHD or LD, and (c) met criteria for ADHD or no clinical diagnosis. Classification results were robust when submitted to a jackknife (leave-one-out) validation procedure. Finally, results provided general support for the developmental lag hypothesis of frontal-subcortical functioning in ADHD when considered vis-à-vis child ADHD data, but findings also supported the notion that ADHD in adults is associated with continuing dysfunction in specific neuroanatomical pathways believed to subservise executive attentional functions (e.g., dorsolateral prefrontal-subcortical; anterior cingulate-subcortical; orbitofrontal-subcortical).

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INTRODUCTION

With the emergence of the empirically-based ADHD taxonomy in the *Diagnostic and statistical manual of mental disorders, fourth edition (DSM-IV*; American Psychiatric Association, 1994), the debate over a proper definition of ADHD in children became less intense than it had been for nearly 30 years (see Appendix A, p. 158, for review). However, ongoing controversies regarding the clinical and nosological status of the disorder in adults raised new research priorities. For example, although clinical observation suggests that adults exhibit inattention, hyperactivity, and impulsivity differently than children, it is unclear precisely how adult expressions differ. Moreover, firm symptom criteria validated by data from adult samples have not been developed, and criteria identified through child research “are at best working hypotheses” for ADHD in adults (Conners, Erhardt, & Sparrow, 1999b, p. x). Therefore, of highest priority is the need for studies examining whether the *DSM-IV* ADHD symptom dimensions identified in research with children are valid for adults.

In addition, many clinic-referred adults complain of problems with attention and exhibit symptoms and secondary problems similar to those seen in ADHD. For example, patients with learning, mood, and cognitive disorders are often inattentive, patients with antisocial and borderline personality disorders are frequently impulsive, and patients with mood, neurobehavioral, and substance use disorders, can be restless. Moreover, many adult patients exhibit neurocognitive deficits (e.g., low cognitive arousal, poor cognitive flexibility, inadequate motor inhibition, impaired working memory) and other secondary problems (e.g., learning difficulties, psychiatric comorbidity, low self-concept) similar to

those found in studies with ADHD children. However, data are mixed regarding the profile of neurocognitive deficits involved in adult expressions of ADHD. Moreover, it is unknown whether patterns of neurocognitive performance deficits that are “unique” to ADHD among clinic-referred groups of adults with other neurobehavioral disorders (e.g., learning disabilities, LD) can be identified. Therefore, it is important to further evaluate the discriminant validity of ADHD in adults by examining the degree to which differences in symptom expression, neurocognitive functioning, and secondary functional impairments (a) differentiate clinic-referred adults who do and do not meet ADHD criteria and (b) distinguish patients who exhibit separate subtypes of the disorder under *DSM-IV*.

The current study contributes to ongoing efforts to bring clarity to these issues by building on research with children that ultimately led to the current diagnostic criteria for ADHD and by extending research findings on cognitive functioning in adult patients with the disorder. This research and related advances in theories of ADHD are summarized below. The summary reveals basic research questions that should be examined in adult samples to (a) promote development of an empirically-based definition of adult attention disorders, (b) more firmly establish the discriminant validity of adult variants of the disorder, (c) further examine the nature and severity of the cognitive deficits experienced by ADHD adults, and (d) help clarify the diagnostic utility of neuropsychological measures of executive functioning among clinic-referred adults.

Identification of Empirically-Derived *DSM-IV* Dimensions and Types of ADHD

The shift to a unidimensional conceptualization of ADHD under *DSM-III-R* added considerable fuel to the long-standing debate concerning the classification status of ADHD. Subsequently, much new research examining the nature and number of the symptom

dimensions and subtypes among children was initiated. The research that followed with children may be organized around several questions it was conducted to address, including: 1) How many symptom dimensions exist in ADHD?; 2) How many subtypes of the disorder can be identified?; 3) Are inattention, hyperactivity, and impulsivity specific to ADHD?; 4) Do purported subtypes of ADHD show differential functional impairments?; and 5) What cognitive deficits characterize ADHD, and how are they related to key symptom dimensions of the disorder?

How Many Symptom Dimensions Exist in Childhood ADHD?

Empirical studies investigating the dimensional structure of symptoms of ADHD in children often relied on factor analyses of parent and/or teacher rating scale data (e.g., August & Garfinkel, 1993; Bauermeister, Alegria, Bird, & Rubio-Stipec, 1992; Carlson, Lahey, Frame, Walker, & Hynd, 1987; Carlson & Lahey, 1983; Conners, 1969; DuPaul, Anastopoulos, Power, Reid, Ikeda, & McGoey, 1997; Frick, Applegate, Kerdyck, Ollendick, Hynd, Garfinkel, et al., 1994; Halperin, Matier, Bedi, & Sharma, 1992; Healey, Newcorn, Halperin, & Wolf, 1993; Lahey, Stempniak, Robinson, & Tyroler, 1978; Lahey, Pelham, Schaughency, Atkins, Murphy, Hynd, et al., 1988; Lahey & Carlson, 1991; Lahey, Carlson, & Frick, 1994b; McBurnett, Pfiffner, Willcutt, Tamm, Lerner, Ottolini, et al., 1999; Neeper & Lahey, 1986; Quay, 1986; Robins, 1992). A small number of these factor analytic studies of parent and teacher ratings generated evidence that supported a unidimensional definition of the disorder (e.g., Robins, 1992). However, the overwhelming majority of early and recent factor analytic studies of such rating scale data showed that items describing symptoms of inattention and those reflecting motor hyperactivity loaded on separate factors, while items related to impulsivity loaded on hyperactive factors in some studies (e.g., Lahey

et al., 1978; Lahey et al., 1988; Neeper & Lahey, 1986; Quay, 1986), but split their variance across inattentive and hyperactive factors in others (e.g., Carlson et al., 1987; Carlson & Lahey, 1983; Conners, 1969; Conners, 1970; Conners, 1986). Therefore, factor analyses of parent and teacher rating scale data suggested that symptoms of ADHD in children occurred along two primary dimensions (inattention and hyperactivity) and that the relation of these broad dimensions to impulsivity in children was unclear.

Moreover, reviews of the literature examining factor analytic studies of ADHD were conducted (i.e., Lahey, Applegate, McBurnett, Biederman, Greenhill, & Hynd, et al., 1994a; McBurnett, 1994). These reviews revealed the factor analysis literature consistently showed two dimensions were needed to account for the covariation of ADHD symptoms: 1) inattention; and 2) hyperactivity-impulsivity (as was consistent with Bauermeister et al., 1992; Lahey et al., 1994b; and Lahey et al., 1988). In addition, data from the *DSM-IV* field trials for the disruptive and attention deficit disorders were both factor analyzed and evaluated to determine the diagnostic utility of each symptom proposed for the *DSM-IV* definition of the disorder (Frick et al., 1994). Again, data supported the notion that symptoms exhibited by children and adolescents with ADHD form two separate dimensions: inattention and hyperactivity-impulsivity (Frick et al.; Lahey et al., 1994b). Therefore, neither the one-dimensional conceptualization of *DSM-III-R*, nor the three-dimensional approach of *DSM-III*, was supported by the data, and a new, two-dimensional definition of the disorder appeared appropriate for the *DSM-IV* typology of ADHD.¹

¹ Although *DSM-IV* makes provision for three separate diagnoses for ADHD, these diagnoses are based on problems that occur on a maximum of two symptom dimensions with problems occurring on the inattentive dimension (ADHD-I), the hyperactive/impulsive dimension (ADHD-HI), or both (ADHD-C).

As Lahey et al. (1994b) also note, four types of corollary evidence emerged from the literature reviews conducted for the upcoming *DSM-IV* (Lahey et al.; McBurnett, 1994) that tended to substantiate this bidimensional conceptualization of the disorder. First, these two separate dimensions (inattention and hyperactivity-impulsivity) may progress on distinct developmental trajectories, with symptoms of hyperactivity-impulsivity decreasing substantially with age and symptoms of inattention remaining consistent over time (Lahey et al.). Second, hyperactivity-impulsivity was more strongly associated with conduct disturbance (Lahey, Schaughency, Hynd, Carlson, & Nieves, 1987), and some studies suggested that when occurring apart from hyperactivity, the inattentive dimension showed stronger association with internalizing disorders, slower cognitive tempo, and social withdrawal (Goodyear & Hynd, 1992), as well learning problems (Faraone, Biederman, Weber, & Russell, 1998). Third, these dimensions may differ in terms of sex ratios, comorbid psychiatric diagnoses, and response to medication treatment (Lahey et al., 1994a). Fourth, Goodyear and Hynd (1992) noted that these symptom dimensions appear distinct in that they are associated with different forms of secondary functional impairment. Specifically, in their detailed review of literature addressing differences between *DSM-III* diagnoses of ADD-H and ADD-W/O, Goodyear and Hynd reported that children with poor attentional functioning but not hyperactivity (ADD-W/O) showed “deficits...similar to children with learning disabilities” while children with hyperactivity and inattention (ADD-H) did not (p. 273). However, no studies with adult samples contributed to the controversy and debate after *DSM-III-R* that ultimately led to the two-dimensional definition of ADHD under *DSM-IV*. Moreover, it is unknown whether adults with learning disability diagnoses show deficits similar to adults with the inattentive type of ADHD under *DSM-IV*.

How Many Subtypes Exist Among ADHD Children?

As various definitions of ADHD emerged with successive publications of *DSM-II* through *DSM-III-R*, some researchers investigating the dimensional symptom structure of ADHD also attempted to clarify how many distinct subtypes of children with the disorder could be identified. In one important study, investigators utilized data analysis strategies that combined factor analysis of clinician ratings with cluster analytic techniques (Lahey et al., 1988). Specifically, Lahey et al. factor analyzed clinician ratings of *DSM-III* and *DSM-III-R* symptoms of ADHD (20 separate symptoms) from a clinic-referred sample of children. The separate factors that emerged from this exploratory factor analysis were then submitted to Ward's cluster analysis to determine whether empirically-derived groups of participant clusters could be identified that closely-matched the *DSM-III* subtypes of the disorder (i.e., ADD-H and ADD-W/O). Lahey et al. argued that if this finding emerged, it would support the validity of the monothetic, three-dimensional definition of the disorder under *DSM-III*. The cluster analysis was also performed to determine the extent to which the empirically-derived clusters of children matched diagnoses the children actually received as part of their clinical assessment. Lahey et al. used a chi-square contingency table to examine correspondence between clinical diagnoses and empirically-derived clusters. Three factors emerged from the exploratory factor analysis of the 20 *DSM-III* / *DSM-III-R* symptoms of the disorder, including a hyperactivity-impulsivity factor, an inattention-disorganization factor, and a sluggish tempo factor (Lahey et al.). The sluggish tempo factor included items descriptive of drowsiness, sluggishness, and difficulties in "remembering and utilizing information," such as problems with "forgetfulness and following instructions" (Lahey et al., p. 334). Moreover, the findings from the cluster analysis conducted provided strong

support for the factor solution of the 20 clinician-rated items that emerged in that the clusters showed close correspondence to child participant's clinical diagnoses of ADHD. Indeed, ninety percent of children with clinical diagnoses of ADHD fell into one of the clusters that resembled one of the *DSM-III* subtypes of ADHD. Moreover, the findings of Lahey et al. strongly suggested that the distinction between a subtype of the disorder primarily characterized by problems with hyperactivity and a subtype characterized by problems with inattention was valid.

DSM-IV Definition of ADHD

The literature reviewed above, including the *DSM-IV* field trial data, strongly supported the two-dimensional conceptualization of the disorder as expressed in children. Therefore, when the *DSM-IV* was published in 1994, the diagnostic category was again named "Attention-Deficit/Hyperactivity Disorder" (ADHD) and was modified to reflect two primary, but fundamentally distinct, sets of symptoms: 1) behaviors reflecting difficulty with poor attentional functioning (nine symptoms); and 2) behaviors reflecting difficulty with hyperactivity (six symptoms) *and* impulsivity (three symptoms). The former set included nine behaviors/symptoms that characterize the subcategory ADHD–Predominately Inattentive Subtype (ADHD–I), and six of nine symptoms of inattention must be present for an individual to reach full diagnostic threshold (*DSM-IV*). The second set of symptoms included nine behaviors that characterize the subcategory of ADHD–Predominately Hyperactive/Impulsive Subtype (ADHD–HI), and again, six of nine symptoms of hyperactivity/impulsivity must be present for one to meet full criteria for diagnosis. Individuals who reach diagnostic threshold for both ADHD–I and ADHD–HI are classified in the subcategory ADHD–Combined Type (ADHD–C).

As noted in McBurnett et al. (1999), comparisons may be drawn between the *DSM-IV* subtypes of ADHD and the diagnoses ADD-H and ADD-W/O under *DSM-III*. These investigators suggested *DSM-IV* ADHD-I resembles *DSM-III* ADD-W/O, and they indicated *DSM-IV* ADHD-C resembles both *DSM-III* ADD-H and *DSM-III-R* AD-HD (McBurnett et al.). Importantly, these investigators also asserted that ADHD-HI was not well supported in the literature, and perhaps, should have been excluded from the official definition of the ADHD classification prior to publication of *DSM-IV*. Specifically, they noted the diagnosis ADHD-HI was inconsistent with the long-held notion that hyperactivity rarely, if ever, occurred in the absence of inattention, as was first asserted by Virginia Douglas (1972) over 20 years earlier. In contrast, since the mid-1970's, many clinicians and researchers have believed that an inattentive syndrome may occur apart from hyperactivity — a belief fully consistent with the *DSM-III* definition of the disorder. Nonetheless, the *DSM-IV* Task Force for the Disruptive Behavior Disorders adopted the guiding principle that any changes to the *DSM-III-R* definition would be guided by empirical data (Frances, Widiger, & Pinchus, 1989; McBurnett, 1996; Widiger, Frances, Pincus, & Davis, 1991). Subsequently, all modifications to the unidimensional definition under *DSM-III-R* received some support from results of literature reviews (Biederman, Faraone, Weber, Russell, Rater, & Park, 1997; McBurnett, Lahey, & Pfiffner, 1993) and field studies evaluating their potential clinical utility and validity (Frick et al., 1994; Lahey et al., 1994a; Lahey et al., 1994b; McBurnett et al., 1993; and Waldman, Lilienfeld, & Lahey, 1995).

The principle that nosological definitions of ADHD must be supported by empirical data should be applied to conceptualizations of the disorder in adults as well as children. However, as noted above, few studies (e.g., Conners, Erhardt, Epstein, Parker, Sitarenios, &

Sparrow, 1999a; see below) that lend empirical support to the validity of the *DSM-IV* two-dimensional structure of the disorder in adults have been conducted. Moreover, no data from studies with adults with ADHD guided the *DSM-IV* Task Force in delineating appropriate criteria for the disorder. Therefore, the two-dimensional typology under *DSM-IV* developed on the basis of careful empirical study of children with the disorder can, at best, be considered a working hypothesis for the disorder as expressed at adult developmental intervals.

However, one recent study that addressed these issues was involved in the development of the *Conners Adult ADHD Rating Scales* (CAARS; Conners et al., 1999a). In this study, an initial pool of 93 items covering nine hypothesized domains of symptom impairment in adult expressions of ADHD were administered to a normative sample of 839 adults (444 males; 394 females; one of unknown gender) and a clinical sample of 167 adults. Ratings from these samples were submitted to exploratory and confirmatory factor analyses. The final factor solution accounted for 46.8 percent of the variance in scores on the 42 items retained and involved an Inattention/Memory Problems factor, a Hyperactivity/Restlessness factor, an Impulsivity/Emotional Lability factor, and a Problems with Self-Concept factor. The first two of these factors accounted for nearly 84 percent of the *explained* variance in scores and tapped inattention/memory problems (68 percent) and hyperactivity/restlessness (15 percent) symptom dimensions. The third factor tapped a separate dimension involving problems with impulsivity and poor emotional regulation, accounting for approximately nine percent of explained variance, whereas the fourth factor tapped a low self-concept dimension and accounted for almost four percent of explained variance.

Therefore, in the only published, large-scale study in which dimensions of symptom impairment potentially involved in adult expressions of ADHD were empirically examined, items reflecting problems with memory (i.e., learning more slowly; forgetting to complete tasks), and those concerning difficulties with attention and concentration, were highly correlated with a common symptom dimension (Conners et al., 1999b). Moreover, in contrast to predictions based on child data, items reflecting problems with hyperactivity and impulsivity loaded on separate factors (Conners et al.). These findings suggest that memory dysfunction may represent a feature of ADHD in adults that is inextricably linked to attention dysfunction. In addition, the findings indicated that restlessness and impulsivity may form separate symptom dimensions in adults. Thus, adult expressions of ADHD, and related attention problems, may differ from their manifestations in childhood. These issues need clarification in clinical research with adults.

Are ADHD Symptoms and Secondary Deficits Specific to ADHD?

One group of investigators conducted a series of studies that not only contributed to efforts to clarify the nature and interplay of key ADHD symptom dimensions among children, but also tested the *specificity* of these symptom dimensions to the *diagnosis* of ADHD in clinic-referred groups of ADHD and non-ADHD, as well as non-clinical control, children (Halperin et al., 1992; Halperin, Newcorn, Matier, Sharma, 1993a). In the first of these studies, as predicted, measures of motor activity (actigraph) and behavioral inhibition (CPT) showed ADHD children were significantly more active and impulsive than either psychiatric or non-clinical control groups (Halperin et al., 1992). However, although ADHD patients were significantly less attentive than non-clinical control children, they were indistinguishable from psychiatric controls on a measure of inattention (CPT). Moreover,

these laboratory findings were consistent with data from teacher ratings showing that although ADHD and non-ADHD clinical groups were similarly inattentive, ratings of hyperactivity were significantly higher for ADHD children than clinical or non-clinical control children (Halperin et al., 1992).

In the second of these studies, clinical groups of children with pure (non-comorbid) ADHD (n = 13), a pure anxiety disorder (n = 20), or another (non-ADHD) disruptive behavior disorder (n = 15), all performed significantly less well than a group of non-clinical control children (n = 18) on measures of cognitive and academic functioning (Halperin et al., 1993). However, although the ADHD group performed significantly less well than the other clinical groups and non-clinical children on laboratory measures of inattention and impulse control (Continuous Performance Test; CPT), the ADHD children were distinguishable from non-clinical controls, but not the other patient groups, on objective measures of activity level (actigraph; Halperin et al.).

Interestingly, although objective measures of motor activity were “best able to discriminate ADHD children from both psychiatric and normal controls” in the first study (Halperin et al., 1992), such measures were not able to discriminate ADHD and other clinical groups of children in the second study (Halperin et al., 1993a). Indeed, in the second study, measures of inattention and impulsivity best discriminated ADHD children from the other patient groups and non-clinical controls. It is important to note that in the first of these studies, diagnostic groups were comprised of children with multiple diagnoses across the different classes of the disorders included (i.e., ADHD patients; non-ADHD patients; and non-clinical controls). For example, 20 of 31 ADHD children had another disruptive disorder and nine met criteria for an anxiety disorder. Moreover, among 53 non-

ADHD children, 19 had a disruptive disorder, 15 had an anxiety diagnosis, and seven had an affective disorder (Halperin et al., 1992). Thus, there was significant overlap among the two patient groups in the first study. Nonetheless, despite this high degree of heterogeneity in the clinical groups, objective measures of activity level successfully discriminated children whose primary diagnoses were or were not ADHD while an objective measure of inattention did not (Halperin et al., 1992). Thus, when a high degree of psychiatric comorbidity obtained (as is often the case among clinic-referred children), inattention was not specific to ADHD. However, when “purer” groups were examined in another sample (albeit a sample that partially overlapped with the first sample), inattention was specific to ADHD children, but hyperactivity (when objectively measured) was not (Halperin et al., 1993a). Overall, the degree to which differences in the samples, potential unreliability of the measures, or the relatively small sizes of the groups (Halperin et al., 1992; Halperin et al., 1993a) contributed to these inconsistencies in findings is unclear.

Nonetheless, findings from these studies highlight potentially serious problems in accurately distinguishing adults with and without ADHD in clinical settings. Indeed, symptoms of inattention are known to occur independent of ADHD in clinic-referred samples of adults as part of other *DSM-IV* psychiatric conditions (e.g., Generalized Anxiety Disorder, “difficulty concentrating or mind going blank,” p. 436; Dysthymic Disorder, “poor concentration or difficulty making decisions” p. 349; and several proposed diagnostic categories needing further research). Given that attention problems occur in a variety of adult psychiatric disorders, adults presenting for assessment and treatment of attentional difficulties are, like children, potentially “at risk for being mislabeled ADHD, simply

because the ADHD diagnosis carries the name of the symptom domain” (Halperin et al., 1992, p. 194).

Moreover, clinical difficulties in discriminating ADHD and non-ADHD adults may extend to other ADHD symptom dimensions. For example, varieties of motor restlessness similar to those expected in adults with ADHD are found in diagnostic criteria for anxiety and depressive disorders, substance use disorders, and several cognitive disorders in *DSM-IV* (e.g., Major Depressive Episode, "psychomotor agitation...almost every day," p. 327). In addition, impulsivity may be a key component of some personality disorders under *DSM-IV* (e.g., Borderline Personality Disorder, "impulsivity...that is potentially self-damaging," p. 654; and Antisocial Personality Disorder, "impulsivity or failure to plan ahead," p. 650). Therefore, research examining whether ADHD and non-ADHD clinic-referred adults show differential ratings on the empirically derived dimensions from the CAARS scales (Conners et al., 1999b) will help clarify these concerns. Moreover, studies examining whether such adults show differential impairment on measures of secondary deficits may identify variables on which adults presenting with attentional complaints who do and do not meet criteria for ADHD, or other disorders, may be discriminated.

What Symptoms and Secondary Impairments Characterize ADHD in Adults?

Where research examining specificity of core symptom dimensions in adults is concerned, although one study has empirically examined potential symptom dimensions involved in adult attention problems (Conners et al., 1999b; reviewed above), no known study has evaluated the specificity of ADHD symptoms to those meeting criteria for the disorder among clinic-referred adults. However, studies examining potential deficits in neuropsychological functioning that characterize adult variants of ADHD have emerged

with increasing frequency in the last 10 – 15 years. Several of the relatively small number of published studies compared ADHD and non-clinical adults on measures believed sensitive to deficits in neurocognitive executive functioning. Very few of these studies used, or included, clinical control groups in comparisons on such measures. As indicated in the review below, overall findings from studies using both types of control groups are mixed. However, as is consistent with child ADHD research (see Barkley, 1997a, for an extensive review), findings from adult ADHD samples implicate dysfunction in the frontal-subcortical circuits (Voeller, 2001) believed to subserve executive, higher-order neurocognitive functioning. In the review of the adult ADHD research that follows, findings are organized according to the domains of neurocognitive functioning purportedly evaluated by the measures employed.

Verbal Learning and Memory

Assessment of verbal learning and memory involves tasks measuring one's capacity to encode, learn, and retrieve novel verbal information. Among studies comparing verbal memory functioning in ADHD and non-clinical control groups of adults, several reported that patients showed significantly weaker performance in immediate recall on list learning tasks (Downey, Stelson, Pomerleau, & Giordani, 1997; Holdnack, Moberg, Arnold, & Gur, 1995; Mungas, 1983; Rugle & Melamed, 1993; Seidman, Biederman, Weber, Hatch, & Faraone, 1998) while only one did not (Lovejoy, Ball, Keats, Stets, Spain, Janda, et al., 1999). Of only two studies that examined immediate recall on a list learning task and utilized a clinical control group, one reported that adults with childhood histories of ADD showed significant deficits relative to other clinic-referred adults with attentional complaints who did not meet criteria for childhood ADD (Jenkins, Cohen, Malloy, Salloway, Johnson,

Penn, et al., 1998). However, in a second study that compared ADHD adults with groups of psychiatric control adults in verbal list learning, ADHD patients performed better than amnesic patients, but comparably with those with a variety of other psychiatric diagnoses, including depressive and anxiety disorders (Mungas, 1983). Of only two recent studies that compared adults with ADHD and non-clinical controls in memory for short stories, one reported significantly weaker performance in ADHD adults (Johnson, Epstein, Waid, Latham, Voronin, & Anton, 2001), while the other study reported comparable levels of performance across groups (Gansler, Fucetola, Kregel, Stetson, Reid, Ikeda, et al., 1998), in immediate and delayed recall.

In the Holdnack et al. (1995) study, the investigators performed extensive exploratory analyses to evaluate the nature of the verbal memory deficits exhibited by ADHD adults. Interestingly, ADHD adults received significantly lower semantic and serial clustering scores on the CVLT, indicating that as a group, they did not benefit from the memory strategies that often appear to help healthy adults recall more information. However, these investigators note that rather than not using semantic clustering at all, ADHD adults exhibited inconsistent use of a semantic clustering strategy, and thus, derived only limited benefit from this strategy across trials. It is also interesting to note that ADHD and non-clinical adults did not differ in terms of retention effects, indicating that despite initial difficulties in either encoding or immediate retrieval, ADHD adults had little difficulty retaining, and later retrieving, verbal information once it was acquired. Further follow-up analyses revealed that ADHD adults showed a clear pattern of poorer performance on the first list learning task on the CVLT but better performance on the second such task (interference task). Holdnack et al. note that this pattern is unusual, for the two

tasks are essentially the same, and typically, adults build-up some semantically-related interference from the first list learning task which is exhibited when performing the second task (i.e., the interference task). ADHD adults showed no semantically-related interference, perhaps because they inconsistently applied a semantic clustering strategy, or perhaps because the novelty of the task was eliminated by the time the interference task was administered (Holdnack et al.).

Verbal Working Memory

Verbal working memory involves a memory system that allows one to keep verbal information cognitively active in order to operate on it, or to hold information in mind while performing some manipulation on that information (Smith, 2000). Among studies evaluating verbal working memory functioning in adults with an ADHD diagnosis, some studies found deficits when patients were compared to non-clinical controls (Arcia & Gualtieri, 1994; Lovejoy et al., 1999; Walker, Shores, Trollor, Lee, & Sachdev, 2000), while only one study reported no evidence of such impairment (Seidman et al., 1998). However, two studies that used clinical control groups found some evidence of impaired verbal working memory in ADHD adults relative to controls (Jenkins et al., 1998; Walker et al., 2000), but results appeared to depend on the specific tasks used to assess this construct. Specifically, when the four, increasingly demanding trials of the Paced Auditory Serial Attention Test (PASAT; Gronwall, 1977) were used, adults with ADHD performed significantly less well than clinical controls (i.e., adults presenting with attentional complaints but without childhood ADD) only in the most difficult condition (i.e., the 1.2 second inter-stimulus interval trial; Jenkins et al, 1998). Moreover, adults with childhood ADHD also performed significantly less well than controls on total number of correct

responses on the PASAT but obtained scores similar to clinic-referred control adults on a digits backward task (Jenkins et al.). In this study, whether ADHD adults exhibited significantly weaker performance appeared related to level of task difficulty, or degree of cognitive effort required to perform the task. In another study that used both clinical (adults with “mild psychiatric disorders”) and non-clinical control groups, ADHD adults exhibited significantly weaker performance relative to healthy adults, but similar levels of performance in comparison to psychiatric controls, on a digits backward task (Walker et al., 2000). However, on arithmetic and digits forward tasks, none of the groups differed significantly (Walker et al.).

Verbal Fluency

Among studies evaluating verbal fluency in adults with an ADHD diagnosis, two studies using non-clinical control adults reported significantly poorer performance among those with ADHD (Lovejoy et al., 1999; Walker et al., 2000), while two studies found no such impairment (Holdnack et al., 1995; Johnson et al., 2001). Moreover, the only two studies that evaluated verbal fluency in adult ADHD that utilized clinical control groups split their results, with one study reporting significant differences between adults with childhood ADD and patients without childhood ADD (Jenkins et al., 1998), and one study reporting that ADHD adults and those with mild psychiatric disorders performed similarly (Walker et al., 2000). This latter study also compared groups of ADHD, and clinical and non-clinical controls, on facility in category naming. Interestingly, results indicated that ADHD adults performed significantly less well than healthy adults but were similar in performance to clinical control adults (Walker et al.).

Visual Learning and Memory

Interestingly, research with ADHD adults has, on balance, found little evidence of deficits in short-term recall of visual information (Johnson et al., 2001; Riordan, Flashman, Saykin, Frutiger, Carroll, & Huey, 1999; Seidman et al., 1998). However, one study found that ADHD adults performed better than adults with mild closed head injury, but significantly less well than non-clinical control adults, on a pattern memory task (Arcia & Gualtieri, 1994). Moreover, one very recent study reported significant differences between ADHD adults and non-clinical controls on a measure of delayed visual reproduction (Johnson et al., 2001). Nonetheless, given the general lack of support in the adult ADHD literature, thus far, for this finding, the authors of the latter study appropriately questioned the generalizability of the finding (Johnson et al.).

Simple Psychomotor Processing Speed

Simple psychomotor speed involves timed performance on visuomotor tasks that do not place heavy demands on working memory resources. The primary measure used to assess this construct in studies with ADHD adults is Trails A from the Trail Making Test (Spreeen & Straus, 1998). Some neuropsychological studies reported significant differences between ADHD and non-clinical groups of adults in psychomotor speed (Gansler et al., 1998; Holdnack et al., 1995; Lovejoy et al., 1999), whereas several other studies did not (Arcia & Gualtieri, 1994; Mattes, Boswell, & Oliver, 1984; Johnson et al., 2001; Walker et al., 2000). In the only study that utilized a clinical control group, ADHD and controls showed a non-significant difference in simple psychomotor speed (Walker et al., 2000).

Complex (Effortful) Psychomotor Processing Speed

Measures assessing this construct require fast processing and responding and involve an element of cognitive flexibility, working memory, or sustained responding during boring task conditions. The primary measures used to assess this construct in studies with ADHD adults are reaction time (RT) indices on continuous performance tests (CPTs), cancellation tasks, or Trails B. Other measures utilized include Luria's complex motor sequences task (Luria, 1966) and the Coding subtest from the WAIS-R. Numerous studies have evaluated effortful psychomotor processing speed in adults with ADHD, and again here, the findings show notably mixed results. Some neuropsychological studies reported significant differences between ADHD and non-clinical groups of adults in effortful psychomotor speed (Lovejoy et al., 1999; Johnson et al., 2001; Riordan et al., 1999; Walker et al., 2000), whereas several studies did not (Arcia & Gualtieri, 1994; Gansler et al., 1998; Holdnack et al., 1995; Johnson et al., 2001; Walker et al., 2000). The Walker et al. study found that ADHD adults performed significantly less well than non-clinical control adults on some measures of complex psychomotor speed (e.g., Coding subtest; WAIS-R) but not others (e.g., mean hit RT; Conners CPT). Importantly, all three of the studies that compared complex psychomotor speed in ADHD and clinical control groups reported non-significant differences (Arcia & Gualtieri, 1994; Jenkins et al., 1998; Walker et al., 2000).

Cognitive Inhibition (Interference Control)

The primary measure used thus far to assess control of cognitive interference, or cognitive inhibition, among adults with ADHD was the Stroop Task (Golden, 1978). When comparing ADHD adults and non-clinical controls, research results, again, are rather inconsistent. Four studies examining this construct reported significant differences between

ADHD adults and controls (Hopkins, Perlman, Hectman, & Weiss, 1979; Lovejoy et al., 1999; Riordan et al., 1999; Walker et al., 2000), whereas three studies found non-significant differences (Gansler et al., 1998; Johnson et al., 2001; Seidman et al., 1998). The only study that utilized a clinical control group found no significant differences between ADHD adults and controls on the word, color, or color-word, conditions of the Stroop Task (Walker et al., 2000).

Response Inhibition/Impulse Control

Several studies with ADHD and non-clinical control adults reported deficits in response inhibition on continuous performance measures among ADHD adults (Gansler et al., 1998; Klee, Garfinkel, and Beauchesne, 1986; Riordan et al., 1999; Walker et al., 2000), while other studies reported no such differences (Holdnack et al., 1995; Seidman et al., 1998; Zametkin, Nordahl, Gross, King, Semple, Rumsey, et al., 1990). Interestingly, the only two studies that used clinical control groups reported non-significant differences between ADHD adults and controls (Downey et al., 1997; Walker et al., 2000). It is important to note that each study reporting non-significant differences between adults with ADHD and non-clinical control adults used a *low target rate* version of the CPT (i.e., either the Gordon Diagnostic System, GDS, Gordon & Mettelman, 1988; or an auditory CPT). As noted by Johnson et al. (2001), CPTs with higher target rates likely promote more commission errors among patients with response inhibition deficits (and thus, may be more construct valid), whereas low target rate CPTs may generate more omission errors.

Sustained Attention

One of the most consistent findings in the adult ADHD neuropsychological literature is that adults with the disorder generate significantly more omission errors, or show more

variable RTs, on measures of continuous performance than non-ADHD adults (Arcia & Gualtieri, 1994; Gansler et al., 1998; Holdnack et al., 1995; Seidman et al., 1998; Walker et al., 2000). Only one study with non-clinical controls generated no evidence of such performance deficits among ADHD adults (Zametkin et al., 1990). In the only study that compared the sustained attentional performance of adults with ADHD and clinical control patients found that the groups were similar in terms of number of omission errors and variability in RT across the test (Walker et al., 2000).

Cognitive Flexibility/Shifting Set “On the Fly”

Measures of cognitive flexibility require examinees to rapidly adjust responding as rules defining what constitutes a correct response change across the course of a task. Traditionally, the Wisconsin Card Sorting Task (WCST; Grant & Berg, 1948) has been used to measure this construct. Importantly, five studies comparing ADHD and control groups of adults on various measures from the WCST, four of which used non-clinical controls (Gansler et al., 1998; Holdnack et al., 1995; Johnson et al., 2001; Seidman et al., 1998), and one of which used clinical controls (Jenkins et al., 1998), found non-significant differences between the ADHD and control groups.

Summary of Neuropsychological Literature on Adult ADHD

Overall, the empirical literature reviewed above indicates that adults with ADHD often show abnormal performance on measures of response inhibition, sustained attention, effortful and simple psychomotor speed, verbal learning, verbal learning and memory, and verbal working memory. However, in each of these domains of neurocognitive functioning, with the exception of the realm of cognitive flexibility, some studies support, and some do not support, the notion that adults with ADHD exhibit deficits relative to non-clinical

control groups of adults. Indeed, several of the studies reviewed above indicated that the degree of impairment in the ADHD group was relatively mild compared to the performance of either non-clinical controls or the expected level of performance relative to normative data published with the neuropsychological instruments (Jenkins et al., 1998; Riordan et al., 1999; Walker et al., 2000). This observation has also been made in studies evaluating psychiatric comorbidity and psychosocial functioning in ADHD adults (e.g., Biederman et al., 1997). Moreover, in all of the studies reviewed above that utilized clinical control groups, ADHD adults performed either slightly below the clinical control group (i.e., except in the cases of amnesic patients [Mungas, 1983] or mild closed head injury patients (Arcia & Gualtieri, 1994)), or on par with the clinical controls, rendering the two groups statistically indistinguishable. This review emphasizes the need to clarify to what degree ADHD adults show deficits in secondary functioning relative to adults without psychiatric disorders, and is the degree of impairment that ADHD adults sufficient to distinguish them from other clinically-referred adults with attentional complaints who do not meet criteria for ADHD ?

Do Subtypes of ADHD Show Differential Functional Impairments?

As noted above, research examining the validity of the *DSM-III* typology of the disorder for children suggested that attention deficits that occurred apart from hyperactive behaviors (ADD-W/O) were often accompanied by secondary cognitive deficits as well as comorbid learning and anxiety disorders (Goodyear & Hynd, 1991; Lahey & Carlson, 1991; Lahey et al., 1987; McBurnett et al., 1999). In contrast, joint presentations of hyperactivity and attention deficits were often accompanied by comorbid oppositional and conduct disorders, as well as secondary deficits in interpersonal and personality functioning (Lahey & Carlson; Lahey et al.; McBurnett et al.). Documentation of subtype specific functional

impairment would support the discriminant validity of the *DSM-IV* symptom typology of ADHD.

Subtype specific secondary impairment may be identified through evaluation strategies that combine neuropsychological, psychoeducational, rating scale, and diagnostic interview measures of functional domains found deficient in some studies of children with ADHD. Secondary impairment may be evident on measures of cognitive ability, academic achievement, verbal memory, working memory, information processing speed, emotional lability, self-concept, and comorbid psychopathology. Moreover, the clinical utility of the *DSM-IV* typology of ADHD for adults would be supported if such data not only discriminated clinic-referred adults with and without ADHD, but also differentiated inattentive and hyperactive variants of the disorder.

Although several studies with children used laboratory-based measures of ADHD symptom domains (i.e., inattention, hyperactivity, and impulsivity) to differentiate diagnostic groups of children (e.g., ADHD, schizophrenic, and non-clinical control children; Halperin et al., 1992; Halperin et al., 1993a), only one study with children has demonstrated the utility of laboratory-based measures of each ADHD symptom domain for identifying *DSM-IV* subgroups of ADHD children (Marks, Himelstein, Newcorn, & Halperin, 1999). Where adults with ADHD are concerned, relatively little data exist to support the validity of the *DSM-IV* symptom typology. Moreover, although several recent studies have revealed differences between ADHD and non-clinical groups of adults, research with clinic-referred samples of adults with ADHD demonstrating that the *DSM-IV* typology is valid and clinically meaningful for adult developmental expressions of the disorder is largely absent.

Recent Theoretical Perspectives on ADHD

As noted in the historical review section above, since the disorder was first identified, researchers have developed hypotheses regarding which symptoms represent the core deficits in ADHD. This section provides an overview of three important conceptual models of ADHD that emerged within the past 15 years, including Barkley's (1997b) theory of ADHD as *behavioral disinhibition*, Mirsky's model of ADHD as a core deficit of *inattention* (Mirsky, 1978, 1987, 1996; Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991), and Denckla's (1991, 1993, 1994, 1996a, 1996b, 1996c) cognitive neuroscience/neuropsychological perspective of ADHD as *executive dysfunction*. These models represent separate attempts to account for the difficulties with inattention, hyperactivity, and impulsivity exhibited by ADHD children (and by extension, adults), yet there are many similarities across these perspectives. As is evident below, each model proposes that specific forms of cognitive impairment are inextricably linked to ADHD behavioral symptom expression.

Barkley: ADHD as Behavioral Disinhibition

Barkley (1997b) recently concluded that, at least among children with the disorder, impulsivity represents the leading deficit in ADHD, with hyperactivity close behind, in terms of impairment generated. He suggested that impulsivity (i.e., behavioral disinhibition) generates serious impairment, because it essentially bypasses the brain's executive inhibitory control processes — processes that allow one to stop, plan, evaluate, and re-evaluate a potential course of action prior to engaging in overt behavior — by denying these processes sufficient time to engage before interfering behaviors are performed (Barkley, 1997a, 1997b). Barkley further contended that this fundamental deficit causes ADHD children to

exhibit diminished sensitivity to the consequences of behavior and compromised ability to acquire rule-governed behavior (i.e., using learned, verbally-mediated rules to guide behavior through self-regulation). Moreover, Barkley posits that this phenomenon not only promotes overt behavioral impulsivity and hyperactivity, but also cognitive impulsivity (i.e., poor governance of thinking processes such as concentration, planning, and sustained attention). However, although Barkley (1997b) argued that cognitively-based symptoms of inattention can be produced by disinhibition, inattention should not be considered a core problem or defining feature of ADHD. Indeed, Barkley (1997a) proposed the *DSM-IV* ADHD—Predominately Inattentive Type may represent a fundamentally distinct syndrome that should not be included with impulsive and hyperactive variants of the disorder.

Nonetheless, Barkley's (1997a) view of ADHD as behavioral disinhibition is largely based on connections he draws between the constructs of attention and executive functioning. Barkley (1996) defines attention as "the relation of behavior to its environment" (p. 307), and he views environment as comprised of internal and external sensory events. Barkley (1996) attempts to clarify this definition of attention by noting attention may be compared to the concept of a statistical correlation. Specifically, he indicates that attention characterizes, or describes, how one set of variables (behaviors) are modified with changes in another set of variables (environments). For Barkley (1996, 1997b), when alterations of behavior occur for reasons that cannot be linked to the immediate environment, but rather, for reasons embedded in a future, anticipated context, attention has entered the realm of executive functioning. Thus, Barkley posits executive functioning is a special case of attention. On this point, he states, "executive behavior ultimately functions to change the likelihood of later events (consequences) happening to the

individual" (Barkley, 1996, p. 312). Given that Barkley's theory of ADHD as behavioral disinhibition is inextricably tied to the notion of executive functioning, a detailed review of his model is not provided here, but the concept of executive functioning, and its complex interconnection with attention, is discussed more extensively in the overview of Denckla's model below.

Mirsky: ADHD as Core Deficit of Inattention

In sharp contrast to Barkley's argument that poor attentional functioning in ADHD is the result of behavioral disinhibition, Mirsky et al., (1991) asserted that specific patterns of deficits in attention functioning can account for all symptoms exhibited by children with various psychiatric disorders, including ADHD. Building on the work of neuropsychologists (e.g., Heilman, Watson, Valenstein, 1993; Mesulam, 1990), cognitive neuroscientists (e.g., Posner, Petersen, Fox, & Raichle, 1988; Posner & Peterson, 1990), and neurophysiologists (e.g. Pribram & McGuinness, 1975), as well as Zubin's (1975) attempt to categorize the attentional dysfunctions in schizophrenic patients, Mirsky et al. (1991) proposed a multi-component, restricted taxonomy of attention functions.

This multi-component view of attention began with Zubin's (1975) proposal that three primary attentional capacities (i.e., the ability to focus/execute, sustain, and shift) governed all important aspects of information processing. *Focus* referred to the ability to channel, or concentrate, attentional resources on a task and filter out distracting stimuli in the surrounding environment, and *execute* referred to the ability to carry out a motor response based on task focus (Zubin, 1975; Mirsky, 1987). Zubin's (1975) attentional construct labeled *sustain*, referred to the capacity to stay mentally engaged in a task for an appropriate interval while governing motor behaviors necessary for successful completion of

the task. The construct *shift* referred to the ability to flexibly alter one's mental and behavioral response set in order to accomplish tasks in an efficient manner (Zubin, 1975; Mirsky et al., 1991). As Mirsky et al. (1991) factor analyzed neuropsychological test data in an attempt to validate these hypothesized dimensions of attentional functioning, the data consistently extracted a fourth attentional dimension seemingly related to the ability to briefly hold information in mind while executing a motor response or performing a mental operation on it. Mirsky et al. (1991) eventually labeled this attention function, *encode*. More recently, Mirsky reported evidence of a fifth factor related to the reliability, or *stability*, of attentional effort across time (Mirsky, 1996; Mirsky, Pascualvaca, Duncan, & French, 1999). Key constructs comprising Mirsky et al.'s (1999) five-factor model of attentional functioning may be summarized in the following way: 1) attention is a multifaceted and complex process that can be divided into several inter-related, but relatively distinct, functions including, "focus/execute, sustain, stabilize, shift, and encode" (p. 77); 2) these attention functions are governed by specific neuroanatomical regions that are organized into an overall system responsible for regulating attention; 3) the neuroanatomical loci comprising the attentional system are dispersed widely in the brain, and thus, are vulnerable to dysfunction since injury to one region may disrupt aspects of functioning in the overall system; 4) although damage in one region involved may lead to "circumscribed or specific deficits in a particular attention function," the organization of the system suggests shared responsibility across regions and implies that specializations in function are "not absolute," and "some structures may substitute for others in the event of an injury" (p. 77); and 5) the brain regions involved in each attention function can be identified through knowledge of which regions are activated by the specific neuropsychological tests

used to identify the dimensions of attentional functioning (see below). Mirsky et al. (1999) hypothesized that the following brain regions are involved in the five attention functions: 1) the ability to *focus* is governed by the structures of the corpus striatum (caudate, putamen, and globus pallidus), as well as the superior and inferior parietal cortices, and the *execution* of appropriate motor responses is regulated by the corpus striatal and inferior parietal regions of the brain; 2) the capacity to *sustain* attentional focus is governed by the rostral structures of the midbrain such as the mesopontine reticular formation and reticular thalamic nuclei; 3) the ability to maintain a stable, or reliable, flow of attentional effort across time, the *stabilize* function (a construct clearly related to the sustain function), is believed dependent on brain stem structures and midline thalamic nuclei; 4) the capacity to efficiently *shift* attentional focus "from one salient aspect of the environment to another" (Mirsky, 1996, p. 77) is governed by the anterior cingulate gyrus and other regions in the prefrontal cortex; and 5) the capacity to accurately *encode* stimuli for processing is regulated by the amygdala and hippocampus.

Mirsky et al.'s (1999) model is intuitively appealing and clinically relevant in that the neuropsychological tests used to identify the model are commonly used in clinical practice. The following measures reflect the attentional functions included in Mirsky et al.'s (1999) model: (a) The *focus/execute* function is measured by tasks that "capture the ability to identify salient task elements and perform motor responses under conditions of distraction," (Mirsky, 1996, p. 81) such as the Digit Symbol Coding Subtest from the WAIS-III (Wechsler, 1997a); (b) The *encode* function is reflected in tasks requiring "sequential registration, recall, and mental manipulation of numeric information" (Mirsky, 1996, p. 82), such as the Digit Span and Arithmetic Subtests from the WAIS-III (Wechsler, 1997a), and

total number of correct responses from the PASAT (Gronwall, 1977; PASAT: User's Guide, 1998); (c) The *shift* function requires the ability to flexibly adapt one's cognitive response set and behavioral strategy as environmental conditions change and is measured by variables such as total number of categories achieved and perseverative errors on the Wisconsin Card Sorting Test (WCST; Grant & Berg, 1948; Heaton, 1993); (d) The *sustain* function requires one to carry out the focus/execute attentional function "for an appreciable interval of time" (Mirsky, 1996, p. 82) and is measured by variables such as total number of hits, number of correct rejections, and parameters assessing vigilance, from Continuous Performance Tests (CPTs; Conners, 1992, 1995); and (e) The *stability* of attentional functioning is reflected in measures sensitive to variations in the sustain function across time, such as variability in hit reaction time across time intervals and conditions of CPTs.

Mirsky et al. (1999) suggested that deficits in attention exhibited by ADHD children result from brain damage or dysfunction in one, or more, brain regions involved in the attentional system outlined above. He noted that the etiology of the suspected damage or dysfunction is likely "as varied and complex as the manifestations of the attention disorders themselves" (Mirsky, 1996, p.78). However, Mirsky indicated that mechanisms responsible for breakdowns in the attentional system may be genetically derived (as in schizophrenia), the result of a metabolic disorder (e.g., phenylketonuria), the sequelae of exposure to environmental toxins (e.g., lead poisoning; maternal smoking during gestation), or the outcome of infectious diseases or malnutrition during critical periods in development. Overall, Mirsky et al.'s (1999) model of ADHD as a core deficit in attentional functioning represents a substantially more refined version of early perspectives on the disorder as brain damage, or dysfunction, reviewed in Appendix A (p. 158).

Support for Mirsky's Model and Relevance for the Current Study

The separate elements of attentional functioning set forth in Mirsky's four factor model were identified by separate principal components analyses in a sample of adult psychiatric outpatients and an epidemiological sample of school children (both presented in Mirsky et al., 1991). The four-factor model (i.e., focus/execute, sustain, encode, shift) was subsequently validated in six separate independent adult and adolescent non-clinical and neuropsychiatric samples (e.g., Kremen, Seidman, Faraone, Pepple, & Tsuang, 1992). The fifth element of attention (stability) was identified in more recent studies (Mirsky, Fantie, & Tatman, 1995a). Importantly, in research highlighting potential clinical applications of the attention model, Mirsky and colleagues found that children with differing forms of psychiatric or neurocognitive disturbance (e.g., epilepsy; Mirsky, 1978) and schizophrenia (Mirsky, Yardley, Jones, Walsh, & Kendler, 1995b) exhibited distinct profiles of attentional deficits.

Indeed, the importance and potential clinical relevance of Mirsky's multifactorial model of attention was further demonstrated in an epidemiological study examining the antecedents of negative classroom behavior (e.g., shyness, poor concentration, aggressiveness) in a stratified sample of 435 seven to nine year old children from East Baltimore (Kellam, Ialongo, Brown, Laudolff, Mirsky, Anthony, et al., 1989). Findings showed that children rated as unusually shy by classroom teachers were also found most likely to receive ratings reflecting poor concentration (Kellam et al., 1989; Kellam, Werthamer-Larsson, Dolan, Brown, Mayer, Rebok, et al., 1991). However, in perhaps the most important finding, teacher-rated children showing poor concentration and aggression and children showing poor concentration and shyness demonstrated distinctive patterns of

impairment in Mirsky's attention model (Kellam et al., 1989). Specifically, children rated by teachers as exhibiting excessive shyness and poor concentration performed significantly less well in the sustained attention dimension as reflected by errors of omission on a CPT. In contrast, while children with poor concentration and aggression also performed significantly less well in the sustained attention dimension, their sustained attention deficit was related to difficulties with behavior inhibition as indicated by errors of commission on a CPT measure (Kellam et al.). Moreover, children with aggressiveness and poor concentration exhibited poor attentional performance on the focus/execute dimension as reflected by significantly poorer performance on the Coding Subtest from the *Wechsler Intelligence Scale for Children, Revised* (WISC-R; Wechsler, 1974).

Although Mirsky's four- and five-factor attention models were not intended to be specific to ADHD, they may represent potentially useful theoretical frameworks for identifying dimensions of neurocognitive functioning on which adults with and without may ADHD differ. Given that Mirsky and colleagues found that children with differing forms of psychiatric or neurocognitive disturbance (e.g., epilepsy; Mirsky, 1978) and schizophrenia (Mirsky et al., 1995b), as well as children with different forms of negative classroom behavior (Kellam et al., 1989), exhibited distinct profiles of attentional deficits, the approach may provide a useful method for distinguishing different forms of neurocognitive deficits in executive functioning exhibited by adults with and without ADHD, as well as across the subtypes of *DSM-IV* ADHD. Mirsky's division of the frequently poorly operationalized construct of attention into distinct elements that can be assayed by specific measures provides a potentially useful approach for clarifying long-standing questions regarding the specific forms of attentional and cognitive deficits the underlie ADHD in children and

adults. Specifically, differential patterns of neurocognitive impairment across groups on factors derived from an adult sample presenting with attentional complaints would support the discriminant validity of ADHD as currently defined under *DSM-IV*.

Denckla: ADHD as Executive Dysfunction

Denckla (1991, 1993, 1994, 1996a, 1996b, 1996c) proposed that the neuropsychological construct, executive function, could explain many of the cognitive, attentional, and motor impulse problems exhibited by children and adults with ADHD. Her model of ADHD as a problem of executive functioning emerges, in part, from her belief that the *DSM-IV* definition of the disorder is flawed on several counts. Specifically, Denckla's (1996b) theoretical paper highlights flaws that she believes become evident when the disorder is considered from the perspective of cognitive neuroscience. First, she agrees with Shaywitz, Fletcher, and Shaywitz (1995) that considerable confusion is engendered by the way *DSM-IV* appears to define the term "attention" (Denckla, 1996b, p. 115). Specifically, even under the *DSM-IV* Inattentive Type of ADHD, the symptom definitions are overly focused on "observations of what is done" rather than "the simple appearance of paying attention" (p. 115). Denckla emphasizes that attention is a cognitive phenomenon, and as such, is best reflected in measures tapping the cognitive aspects of the construct (described below), and not by "naturally observed behaviors [that] do not bear any strong relationship to laboratory measures or clinical tests constructed to assess some aspect of attention as a cognitive domain" (p. 115). Second, she asserts that developers of the current definition of ADHD relied too heavily on ratings of outward behaviors as perceived by parents and teachers. Such reporters necessarily make broad assumptions about what is the focus of one's attention from observations of overt behaviors, but as she states, "although it is usually

safe to assume that where the eyes focus, the attention is focused or that adventitious physical activity precludes required mental activity, such is not always the case" (Denckla, 1996a, p. 115). Finally, she criticizes the current conceptualization of the disorder for being vague about which aspects of the multifactorial construct of attention are impaired or intact in specific individuals with ADHD. Denckla (1996a) proposes that the construct executive functioning provides a means to better address the question, "what variety of attention, in the sense used by cognitive neuroscientists, is impaired in the clinical entity of ADHD" (p. 114).

Definition and Key Aspects of Executive Functioning

The construct executive functioning refers to (a) The capacity to simultaneously attend to one or more important aspects of a situation that are related to some goal while intentionally not attending to the multiplicity of other components of a situation unrelated to that goal; (b) The ability to inhibit behavioral responses inconsistent with the accomplishment of that goal; (c) The capacity to place oneself in a hypothetical future in which one executes steps necessary for the overall accomplishment of a goal (i.e., planning); and (d) the ability to access previously learned information to guide actions and adjust strategies over time while performing goal directed behaviors despite difficulties/distractions that arise (Denckla, 1996a). Therefore, like attention, executive functioning is a multifaceted construct. At a minimum, it involves intention, working memory, inhibition, self-monitoring, and planning (Denckla, 1994, 1996a, 1996b).

Intention. This construct refers to "anticipatory, goal-oriented preparedness to act" (Denckla, 1994, p. 117). Neuropsychologists assert that intention involves initiation and maintenance of movement, inhibition of unrelated, unnecessary movements, and flexibility in shifting from one movement to another, as situational demands require in working toward

a desired goal (Heilman et al., 1993). Neuroanatomically, intention is believed intimately tied to redundant dopaminergic pathways between basal ganglia circuits and the motor control regions of the prefrontal cortex (Heilman et al.; Petrides, 1994). Moreover, Denckla (1996a) notes that since the prefrontal cortex has rich interconnections with limbic system structures (emotion control centers), parietal association areas (visual processing regions), and basal ganglia (motor programming circuits), it is "well positioned to control when responses occur to attended and motivationally significant sensory stimuli" (p. 116).

Role of working memory. Most neuropsychologists and cognitive neuroscientists agree that working memory is a critical component of both attention and executive functioning (Baddeley, 1993; Denckla, 1996b; Kimberg, D'Esposito, & Farah, 1998; Pennington, 1996). Moreover, although subtle variations in definitions of working memory are evident across research laboratories, all schools of thought construe working memory as a highly evolved neurocognitive capacity that holds important information at the fore of conscious thought despite the passage of time and the presence of distracters in service of a desired outcome. In addition, there is general agreement that working memory is distinct from all other forms of memory in that it is highly transient (e.g., two-three seconds duration; Goldman-Rakic, 1995a, 1995b), situation specific, and subject to active cognitive manipulation (e.g., when performing mental arithmetic; Logie, Gilhooly, & Wynn, 1994).

The distinction between working memory and longer-term forms of storage is somewhat analogous to the difference between random access memory (RAM) and hard-drive memory on a computer (Denckla, 1996b). It is this distinction that characterizes Denckla's (1996a) perspective on the role of working memory in executive functioning, for in her model, a critical feature of executive functioning is "on-line" response preparation (p.

116). Here, working memory holds information gathered from long-term memory, stores data regarding stimulus features of the current environment, and recalls goals the organism seeks here-and-now and in the longer-term future. Moreover, it is perhaps most important to note, working memory provides a forum in consciousness in which *executive processes* can integrate data from these various sources, make cognitive interpretations, filter out extraneous stimuli, execute goal-directed motor responses, and at every step, perform *live* re-evaluations of the entire process. As Denckla (1996a) states it, working memory is the process that provides the capacity to "behave on the basis of represented knowledge rather than immediately presented information/knowledge" (p. 116).

Additional concepts related to executive functioning. Denckla (1996a) simplifies the construct of executive functioning by emphasizing that at its core, it is a control process that involves *inhibition*, or delayed responding. She states, "in the simplest of visual-motor tasks, the delay implicit in the dash is a property of executive functioning" (Denckla, 1996b, p. 265). Denckla (1996b) further indicates that among other capacities inextricably linked to executive functioning is the ability to not only form an anticipatory set (noted above as part of intention), but the ability to *sustain* a behavioral set across time until a goal has been accomplished. Moreover, executive functioning allows one to move beyond merely realizing the necessity of preparing oneself for action but also to exercise the essential capacity of *organizing* a complex sequence of goal-directed behaviors across time. Furthermore, the ability to free oneself from cognitive and behavioral *interference* arising from prepotent response tendencies that may have been adaptive under other conditions but are no longer adaptive, is a critical aspect of executive function.

Future orientation and relation to attention. Denckla (1996b) highlighted the distinctive "future tense aspects of executive functioning constructs" (p. 266). These future tense qualities include "attention to the future," "prospective memory" (i.e., remembering to remember), and "memory for the future" (i.e., the ability to transcend here-and-now reinforcement contingencies; p. 266). She also noted that although the most popular terms associated with executive functioning are "working memory" (p. 266) and "frontal memory" (p. 263), these concepts do not necessarily encompass the critical executive function concepts of organization and integration of cognitive and behavioral processes over time. She further explains that much conceptual overlap exists between memory, attentional functioning, and executive functioning, in that "what is remembered and what is here-and-now attended-to enter the 'computational arena' of on-line working memory, while the executive functioning system itself *selects for attention and selects from memory* [italics added]" (Denckla, 1996b, p. 266).

Importantly, Denckla (1996b) indicates that executive function can be viewed as a special form of attention, while working memory may be understood as a special form of general memory and an absolute prerequisite to executive functioning. Specifically, working memory is inseparable from attentional functioning (in that it is an on-line form of memory), and it is inextricable from notions of executive functioning (in that it is future-oriented memory). Important conclusions that can be drawn from these considerations are that (a) executive functioning and working memory are both special forms of cognition that are (b) inextricably tied to notions of attention and that (c) necessarily become involved when cognitive activities become effortful (i.e., non-automatic). Moreover, deficits in either domain will likely produce clinically meaningful attention problems.

Developmental Perspective

Denckla (1994, 1996b) asserts that only within a developmentally-sensitive framework does the construct of executive functioning take on its greatest utility for models of psychopathology in children and adults. For example, grade school children who lack the capacity to inhibit prepotent emotional responses while cognitive interpretations of a situation are taking place will have noteworthy difficulty conforming to task demands (in school settings) when those tasks are not intrinsically pleasing (Denckla, 1996b). She explains that children who have developed the "salient executive function achievement" of objectively conforming to task demands despite the intrinsic value of the task at hand, do so, because "working memory enters...keeping perceptions of old memories in an on-line computational space" that presumably keeps the potential outcomes of non-conformity in mind (p. 267). It is also important to note that, in this example, if development proceeds normally, and socially conforming behaviors become over-learned to the point that they occur almost automatically, *executive functioning ceases to play a role, for under those conditions, working memory is no longer required for one to perform behaviors consistent with situational demands*. However, changing stimulus conditions may render even over-learned behaviors "effortful" (e.g., decreased time to perform a series of over-mastered behaviors). In this case, executive functioning re-enters the equation to govern the allocation of mental effort to the task at hand.

Neuroanatomical Substrate of Executive Functioning

In addition to the brain regions noted above as involved in intention and working memory, neural structures most often associated with executive functioning are the prefrontal cortex and striatal regions (Petrides, 1994). Among the separate frontal systems

(primary motor, premotor, frontal eye fields, dorsolateral, ventromedial, orbital prefrontal; Damasio & Anderson, 1993; Middleton & Strick, 2001), the dorsolateral prefrontal cortex is most heavily involved in executive functioning and forms the primary "frontal" substrate in the frontostriatal mechanisms (Denckla, 1996a). It is important to note here that Denckla (1996a) emphasizes the conceptual connections between the neuroanatomical substrate of executive functioning, the construct validity of its measurement, and developmental issues. Specifically, much evidence suggests that frontal systems are not fully mature until up to the fourth decade of life (Fuster, 1997; Slattery, Garvey, & Swedo, 2001). Subsequently, it is virtually meaningless to speak of the construct validity of measures of executive functioning apart from considerations of the developmental sensitivity of those measures. Executive functioning must be viewed on a continuum from infancy to late adulthood as increasing development first matures and expands, plateaus, and then slowly strips away executive cognitive processes across the lifespan. Denckla (1994) notes that "such a broad and temporally progressive range" in the development of these capacities "adds a subtlety of shading to executive function assessment; hierarchical arrangements within the executive functioning domain may be developmentally derived, in an idealized 'mental age' stepwise fashion" (p. 119).

Critical Features of Executive Functioning Measures

Relative to other domains of neuropsychological assessment, measurement of executive functioning is still in its infancy, especially where adult populations are concerned. In a list of measures believed sensitive to executive functioning assessment (e.g., WCST, verbal fluency tests, Stroop task), only five of 12 tests listed were considered potentially valid for adults (Denckla, 1994). Denckla (1994) stated the following regarding

the need to identify additional construct valid and reliable measures of executive functioning:

What is urgently needed is an initiative to engage methodologists to create formulas for the executive functioning domain that capture the everyday clinician's statement, "this person cannot do X even though he (or she) knows Y." Some sort of "back-front" difference score (discrepancy, Heaven help us!) or "front/back" ratio (e.g., vocabulary-word fluency discrepancy or word fluency/vocabulary ratio) is needed as a scoring strategy for closely related tasks if executive functioning as a domain is to be assessed meaningfully (p. 137).

With these considerations in mind, specific tests potentially measuring the elusive executive functioning phenomenon are discussed more fully below in sections outlining difficulties in measuring the construct and proposing novel measures of executive functioning in adults. Before moving on to that discussion, cognitive phenomena that measures of executive functioning should attempt to target are briefly reviewed here.

Denckla (1994, 1996b) and others (Barkley, 1996; Eslinger, 1996; Pennington & Ozonoff, 1996) emphasize that neuropsychological measures of executive functioning must attempt to quantify aspects of cognition that reflect control of motor responding (inhibition) and active management of stored information (working memory). For example, when a participant exhibits control over his/her allocation of mental effort and shows different response strategies as testing conditions change, executive functioning has been invoked. These researchers also agree that executive functions are likely invoked when successful performance requires one to solve unusual types of problems for which he/she has not prepared, to learn new response strategies on the spot, or to maintain goal-directed behavior over a relatively long period of time under boring conditions or after a period of delay or distraction. Moreover, these researchers note that executive functioning measures should

tap one or more aspects of the process by which examinees devise (or learn), apply, monitor, and revise response strategies across time as testing conditions change.

Difficulties in Measuring Constructs Associated with Executive Functioning

Denckla (1996b) provides an overview of current problems in measuring executive functioning. First, she notes that purported measures need to control for general intelligence (especially in adults, presumably), because standard variables generated by some neuropsychological executive functioning tasks may not be sensitive to deficits in developmentally mature, or cognitively gifted, individuals. For example, some studies with head-injured adults with lesions in the frontal lobe report essentially normal performance on the WCST (Anderson, Damasio, Jones, & Tranel, 1991). However, Heaton (1993) demonstrated that WCST performance is correlated with measures of verbal IQ. Subsequently, Denckla (1994, 1996b), and others (Voeller, 2001), recommend that a cognitive ability measure be used to control for "the complex overlap between g [general intelligence factor] and executive functioning" (Denckla, 1996b, p. 268). However, as noted below, this issue is controversial, some investigators recommend not controlling for IQ when measuring executive functioning, because decreased IQ estimates in the lower executive functioning group likely emerge from aspects of the IQ measures requiring executive control (Seidman, Biederman, Farone, Weber, & Ouellette, 1997).

Where measures of cognitive functioning are concerned, it is interesting to note that Pennington (1996) suggests that estimates of fluid intelligence can be used to provide a generally adequate measure of executive functioning, whereas, measures of crystallized intelligence do not have an executive functioning component. Here, Denckla (1996b) asserts that the Performance IQ from the Weschler intelligence scales provides a rough

measure of executive functioning, given its emphasis on "doing" and the heavy use of timed tests on the Performance Scale (p. 268). However, she notes that increased sensitivity to executive functioning capacities can be obtained by examining the discrepancy between a participant's Block Design and Object Assembly Subtest scores. For example, if one's Block Design score is high and his/her Object Assembly score is low, the finding would indicate he/she demonstrated adequate visual-motor functioning when a model was present but less than adequate performance when a model was not present (Denckla, 1996b). In this example, the discrepancy between these two measures reflected executive functioning, because when the examinee was required to generate the representation of the desired goal internally (i.e., the completed assembly), he/she struggled, but when the representation was provided during the task, he/she did not. Moreover, for the same reasons, it may be argued that the major difference between these two tasks is that one places a larger demand on working memory resources (i.e., Object Assembly subtest).

Denckla (1996b) also notes that poor performance on measures of executive functioning in the absence of a separate evaluation of a participant's skill level in the overall domain tapped by the executive functioning measure will lead to non-specific findings regarding executive functioning. For example, it may be difficult to determine whether a participant's poor performance on a measure of executive functioning requiring mental manipulation of numbers resulted from difficulties with executive functioning or from low facility with numbers, or even a math learning disability. Moreover, given the complex nature of instructions for some measures purported to demonstrate impaired operation of executive functioning processes (e.g., the *Paced Auditory Serial Attention Test*; PASAT, 1993), it may be problematic to conclude that poor performance on the relevant dependent

variable represented poor executive functioning unless the examiner took steps to ensure the participant fully understood requirements of the task prior to administration.

This point is further illustrated through reference to the Stroop effect (Golden, 1978) — a phenomenon long-held to be indicative of executive functioning. The discordant condition of the Stroop Task requires participants to read the names of colors printed with ink of another color. The Stroop effect is measured in terms of the time required to inhibit a powerful pre-existing tendency to read the printed word naming a conflicting color when required to name the color of the ink. Denckla, provides the hypothetical example of a participant who performs adequately on the Stroop due to a high level of illiteracy ("content domain incompetence;" p. 269), when in fact, the interference associated with the Stroop effect was not operating due to illiteracy. As Denckla (1996b) states, "perhaps it is impossible to 'do,' with that which you do not 'know'" (p. 269). In short, the degree to which poor performance on an executive functioning measure can be assumed to validly capture actual deficits in executive functioning must be judged in relation to the participant's level of competence in the overall domain tapped by that measure (Denckla, 1996b).

Norm-Referenced Measures of Executive Functioning in Adults

As noted above, Denckla (1996b) indicated that measurement of executive functioning capacity is in a very early stage of development, and clinically-relevant measures of the construct that may ultimately demonstrate adequate validity and reliability are "urgently needed" (p. 137). Moreover, she noted that traditional dependent measures from neuropsychological tests often appear to insufficiently tap the domain of executive functioning. The situation is especially problematic where measurement of executive functioning in clinical samples of adults is concerned given the lack of validated,

developmentally sensitive measures of executive functioning for adults. Nonetheless, two of three leading theoretical models for ADHD in children and adults (Barkley, 1997b; Denckla, 1996b) are fundamentally based on the construct of executive functioning. This observation serves to strengthen Denckla's (1996b) call for measures theoretically related to executive functioning to be identified as candidates for testing in pilot studies and possible validation in replication studies. However, the purpose of this section is to briefly identify existing dependent variables in performance domains that (a) can be generated from commonly used neuropsychological test batteries, (b) meet the criteria for candidate measures of executive functioning as described by Denckla (1994, 1996b), and (c) potentially have direct clinical relevance for assessment of ADHD in adults as defined under *DSM-IV*.

Maintenance of Effort Across Time

As noted above, several researchers (Barkley, 1996; Denckla, 1994, 1996b; Eslinger, 1996; Pennington, 1996; Pennington, Grossier, & Welsh, 1993) agree that executive functions are likely invoked when a task requires one to maintain goal-directed behavior over a relatively long period of time under boring conditions or after a period of delay or distraction (i.e., sustained *intention*; Denckla, 1996a). Dependent variables that reflect overall maintenance of effort on a task for relatively long intervals of time will likely tap executive functioning. Potential measures tapping maintenance of effort across time include: (a) measures of perceptual sensitivity (d-prime; *d'*) from continuous performance tests (Conners, 1992, 1995) — measures that may reflect overall sensory "readiness" and response preparation; (b) measures reflecting degree to which participant performance deteriorated as a function of time (e.g., indices of mental arithmetic performed during sequential time intervals such as the PASAT, 1993); and (c) measures reflecting degree to

which participant performance deteriorated as a function of variation in task difficulty (e.g., indices of mental arithmetic performed under increasingly strict time constraints such as occurs during the PASAT, 1993).

Maintenance of Cognitive Set Across Time

Similar to dependent variables that monitor sustained attention, measures reflecting maintenance of cognitive set across time may tap executive functioning when task requirements are sufficiently difficult that working memory is required for successful performance. One measure potentially tapping maintenance of cognitive set across time is percent perseverative errors on the *Wisconsin Card Sorting Test* (WCST; Heaton, 1993). Percent perseverative errors on the WCST occur when continues to use the current sorting principle after the task has switched to another sorting principle. However, it is particularly important to control for the effects of high cognitive ability when using this measure in adult samples as noted in the review above (Denckla, 1996b).

"Fluid" Aspects of Intelligence

As noted above, Denckla (1996b) asserts that executive functions are likely elicited when a task requires one to solve novel tasks under time-limited conditions. Dependent variables that monitor, or reflect, novel problem solving, and perhaps visual working memory, under timed conditions are reflected in the Processing Speed Index from the WAIS-III (Wechsler, 1997b). Moreover, the overall Perceptual Organization Index from the WAIS-III may tap executive functioning given its requirements for (a) rapid access to visual memory representations to identify missing elements of a stimulus scene (Picture Completion subtest), (b) relatively demanding mental rotation and re-organization of

increasingly complex stimulus forms (Matrix Reasoning subtest), and (c) construction of novel designs under standardized conditions and time limits (Block Design subtest).

Working Memory vs. General Memory

Also reviewed above, working memory is a critical component of executive functioning and is believed to be qualitatively different from general forms of verbal memory (e.g., rote memory - recalling verbal information without performing any mental manipulation on that verbal information; Denckla, 1996b; Kimberg et al., 1998). Dependent variables that may reflect this form of executive functioning are test scores from traditional verbal working memory tasks (e.g., Letter-Number Sequencing subtest, WAIS-III; Working Memory Index, WAIS-III) and traditional general verbal memory tasks (e.g., Logical Memory Immediate and Delayed, and Verbal Paired Associates Immediate and Delayed; *Wechsler Memory Scale, Third Edition, WMS-III*; Wechsler, 1997a). A consistent pattern of weaker performance on the verbal working memory tasks may reflect an underlying deficit in on-line, executive control, verbal memory (Denckla, 1996b).

Very Effortful Performance Across Time

A robust test of executive control processes in adults may be seen in measures of working memory functioning under conditions likely perceived as very demanding or highly stressful. Executive functioning indices of overall performance are potentially available in the PASAT (e.g., total correct responses on the PASAT, 1993).

Inhibition Under Variable and Boring Task Conditions

Denckla (1994, 1996b) noted that unlike tasks that provide substantial external stimulation, tasks perceived as boring may elicit executive functioning. Specifically, boring, non-stimulating tasks require participants to internally regulate attentional focus and

cognitive arousal. Subsequently, when continuous performance tasks systematically vary length of time between stimulus presentations while consistently requiring examinees to inhibit responses to certain stimuli, inhibition scores (e.g., number of commission errors; Conners CPT) across time and variable stimulus intervals may reflect executive control of prepotent motor responses.

As noted above, each test variable discussed is a potential candidate for measurement of executive functioning in clinical samples of adults given that the neuropsychological tests from which they are derived are widely used in clinical practice. To examine executive functioning among clinic-referred adults in a manner consistent with Denckla's (1996b) and Barkley's (1997b) promising theoretical models of ADHD as a core deficit in executive function, 10 neuropsychological variables generally meeting the criteria for executive functioning measures presented above were (a) used to examine potential differences in overall executive functioning among distinct groups of adults in this clinic-referred sample, and (b) empirically evaluate whether separate domains of executive dysfunction could be identified in which the performance of groups identified through clinical assessment showed significant differences. Upon the completion of these analyses, the empirically-derived domains of neurocognitive executive dysfunction were utilized to (a) further evaluate the discriminant validity of ADHD in adults, and (b) examine the diagnostic utility of such variables in distinguishing ADHD adults from other clinic-referred adults.

OBJECTIVES AND HYPOTHESES

As noted above, phenomenological observation and clinical need prompted inclusion of ADD-W/O in *DSM-III* despite a lack of empirical data. Similarly, although no adults participated in studies used to define the *DSM-IV* ADHD criteria, clinical need required inclusion of adults in this classification. Nonetheless, the working hypothesis that the child-based *DSM-IV* definition of ADHD provides a valid taxonomy for adult attention disorders should be examined empirically.

Specifically, research should evaluate the validity of the *DSM-IV* definition of ADHD for adults by using data from adult samples to examine questions similar to those investigated in studies with ADHD children. Therefore, the primary objectives of the current study were to evaluate the following questions: 1) What symptom dimensions exist in adult ADHD?; 2) In what domains, and to what degree, do ADHD adults exhibit deficits in neurocognitive “executive” functioning?; 3) Does ADHD in adults show discriminant validity in terms of (a) empirically derived domains of symptom impairment (i.e., inattention memory problems, hyperactivity/restlessness, impulsivity/emotional lability, and problems with self-concept), (b) rationally and empirically derived domains of executive functioning, (c) other domains of functional impairment (e.g., non-executive forms of cognitive ability, academic functioning, and delayed verbal memory), (d) psychiatric comorbidity?; 4) Do subtypes of ADHD under *DSM-IV* show adequate discriminant validity in these symptom and executive domains?; and 5) Do neuropsychological measures of executive attentional functioning have diagnostic utility in differentiating clinic-referred adults with attentional complaints who ultimately (a) meet criteria for ADHD, (b) exhibit separate subtypes of

ADHD under *DSM-IV*, (c) exhibit learning disorders, and (d) do not meet criteria for any clinical diagnosis?

What Symptom Dimensions Exist in Adult ADHD?

As indicated in the review above, empirical studies investigating the dimensional structure of symptoms of ADHD in children often relied on factor analyses of parent and/or teacher rating scale data. The 18 symptoms of ADHD under *DSM-IV* have not been submitted to exploratory factor analysis in a published study using a clinic-referred adult sample. In order to conduct a study with ADHD adults that explicitly builds upon previous work conducted with children with the disorder, this manuscript reports factor analyses of self- and observer-rating scale data of 18 items from the *DSM-IV* Symptom Scales on the recently developed Conners Adult ADHD Rating Scales (CAARS; Conners et al., 1999b). Each of these 18 items represents one *DSM-IV* ADHD symptom (i.e., nine symptoms of inattention, six symptoms of hyperactivity, and three symptoms of impulsivity).¹ Separate exploratory factor analyses were performed with self- and observer-ratings to help clarify whether the dimensional structure of ADHD symptoms in clinic-referred adults is similar to that found in factor analytic studies with ADHD children. The self and observer versions of the CAARS were administered (with very few exceptions) to all participants.

Hypotheses Related to Symptom Dimensions of Adult ADHD

H1a It was hypothesized that a factor structure matching that found in recent studies with children with ADHD (e.g., Bauermeister et al., 1992) would emerge from data obtained in this adult sample. Specifically, it was predicted that two-dimensional factor structures

¹ As noted by the authors, "...wording of these 18 items is slightly modified for use with adult respondents (e.g., change "school" to "work") on the relevant CAARS forms" (Conners et al., 1999b, p. 52).

would emerge in separate factor analyses of observer- and self-ratings of *DSM-IV* symptoms of ADHD with items reflecting inattention loading on one factor and items reflecting hyperactivity and impulsivity loading together on a separate factor.

H1b ADHD adults were expected to exhibit significantly greater impairment than LD and clinic-referred control adults on self- and observer-ratings of empirically derived symptom domains identified in recent research with adults (i.e., Inattention/Memory Problems factor, Hyperactivity/Restlessness factor, Impulsivity/Emotional Lability factor, Problems with Self-Concept factor; Conners et al., 1999a) as indicated by mean T-scores on these factors from the CAARS-S:L and CAARS-O:L.

What Domains of Executive Dysfunction are Affected in Adult ADHD?

As indicated above, an increasing body of literature indicates that adults with ADHD exhibit deficits in executive functioning similar to those found in studies with ADHD children. However, the term executive functioning is broad and encompasses numerous neurocognitive capacities (e.g., verbal and spatial working memory, response consistency, planning, effortful allocation of attention, response inhibition, cognitive flexibility), and it is unclear whether adults with ADHD experience impairment along a single, overarching domain of executive dysfunction or along several separate domains. In addition, it is not known whether adults with ADHD and those with learning disorders experience similar, or fundamentally different forms of executive dysfunction. This manuscript reports results of a principle components analysis of data from several standardized measures of executive functioning to help clarify the nature of the neurocognitive executive dysfunction involved in adult ADHD, as well as to gather preliminary evidence of potential differences in

executive functioning between adults diagnosed with ADHD and those meeting criteria for a learning disability.

Hypotheses Related to Domains of Neurocognitive Executive Dysfunction

H2 Given evidence that ADHD-I may represent primarily difficulty with cognitive speed (Faraone et al., 1998) and ADHD-C may involve a core deficit in behavioral inhibition (Lahey et al., 1987), as well as evidence that problems with executive functioning in learning disabilities may be similar to those found in ADHD (Faraone et al.), it was hypothesized that at least two broad domains of executive dysfunction would emerge. One component was expected to primarily involve tasks requiring effortful verbal processing, whereas another component was expected to be dominated by tasks involving effortful motor processing (i.e., requiring maintenance of a state of readiness to respond and response inhibition).

Does ADHD in Adults Show Discriminant Validity On Measures of Secondary Impairment?

Much recent research suggests that ADHD in adults is associated with secondary deficits in several functional domains (Biederman, Faraone, Spencer, Wilens, Norman, Lapey, et al., 1993; Biederman, Faraone, Spencer, Wilens et al., 1994; Biederman, Wilens, Mick, Milberger, 1995). However, among clinic-referred adults, it is unclear whether these secondary deficits are differentially manifested by adults with and without ADHD, or LD, who present with similar complaints. Moreover, recent theoretical models of ADHD (Barkley, 1997b; Denckla, 1996a, 1996b) implicate executive functioning as a core deficit in the disorder. Indeed, Denckla (1996a) posits the disorder is fundamentally a deficit of "in-intention" (inability to exercise the first component of intention, inhibition) rather than inattention (p. 117). This notion is strikingly similar to Barkley's (1997b) assertion the

disorder is characterized by behavioral disinhibition. As noted in the review of these models above, the capacity to inhibit prepotent motor responses is a capacity inextricably linked to notions of executive functioning. Moreover, important constructs in executive functioning (e.g., working memory and mental effort) are critically linked to cognitive capacities such as planning, foresight, judgement, learning, and behavioral efficiency, and ADHD children and adults are frequently found to be deficient in these domains (e.g., Denckla, 1996a).

As noted above, one approach for evaluating the validity of the overall classification of ADHD for adults is to conduct research with clinical samples examining whether secondary deficits in executive functioning and other functional domains are differentially manifested by adults who do and do not meet criteria for ADHD. Findings indicating that ADHD and non-ADHD adult groups show significant differences on measures of executive control and other domains of functioning not involved in making the diagnosis would support the validity of the category for adults as defined under *DSM-IV*.

Hypotheses Regarding Discriminant Validity of Adult ADHD:

Executive Dysfunction and Other Secondary Deficits

H3a Some studies conducted with ADHD children suggested that deficits in executive functioning may be fundamental to both ADHD and learning disabilities (e.g., Denckla, 1996a), whereas deficits in behavioral inhibition may more uniquely characterize individuals with ADHD (Barkley, 1997b; Voeller, 2001). In the current study, adults with ADHD were expected to perform significantly less well than non-ADHD adults on any empirically derived components comprised primarily of measures involving *effortful motor processing* (e.g., commission errors, hits percentile; Conners CPT). However, ADHD and LD adults were predicted to perform similarly on any empirically derived components comprised

primarily of measures involving *effortful neurocognitive processing* (e.g., Working Memory Index, WAIS-III; total correct, PASAT), but both of these groups were expected to perform significantly less well than the Clinic-referred control group on such factors.

H3b It was hypothesized the ADHD, LD, and Clinic-referred control groups would exhibit similar levels of performance on measures of cognitive ability that purportedly do not place a heavy demand on executive control cognitive resources (i.e., Verbal Comprehension Index and Perceptual Organization Index; WAIS-III). Importantly, this hypothesis stands in contrast to H3a in which ADHD adults were predicted to demonstrate significantly weaker performance than the LD and clinic-referred control groups on the more *executive control intensive* measures of cognitive ability from the WAIS-III (i.e., Working Memory and Processing Speed Indices).

H3c ADHD and LD adults were expected to exhibit significantly lower levels of academic achievement in reading, math, writing, and general knowledge, than clinic-referred control adults, as determined by standard scores in these areas from the Woodcock-Johnson Psychoeducational Battery, Revised (WJ-R; Woodcock & Johnson, 1989, 1990). Moreover, it was expected that LD adults would perform significantly less well than ADHD adults in each of these domains of achievement.

H3d ADHD and LD adults were expected to perform significantly less well than clinic-referred control adults in delayed recall of newly acquired verbal material as indicated by the Auditory Delayed Index (ADI) from the *Wechsler Memory Scale, 3rd Edition* (WMS-III; Wechsler, 1997c). However, ADHD and LD groups were not expected to differ from one another on the ADI.

H3e ADHD adults were expected to exhibit more comorbid anxiety, depressive, and substance use disorders than the LD group as determined by structured clinical interview (i.e., *SCID-CV*; First, Spitzer, Gibbon, & Williams, 1997a).

Do ADHD Subtypes Show Discriminant Validity On Measures of Secondary Impairment?

In addition to examining the discriminant validity of the overall category of ADHD in adults, data is needed that examines whether *DSM-IV* subtypes of the disorder show discriminant validity in domains of executive and functional impairment among clinic-referred adults. Further support for the working hypothesis that the *DSM-IV* classification of ADHD is valid for adults may be generated by research showing that predominately inattentive and hyperactive-impulsive subtypes show significant differences in secondary deficits.

Hypotheses Related to Discriminant Validity of DSM-IV Subtypes of ADHD in Adults

H4a ADHD-C adults were expected to perform significantly less well than ADHD-I adults on any empirically derived components comprised primarily of measures involving *effortful motor processing* (e.g., commission errors, hits percentile; Conners CPT).

However, ADHD-C and ADHD-I subgroups were expected to perform similarly on any empirically derived components comprised primarily of measures involving *effortful neurocognitive processing* (e.g., Working Memory Index, WAIS-III; total correct, PASAT).

H4b Moreover, ADHD-C and ADHD-I adults were predicted to perform similarly on measures of cognitive ability believed less dependent on executive functioning (i.e., Verbal Comprehension Index and Perceptual Organization Index; WAIS-III).

H4c However, ADHD-I adults were expected to exhibit significantly lower levels of academic achievement in reading, math, writing, and general knowledge, than ADHD-C adults, as determined by standard scores in these areas from the WJ-R.

H4d ADHD-I adults were expected to perform significantly less well than ADHD-C and clinic-referred control adults in delayed recall of newly acquired verbal material as indicated by the Auditory Delayed Index (ADI) from the WMS-III. In turn, the ADHD-C group was expected to perform significantly less well than the clinic-referred control group on the ADI.

H4e ADHD-C adults were expected to exhibit significantly greater levels of symptom impairment than ADHD-I and clinic-referred control adults, who were not expected to differ from one another, on self- and observer-ratings of hyperactivity/ restlessness and impulsivity/ emotional lability as indicated by mean T-scores from relevant factors on the CAARS-S:L and CAARS-O:L (i.e., Hyperactivity/Restlessness Factor, Impulsivity/Emotional Lability Factor; Conners et al., 1999a). However, ADHD-I adults were expected to show more difficulty with poor self-concept than ADHD-C and clinic-referred control adults, who were not expected to differ from one another, on the Problems with Self-Concept factor (Conners et al.). Yet, ADHD-C and ADHD-I adults were expected to report (self-ratings) and receive (observer-ratings) significantly higher ratings of impairment than clinic-referred control adults on the Inattention/Memory Problems factor.

H4f ADHD-I adults were expected to exhibit more comorbid anxiety and depressive disorders than ADHD-C adults as determined by structured clinical interview (i.e., *SCID-CV*; First et al., 1997a). However, the ADHD-C subgroup was expected to meet criteria for significantly more substance use disorders than the ADHD-I group as determined by the *SCID-CV*.

Do Measures of Functional Impairment Show Good Diagnostic Utility?

The diagnostic utility of measures of neurocognitive executive functioning for clinic-referred adults presenting with attentional complaints remains unclear (Gansler et al., 1998). Therefore, four separate discriminant function analyses (DFAs) were conducted to help clarify whether such measures have diagnostic utility in differentiating clinic-referred adults with attentional complaints who ultimately (a) do *or* do not meet criteria for an ADHD diagnosis, (b) meet criteria for ADHD-C *or* ADHD-I under *DSM-IV*, (c) meet criteria for an ADHD *or* learning disorder diagnosis, and (d) meet criteria for ADHD *or* do not meet criteria for any clinical diagnosis.

Hypotheses Related to Diagnostic Utility of Measures of Executive Functioning

H5a It was predicted that when submitted to DFA, mean factor (composite) scores on empirically derived factors representing separate domains of neurocognitive executive functioning would correctly classify *ADHD and non-ADHD* adults at a level significantly exceeding chance accuracy, with approximately 75 percent overall correct classification. Moreover, use of a jackknife validation procedure (i.e., leave-one-out) was expected to result in an overall correct classification significantly exceeding chance accuracy.

H5b It was predicted that when submitted to DFA, mean factor (composite) scores on empirically derived factors representing separate domains of neurocognitive executive functioning would correctly classify *ADHD and LD* adults at a level significantly exceeding chance accuracy, with approximately 65 percent overall accurate classification. Moreover, use of a jackknife validation procedure (i.e., leave-one-out) was expected to result in an overall correct classification that was marginally better than chance accuracy.

H5c It was predicted that when submitted to DFA, mean factor (composite) scores on empirically derived factors representing separate domains of neurocognitive executive functioning would correctly classify *ADHD and Clinic-referred control* adults at a level significantly exceeding chance accuracy, with approximately 85 percent accurate classification. Moreover, use of a jackknife validation procedure (i.e., leave-one-out) was expected to result in an overall correct classification that significantly exceeded chance accuracy.

H5d However, it was predicted that when submitted to DFA, mean factor (composite) scores on empirically derived factors representing separate domains of neurocognitive executive functioning would not correctly classify *DSM-IV* subtypes of ADHD at a level exceeding chance accuracy.

METHOD

Participants

The initial sample consisted of 107 (56 males; 51 females) consecutive referrals to the Psychological Services Center (PSC) between November 1, 1997 and August 1, 1999. The PSC is an outpatient assessment and treatment center at Virginia Tech serving the New River Valley area of Southwestern Virginia. All referrals were adults reporting attentional, learning, relational, occupational, and/or adjustment difficulties and referred to the PSC for psychological evaluation. Referrals were not included in the study protocol and were referred elsewhere if there was reason to believe that the adult was seriously intellectually deficient or actively psychotic (1 female). Of the initial 107 referrals, four (two males; two females) did not follow-up to receive an assessment. Of the remaining 103 referrals, nine (six males; three females) started, but did not complete, the evaluation due to scheduling difficulties (three participants), an auto accident (two participants), inappropriateness of the initial referral (one participant), or apparent loss of interest or motivation for receiving the evaluation (three participants). All of the remaining 94 participants (48 males; 46 females) in the sample signed consent forms giving permission for their assessment data to be used in research. Participants ranged in age from 18.42 years to 44.25 years (mean age = 23.3 years). Eighty-seven participants classified themselves as Caucasian, and seven participants indicated they belonged to a minority group (i.e., African American = two; American Asian = three; and Hispanic = two). Eighty-three of the participants indicated they were single, eight reported they were married, and three noted they were either separated or divorced.

Upon clinical evaluation (see below), 44 of the sample of 94 participants met *DSM-IV* diagnostic criteria for ADHD (mean age = 23.78 years; mean education level¹ = 15.95; 22 males, 22 females). However, nine of the 44 adults with ADHD had concurrent learning disability diagnoses (mean age = 20.62 years; mean education level = 14.70; three males, six females). Among the nine ADHD adults with learning disability diagnoses, two met criteria for Reading Disorder (mean age = 23.21 years; mean education level = 16.3; one male, one female), six met criteria for Math Disorder (mean age = 20.0 years; mean education level = 14.43; one male, five females), and one (male) met criteria for Disorder of Written Expression. In order to obtain a group of adults with ADHD that did not overlap with the group of adults with learning disorders (LD; described below), the nine adults with comorbid ADHD and LD diagnoses were excluded from this study. The exclusion of these participants resulted in a final group of 35 adults with ADHD. Of these 35 adults diagnosed with ADHD, 20 received a diagnosis of ADHD-Combined Type (mean age = 24.51 years; mean education level = 15.36; 12 males, 8 females), 14 received a diagnosis of ADHD-Inattentive Type (mean age = 24.92 years; mean education level = 14.50; seven males, seven females), and one (female) had a diagnosis of ADHD-NOS.² Of these 35 ADHD adults, eight had a concurrent anxiety disorder (mean age = 29.60 years; mean education level = 15.11; four males, four females), eight had a concurrent mood disorder (mean age = 30.93 years; mean education level = 14.90; four males, four females), and two had a concurrent substance use disorder (mean age = 32.54 years; mean education level = 14.55; one male, one female).

¹ Mean number of years of education.

² No participant received a clinical diagnosis of ADHD-Hyperactive/Impulsive Type.

In the overall sample of 94 adults, 50 participants did not meet criteria for an ADHD diagnosis (mean age = 22.88 years; mean education level = 15.6; 26 males, 24 females). Of these 50 non-ADHD adults, six met criteria for a current anxiety disorder (mean age = 21.75 years; mean education level = 15.18; no males; six females), seven received a current mood disorder diagnosis (mean age = 22.70 years; mean education level = 15.67; four males, three females), but none of the non-ADHD adults met criteria for a current substance use disorder. However, 24 of the non-ADHD participants met criteria for a learning disability (mean age = 23.48 years; mean education level = 15.68; 12 males, 12 females). Of these 24 adults with an LD diagnosis, five had a concurrent anxiety disorder (mean age = 22.02 years; mean education level = 15.22; no males, five females), three had a concurrent mood disorder (mean age = 21.39 years; mean education level = 16.03; one male, two females), and none had a concurrent substance use disorder. Five of the non-ADHD adults met criteria for anxiety (one female) or affective (three males, one female) disorders, but not an LD diagnosis (mean age = 23.03 years; mean education level = 15.32; three males, two females). Finally, 21 of the non-ADHD participants received no diagnosis upon completion of their clinical assessment (mean age = 22.16 years; mean education level = 15.60; 11 males, 10 females). The final composition of the groups included in the analyses are presented in Table 1.

Procedure

Clinical Assessment

Adults who were referred for assessment of ADHD, academic, and/or adjustment problems, were contacted by phone and given a brief description of the clinical assessment protocol. At the conclusion of the initial phone contact, if he/she indicated continued desire

to receive a clinical psychoeducational evaluation, an appointment was made at the PSC for the first day of the adult assessment battery. Upon arrival at the PSC, each client completed initial paperwork, a study consent form (see Appendix B, p.177), a PSC consent form, and a release of information form (Appendix C, p. 180), the latter of which asked the client to provide written consent giving assessment staff permission to contact parents and other observers by mail to gather information for clinical and research purposes. Clients who did not wish parent(s) or observers to be contacted, or if parents were unavailable, still received a clinical assessment. However, as Shaffer (1994) noted, parent reports are useful in retrospectively establishing a history of ADHD symptomatology from childhood and in checking the reliability of historical reports provided by the client. Nonetheless, parent reports were not considered an absolute requirement for a retrospective diagnosis of adult ADHD. Diagnostic work-ups typically took place in three sessions with the first two sessions lasting approximately four hours each, and the third (a working feedback session) lasting approximately one hour.

The first session began with an assessment of the client's current and historical academic and/or work performance using the Overview Section of the Structured Clinical Interview for *DSM-IV* (SCID-I—CV; First et al., 1997a). Next, a closely supervised, trained psychological testing technician administered the SCID-I, a semi-structured diagnostic interview evaluating the appropriateness of every major Axis-I psychiatric disorder included in *DSM-IV*. Each of these interviews was video-taped, and lasted approximately two – three hours.

Importantly, the diagnostic interview was modified to include a semi-structured clinical interview for *DSM-IV* ADHD in adults (developed by the author and modeled, in

part, after the SCID-I; First et al., 1997a). The ADHD diagnostic interview was designed to retrospectively assess whether the client experienced noteworthy impairment from each *DSM-IV* symptom of ADHD during his/her years in preschool and elementary school, as well as to establish the presence or absence of each symptom in his/her adult life. Next, laboratory measures of attention and auditory processing were administered by trained examiners, and these tasks required approximately 30 minutes during the first session. After the first session, if permission was granted and parents and/or observers were available, cover letters, questionnaires covering childhood and adult ADHD symptomatology, and a stamped, addressed, return envelope were mailed to parents and/or observers (i.e., the Wender Parent Rating Scale, WPRS, Ward, Wender, & Reimherr, 1993; CAARS-O:L, Conners et al., 1999b). Session two was scheduled approximately one week later at the PSC and consisted of the administration of laboratory measures of attention (Conners CPT; Conners, 1992, 1995), non-verbal working memory (WCST-CV2; Heaton, 1993), and information processing (PASAT, 1996). Moreover, during the second assessment session, an intelligence test (WAIS-III; Wechsler, 1997a), an achievement test (WJ-R; Woodcock & Johnson, 1989, 1990), and self-reports of child (*Wender Utah Rating Scale*, WURS; Ward et al., 1993) and adult ADHD symptomatology (CAARS-S:L; Conners et al., 1999b) were administered. Overall, the comprehensive psychoeducational assessment occurred during two-to-four outpatient clinic sessions totaling six-to-eight hours of assessment (divided across at least two days).

The appropriateness of a clinical diagnosis of ADHD for each adult presenting for assessment was based on combined data from the following: 1) Extensive life history information gathered using a detailed life history form developed by the current author and a

psychosocial history obtained during the first session and the working feedback session; 2) A structured clinical interview specifically designed to elicit information regarding impairment from symptoms of *DSM-IV* ADHD during childhood and adulthood; and 3) Self-, parent-, and observer-rating scales assessing *DSM-IV* symptoms of the disorder and frequently associated difficulties with restlessness, emotional lability, poor self-concept, and memory problems. As suggested above, in addition to parent-ratings (when parents were available), each client was asked to identify two individuals who knew him/her well and with whom he/she interacted on a near daily basis who could complete additional observer-ratings (CAARS-O:L) about him/her. These additional CAARS-O:L forms were completed by various combinations of observers, including spouse, significant other (partner, fiancée, boyfriend, etc.), roommate, sibling, close friend, employer, and/or professor. When parent ratings were included, up to four CAARS-O:L forms were completed for each participant.

To be included in the ADHD group, participants were required to meet research criteria for the disorder as detailed in Appendix D (p. 181). In short, the research diagnostic algorithm required: 1) Report a life history consistent with an ADHD diagnosis, including emergence of some symptoms indicative of ADHD by seven years of age; 2) Report sufficiently impairing current *DSM-IV* ADHD symptomatology (i.e., during the previous six months) as determined by the ADHD structured clinical interview (i.e., six of nine symptoms of ADHD–I, ADHD–HI, or both); 3) Meet criteria for a retrospective childhood diagnosis of *DSM-IV* ADHD, again, as determined by the ADHD structured clinical interview; and 4) Exhibit self- and observer-rated clinically-meaningful impairment (i.e., ratings of “2, Pretty Much,” or “3, Very Much”) on the *DSM-IV* ADHD Symptom Subscales from the CAARS-S/O:L on a sufficient number of symptoms to reach diagnostic threshold

(Conners et al., 1999b). Participants who reported significant impairment across multiple settings from ADHD symptomatology and endorsed five of nine symptoms, but not six symptoms, in either ADHD symptom domain on the structured clinical interview and the CAARS-S/O:L ratings were given a clinical diagnosis of ADHD-Not Otherwise Specified (ADHD-NOS; n=1).

Factor Analyses

As noted above, in order to conduct a study with ADHD adults that explicitly built upon previous work conducted with children with the disorder, separate exploratory factor analyses were performed with self- and observer-ratings of *DSM-IV* ADHD symptoms. Specifically, to help clarify whether the dimensional structure of ADHD symptoms in clinic-referred adults is similar to that found in factor analytic studies with ADHD children, this manuscript reports factor analyses of self- and observer-rating scale data of 18 items from the *DSM-IV* Symptom Scales on the recently developed CAARS forms (Conners et al., 1999b). Each of these 18 items represents one of the *DSM-IV* ADHD symptoms (i.e., nine symptoms of inattention, six symptoms of hyperactivity, and three symptoms of impulsivity). As noted above, wording of the symptom descriptions was "slightly modified for use with adult respondents" (Conners et al., 1999b, p. 52). The CAARS-Self: Long Version (66 items) was administered to all participants that ultimately comprised the final sample (n=80).

As noted in the clinical assessment section above, in the initial sample of 94 participants that received a complete assessment, up to four CAARS-O:L (66-items) forms were completed by various respondents for individual participants as part of their clinical evaluation when permission was granted allowing PSC staff to contact observers (only one

participant from the initial sample of 94 decided not to grant permission for staff to obtain observer ratings). A total of 240 CAARS-O:L forms were collected for 93 participants in the initial sample that completed the evaluation (Mean = 2.58, SD = 1.08, CAARS-O forms completed per participant). Figure 1 shows the number of participants for whom zero, one, two, three, or four, CAARS-O:L forms were completed. Figure 2 shows the number of CAARS-O:L forms that were completed in each category of respondent. A similar number of CAARS-O forms were completed for the overall ADHD and non-ADHD groups ($t(92) = -.08, p = .94$).

Given that multiple CAARS-O ratings per participant could not be included in the factor analysis of observer-rated *DSM-IV* ADHD symptoms (due to lack of independence between multiple ratings for the same participant, and unequal numbers of ratings across participants), a procedure was needed to determine which observer-rating would be used. In general, procedures were adopted that attempted to identify which observer was in the best position to make such ratings in terms of two questions: 1.) Which observer likely knew the participant most well, over the longest period of time, and had greatest familiarity with his/her typical behavior patterns?; and 2.) Which observer likely saw the participant most frequently in multiple settings in the six months prior to the assessment? Based on these broad considerations, the following four specific decision rules guided selection of particular CAARS-O forms for the factor analysis of observer data: 1.) when a participant was married, ratings from his/her spouse were used (n=8); 2.) for unmarried participants, or those divorced or separated, ratings from a mother-figure (step-mothers, maternal guardians, etc.) were used (n=49); 3.) when ratings from a spouse or mother were unavailable, ratings from a father-figure (step-father, paternal guardian, etc.) were used (n=1); 4.) when none of

the observer-ratings above were available, ratings from a respondent identified as "significant other" (n=11), "best friend" (n=8), "sibling" (n=1), "roommate" (n=10), "friend" (n=4), or "employer" (n=1), were selected, in that order. In cases where a compelling reason existed to use ratings from an observer other than the one indicated by these decision rules, ratings from the next appropriate observer respondent were selected. For example, in three instances, CAARS-O forms were returned from a participant's mother with a note attached saying, in effect, that she had not seen the participant for an extended period of time (e.g., since he/she "left home" after graduating from high school), and subsequently, she doubted she could make accurate ratings of his/her current behavior.

Principle Components Analysis of Executive Functioning (EF) Measures

As indicated above, an increasing body of literature indicates that adults with ADHD exhibit deficits in executive functioning similar to those found in studies with ADHD children. However, the term executive functioning is broad and encompasses numerous neurocognitive capacities (e.g., verbal and spatial working memory, response consistency, planning, effortful allocation of attention, response inhibition, cognitive flexibility), and it is unclear whether adults with ADHD experience impairment along a single, overarching domain of executive dysfunction, or along several separate domains. In addition, it is not known whether adults with ADHD and those with learning disorders experience similar, or fundamentally different forms of executive dysfunction. This manuscript reports results of a principle components analysis of data from 10 standardized measures of executive functioning to help clarify the nature of the neurocognitive executive dysfunction involved in adult ADHD, as well as to gather preliminary evidence of potential differences in

executive functioning between adults diagnosed with ADHD and those meeting criteria for a learning disability.

The neuropsychological measures included in the PCA were first analyzed using a multivariate analysis of variance (MANOVA) to test overall group differences when considering all 10 variables collectively. Significant multivariate analyses were followed by univariate and post hoc analyses (ANOVAs and Fisher's least significant difference [LSD] procedure) when appropriate. For the post hoc LSD procedure, the Bonferroni procedure was used to decrease risk of Type I error (Stevens, 1996). However, it should be noted here that the Bonferroni correction was applied separately to each set of LSD comparisons reported in the ANOVA tables in this study. This procedure was adopted, because experimentwise control of type one error rate can be rather stringent, and thus, some researchers apply the method separately to various subgroups of tests (Stevens, 1996).

Finally, the 10 standardized, neuropsychological measures of executive functioning were submitted to PCA with varimax rotations. Only eigenvalues above 1.00 were retained and submitted to varimax normalized rotation (i.e., rotation of the raw factor loadings divided by the square roots of the respective communalities). This rotation is aimed at maximizing the variances of the squared normalized factor loadings across the variables for each factor (StatSoft, 1998). As indicated above in the delineation of procedures for the exploratory factor analysis of ADHD symptom items from the CAARS-S/O forms, component loadings $\geq .63$ were considered statistically significant given the sample size of 80, the critical value ($\times 2$) for a correlation coefficient (two-tailed test), alpha level of .05, and minimal acceptable power of 80 percent (Hair, Anderson, Tatham, & Black, 1998; StatSoft, 1998).

Mean composite scores on each EF factor for all participants were calculated by (a) converting data for each variable to standard score format (M=100; SD=15) when not already recorded as such, (b) summing standard scores for variables that loaded most strongly on each of the factors, and (c) dividing by the number of such variables. Mean composite scores for each factor were utilized in the analyses regarding discriminant validity of ADHD and in the discriminant function analyses reported below.

Analyses Examining Discriminant Validity of ADHD in Adults

A MANOVA was used to examine group differences on all three empirically derived EF factors collectively. When appropriate, follow-up ANOVAs and LSD analyses were conducted. Moreover, a MANOVA was used to examine differences across the groups when several additional measures of secondary functional impairment were considered collectively. Again, univariate and LSD analyses were performed when appropriate.

Discriminant Function Analyses

As noted above in the Objectives and Hypotheses section, separate discriminant function analyses (DFAs) were conducted to help clarify whether measures of neurocognitive executive functioning have diagnostic utility in differentiating clinic-referred adults with attentional complaints who ultimately (a) do *or* do not meet criteria for an ADHD diagnosis, (b) meet criteria for ADHD-C *or* ADHD-I under *DSM-IV*, (c) meet criteria for an ADHD *or* learning disorder diagnosis, and (d) meet criteria for ADHD do not meet criteria for any clinical diagnosis. Composite EF factor scores were calculated for each participant as described above. Separate DFAs were conducted using composite scores for each empirically derived EF factor to examine the classificatory power of each factor for the clinical groups under consideration (e.g., ADHD vs. non-ADHD), as well as to provide

heuristic information regarding differences in executive dysfunction that may exist across the clinical groups evaluated in this study.

As was consistent with a procedure utilized in recent research with ADHD children examining diagnostic accuracy of EF tests (Grodzinsky & Barkley, 1999), data from the present clinic-referred sample was used to generate cutoff thresholds for group assignment (i.e., rather than using standardized cutoff scores from each test manual). This procedure was used for several reasons. First, all adults in this sample were referred from similar settings within the New River Valley area of Northwestern Virginia, and thus, the groups seemed likely to be better matched to one another on important demographic variables than to the normative samples of adults included with the published norms for the neuropsychological tests utilized (cf., Grodzinsky & Barkley, 1999). Second, it is more difficult to distinguish clinical groups from one another on measures of secondary impairment than it is to discriminate groups of clinical and non-clinical, healthy adults on such measures. However, the degree to which such measures can assist clinicians in making diagnostic decisions remains a pressing research question (Conners et al., 1999b). Third, the determination of cut points on EF measures that maximally discriminate diagnostic groups¹ within the overall population of adults who present with attentional complaints is an empirical question that should be addressed with data from clinic-referred samples. For these reasons, cutoff scores listed in parentheses below each factor on the DFA tables were identified through separate DFAs conducted using each variable (StatSoft, 1998). These scores represent criterion values providing optimal discrimination between the groups in question from this sample. Each participant's composite score on each factor was compared

¹That is, groups formed on the basis of a gold standard (i.e., a structured clinical interview).

to the criterion value (cutoff score) for that variable to determine into which group (e.g., ADHD or Non-ADHD) he/she should be classified.

For the DFAs examining the classificatory power of all three EF factors combined, a single cutoff value (constant) was calculated for the linear combination of the factors. Each participant's composite score on each factor was multiplied by the raw canonical coefficient for that factor. The resulting products for each factor were then summed. If the sum was larger than the constant identified during the canonical analysis, the case was assigned to one group; if it was smaller, the case was assigned to the other group (e.g., ADHD vs. non-ADHD).

The results of the discriminant function analysis for each EF factor were used to compute the eight diagnostic statistics using the 2x2 table and formulas listed in Appendix E (p. 183; based on Kessel & Zimmerman, 1993). These diagnostic statistics included sensitivity, specificity, positive and negative predictive power, rate of false positive and negative diagnoses, the overall hit rate (i.e., total correct classifications), and kappa. Sensitivity represents the degree to which a variable correctly identifies individuals diagnosed with the disorder, whereas specificity represents the degree to which a variable correctly identifies individuals not diagnosed with the disorder. Positive predictive power (PPP) represents the proportion of participants classified by the variable as having the disorder who actually received the diagnosis, while negative predictive power (NPP) signifies the proportion classified by the variable as not having the disorder that truly did not receive the diagnosis. The false positive and false negative rates are the inverse of specificity and sensitivity, respectively (e.g., false positive rate = $1.00 - \text{specificity}$). Thus, values for these diagnostic statistics are not included in the DFA tables. The overall correct

classification is the variable's "hit rate," or the overall proportion of participants correctly classified by the variable. Kappa indicates level of agreement between a variable and a gold standard beyond that accounted for by chance (Kessel & Zimmerman, 1993). The statistical significance of the 2x2 classification table for each DFA was tested using the χ^2 statistic. In addition, the significance of the overall hit rate for each DFA was tested using Press' Q statistic. Press' Q statistic indicates whether a classification matrix may be considered statistically better than chance after comparing the overall number of correct classifications with the total sample size and number of groups (Hair et al., 1998; see formula in Appendix E, p. 183). Once calculated, the value for Press' Q was compared to critical values for the χ^2 statistic ($df = 1$) at increasingly strict alpha levels (i.e., $\alpha = .05$, $\alpha = .01$, $\alpha = .005$, and $\alpha = .001$) to obtain an indication of the degree to which the overall hit rate could be deemed statistically better than chance.

However, it is well known that DFA capitalizes on chance variation in the data to maximize accuracy of diagnostic classifications, reducing the generalizability of the discriminant functions obtained (Hair et al., 1998; Stevens, 1996). Therefore, to obtain more realistic estimates of the overall hit rate for the DFAs combining the classificatory power of all three EF factors, a jackknife procedure (Lachenbruch, 1967) was used to classify each participant after deriving classification functions to which his/her data did not contribute. That is, each participant was re-classified based on a classification statistic calculated using data from the remaining ($n - 1$) participants (Stevens, 1996). This procedure is believed to provide a realistic estimate of the accuracy of the classification derived from the variables in question (Stevens, 1996).

Measures

As the American Psychiatric Association (1994) noted, persons with ADHD appear to perform abnormally on tasks that require “effortful mental processing,” but they also state, “it is not yet entirely clear what fundamental cognitive deficit is responsible for this” (p. 81). Therefore, several standardized, norm referenced tests evaluating different aspects of cognitive functioning in which groups of ADHD and non-clinical groups of children and adults have been found to differ were utilized in this study. Moreover, an ADHD structured clinical interview was developed, and validated instruments were chosen (e.g., a structured psychiatric interview, self- and observer-rating scales, and several computer-based laboratory measures), that could potentially provide sufficiently sensitive and specific measures of inattentive, hyperactive (motor restless), and impulsive behavioral symptom dimensions of ADHD (i.e., measures that may successfully distinguish between inattentive, impulsive, and hyperactive [or restlessness] symptom dimensions). In addition, laboratory tasks evaluating key constructs long associated with the disorder (e.g., sustained attention, behavioral inhibition, effortful mental processing, and verbal and non-verbal working memory) were routinely administered to clients presenting for psychoeducational evaluation at the PSC, and all participants in the current study, were assessed on all measures noted here and detailed below.

Setting and Apparatus

All assessment activities took place at the PSC at Virginia Tech. Testing rooms were equipped with audio and/or video taping equipment 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 an IBM-compatible 486SX computer with super-VGA video display, and the other testing room was equipped with an IBM-compatible Pentium computer with super-VGA video display. It should be noted that the software programs for the attention, information processing, and working memory tasks required an IBM PC 386, 486, or Pentium (or 100 percent IBM compatible) computer system with at least 4 MB of RAM and a CGA, EGA, VGA, or Hercules video adapter attached to a color monitor.

Measures Evaluating Diagnostic Status

Structured Clinical Interviews

Participants' acute diagnostic status was assessed using the *Structured Clinical Interview for DSM-IV Axis I — Clinical Version* (SCID-I-CV; First et al., 1997a).

Personality disturbance was evaluated using a screening device ("SCID-II Screener" self-report questionnaire) covering each *DSM-IV* Axis-II personality disorder and proposed personality disorder categories. The SCID-II Questionnaire was published by American

Psychiatric Press for use with the *Structured Clinical Interview for DSM-IV Axis II*

Personality Disorders — (SCID-II; First, Gibbon, Spitzer, Williams, & Benjamin, 1997b).

In a reliability study for the SCID-II using 284 participants, test-retest kappas ranged from .24 to .74, and the overall weighted kappa was .53, indicating fair agreement (First, Spitzer, Gibbon, & Williams, 1995).

DSM-IV ADHD Symptoms

The presence of each *DSM-IV* ADHD symptom in adulthood and childhood was evaluated using a semi-structured clinical interview for ADHD (i.e., the *DSM-IV Adult ADHD Structured Clinical Interview*; see Appendix F; p. 184) developed by the current

author and modeled after the SCID-I (First et al., 1997a). The *DSM-IV Adult ADHD Structured Clinical Interview* was administered by trained and closely supervised psychological testing technicians. Thirty percent of the initial 94 interviews were checked for reliability, and kappa coefficients were calculated for Axis I diagnoses. The overall weighted kappa was .72, indicating good agreement across raters.

Self-, Parent-, and Observer-Ratings

The *Conners Adult ADHD Rating Scale* (Conners et al., 1999b) was used in self and observer formats. Importantly, the 18 items of the CAARS *DSM-IV* Symptom Subscales (items restating *DSM-IV* symptoms of the disorder in terms developmentally appropriate for adults) were utilized in the factor analysis of *DSM-IV* symptom dimensions.

Measures of Neurocognitive Executive Functioning

Conners Continuous Performance Test (CPT)

The Conners CPT is a relatively long and boring laboratory task that provides measures of sustained attention, response reaction time, and impulsivity (CPT; Conners, 1992, 1995). Participants were read instructions by trained technicians word-for-word as they appear in the Conners CPT Manual (Conners; see Appendix G, p. 196, for purchasing information). In general, participants were informed they would see a series of letters flashing on the computer screen one at a time. They were instructed to hit the spacebar one time for every letter that flashed, with the exception of the letter "X." That is, they were told to try not to hit any X's during the test but to hit all other letters as soon as they flashed. Moreover, participants were informed that the test lasts a relatively long time and that if they needed to stop during the test for any reason, the test would need to be re-administered. This CPT administration procedure was adopted in order to test the hypothesis that ADHD

adults require more time than non-ADHD adults to get mentally geared-up for the activity before they are fully "in the saddle." Subsequently, the data from the first of six time blocks from the Conners CPT were analyzed separately for overall group (ADHD vs non-ADHD) and subgroup (ADHD-C vs ADHD-I) differences in omission errors, commission errors, and mean hit reaction time (variables defined below).

The Conners CPT computer program presents six blocks (approximately two and one-half minutes each) and three different inter-stimulus intervals (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 Conners CPT software generates the following 11 dependent measures: 1.) hit reaction time (Hit RT); 2.) standard error of hit reaction time (SE Hit RT) — a measure of variability in attentional functioning over time; 3.) number and percent commission errors — a measure of impulsivity; 4.) number and percent omission errors — a measure of general inattentiveness; 5.) variability of standard errors (Var SE) — another measure of variability in attention across time; 6.) Beta (β) — a measure of response bias, or, how likely is a participant to decide that a stimulus is a target or a non-target; 7.) d-prime (d') — a measure of perceptual sensitivity, or the degree to which a participant is able to distinguish between target-present and target-absent trials; 8.) change in reaction time by block; 9.) change in reaction time by ISI; 10.) change in standard error by block; and 11.) change in standard error by ISI.

The CPT is known to be a reliable measure of neurocognitive and attentional dysfunction in children and adults with ADHD (Barkley, Grodzinsky, & DuPaul, 1992), schizophrenic patients (Earle-Boyer, Serper, Davidson, & Harvey, 1991), and autistic children (Garretson, Fein, & Waterhouse, 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 the Conners CPT data.

Paced Auditory Serial Addition Test (PASAT)

The PASAT was originally developed by Gronwall (1977) to assess the degree and rate of progress exhibited by patients recovering from closed head injury. Gronwall's test is a laboratory measure of information processing capacity administered under systematically increasing cognitive demand. Specifically, the following information processing demand conditions were administered sequentially to all participants: 1.) Low Demand Condition, 2.4 second ISI; 2.) Moderate Demand Condition, 2.0 second ISI; 3.) High Demand Condition, 1.6 second ISI; and 4.) Very High Demand Condition, 1.2 second ISI. In each condition, 60 addition trials are administered. The 60 addition trials are of roughly equivalent difficulty across the four information processing demand conditions. The task becomes more difficult with each sequentially administered condition, because the participant has less time in which to process the same amount of information. Specifically, in the very high demand condition, participants receive exactly one-half as much time to process the same quantity of information presented in the low demand condition.

In the current study, a computerized version of the PASAT (published by The Psychological Corporation, 1994) was used to administer the test to all participants. During the PASAT, participants listened to a series of single-digit numbers spoken by a male voice recorded in digital sound files and presented at specified intervals. The task required participants to add numbers according to the following rule: add the first number to the

second and speak the answer out loud into a computer microphone placed on a table directly in front of the participant (approximately 2 inches from the participant's mouth). The rules then require the participant to add the second number to the third number and speak the answer out loud, and then to add the third number to the fourth and speak the answer, and so on, throughout the administration of that condition. Before the administration of the actual test, untimed practice administrations were used to ensure that participants understood and were familiar with the task. The examiner introduced the test by showing participants a series of single digit numbers (1-9) printed on a sheet of paper. He/she then explained the addition rule. When the addition rule was fully understood, participants practiced several trials spoken by the examiner at a slow pace. When the untimed practice was completed, participants performed a slow (2.4 second ISI), paced practice session with a tape recorded version of the test. During the tape practice, if participants lost track for any reason, they were encouraged to “pick up and get going again after any two consecutive digits.” After participants successfully completed ten successive trials with the practice tape, the four conditions of the actual test were administered using the computer. Participants received a one-minute rest between each condition.

Wisconsin Card Sorting Test-Computer Version 2 (WCST-CV2)

The WCST-CV2 is a computerized version of the widely used, traditional version of the WCST (Grant & Berg, 1948; Heaton, 1993) published by Psychological Assessment Resources (see Appendix G, p. 196). The WCST is a frequently used measure of executive functioning and provides measures of non-verbal working memory, cognitive flexibility, and response perseveration. The WCST is a widely used in research with ADHD children (e.g., Chelune, Ferguson, Koon, & Dickey, 1986). The WCST-CV2 was administered on an IBM

compatible computer running Windows 95, but the program required IBM-DOS 2.1 or higher and a VGA or SVGA color monitor. The traditional card version of the task requires a participant to hold the response card deck, and he/she is instructed to place the response card beneath the stimulus card he/she believes is the correct match. During the WCST-CV2, participants sat directly in front of the computer monitor, and computer keyboard was placed on a table directly in front of the participant. In the response mode adopted for the current study, four keys were marked with keytop stickers (“F”-one red triangle, “G”-two green stars, “H”-three yellow crosses, “J”-four blue circles) to represent each of the "card" stimuli on the computer screen. These keys were used to gather accuracy and latency data on each response. When a participant’s response matched the sorting principle in effect at the time, the computer provided visual and auditory feedback indicating whether that response was “right,” or “wrong.” Once the participant correctly sorts 10 consecutive cards, the sorting principle is changed without warning (e.g., from color to shape). Research indicates that computerized versions of the WCST provide advantages over the traditional method of examiner administration in terms of increases in accuracy of administration and scoring (Tien, Spevack, Jones, Pearlson, Schleapfer, & Strauss, 1996).

Wechsler Adult Intelligence Scale—Third Edition (WAIS-III)

Cognitive ability was evaluated using the WAIS-III (Wechsler, 1997b). The Wechsler adult intelligence tests (*Wechsler Adult Intelligence Scale-Revised*, WAIS-R, Wechsler, 1981; and WAIS-III, Wechsler, 1997b) are the most commonly used measures of adult intelligence. The WAIS-III was used in this study to assess overall cognitive functioning, executive functioning deficits often exhibited by individuals with attentional disorders, and the potential presence of a learning disability. Tests were administered

according to standardized instructions (Wechsler, 1997a) by trained and closely supervised psychological testing technicians. As with the WAIS-R, the WAIS-III is considered to be useful in assessing a variety of neurological impairments, including various forms of cognitive deficits (e.g., memory problems and aphasia) as well as motor skills deficits (Kaufman, 1990, 1994; WAIS-III technical manual, 1997). The WAIS-III factor scores provide indices of cognitive functions potentially related to cognitive deficits exhibited by young adults with attentional and learning disorders.

Wechsler Memory Scale—Third Edition (WMS-III)

Immediate and delayed verbal memory functioning was assessed using the verbal memory sections of the WMS-III (Wechsler, 1997c). The Logical Memory and Verbal Paired Associates subtests of the WMS-III were administered to each participant. Adults referred for a psychoeducational assessment at the Psychological Services Center (PSC) frequently present with “ADHD-like” symptoms and appear to exhibit deficits in receptive auditory verbal memory. The Logical Memory and Verbal Paired Associates Subtests of the WMS-III are valid measures of overall immediate and delayed short-term receptive auditory verbal memory functioning, as well as memory for complex language and attention span for receptive language (D'Elia, Satz, & Schretlen, 1989). Therefore, these subtests from the WMS-III were used to generate standard scores on which the empirically-derived participant clusters were compared.

Assessment of Academic Achievement

Woodcock-Johnson Psycho-Educational Battery-Revised (WJ-R)

The WJ-R (Woodcock & Johnson, 1989, 1990) is a comprehensive achievement test comprised of a broad range of individually administered tests for evaluating cognitive

abilities, scholastic aptitudes, and educational achievement. All sections of the standard achievement battery from the WJ-R were administered to all participants. Broad achievement scores in reading, math, written language, and knowledge were used, along with measures of Verbal IQ (or the Verbal Comprehension Index as clinically appropriate) from the WAIS-III, to calculate ability-achievement discrepancies used to help identify participants with learning disorders. The rule that determined whether a participant's VIQ or VCI was used to calculate his/her ability—achievement discrepancy required that when a participant's VCI was ≥ 10 standard score points higher than his/her WMI from the WAIS-III, his/her VCI was used to compute this discrepancy (per Kaufman, 1990, 1994). Kaufman (1990, 1994) notes that when this pattern of scores obtains for the Verbal Comprehension and Working Memory Indices, then a participant's Verbal IQ likely captures two disparate aspects of verbal intellectual ability, and as such, does not represent an optimal estimate of his/her verbal capacity. In such cases, Kaufman (1994) recommends using the VCI to estimate one's verbal cognitive ability.

RESULTS

Sample Characteristics

Sample characteristics and group comparisons on these characteristics are summarized in Table 1. The groups were not significantly different by sex, age, or highest level of education. Statistically significant differences were found on FSIQ and PIQ from the WAIS-III. Post hoc comparisons (Fisher's least significant difference procedure; LSD) indicated that the ADHD group obtained significantly lower FSIQ and PIQ scores than the LD and clinic-referred control groups. The issue of whether to statistically or methodologically control group differences in IQ in neuropsychological studies is controversial. Some investigators emphasize the need to control for differences in cognitive ability when evaluating executive functioning (EF), given high correlations between measures of these constructs (Denckla, 1994, 1996b; Voeller, 2001). However, as noted above, other investigators recommend against controlling for IQ, because decreased IQ estimates in the lower EF group likely emerge from aspects of IQ measures requiring executive control (Seidman et al., 1997). Based on this argument, investigators conducting one recent study comparing EF in ADHD and control adults who differed on estimated IQ decided a priori not to covary IQ in neuropsychological analyses (Johnson et al., 2001). Based on this earlier study, and because controlling for differences in IQ may inadvertently remove variance attributable to the phenomenon this study was conducted to measure (i.e., effects of ADHD), the a priori decision was made not to use PIQ (the measure accounting for the significant difference in FSIQ across groups) as a covariate in analyses of neuropsychological measures reported below.

What Symptom Dimensions Exist in Adult ADHD?

Hypothesis 1a was tested via exploratory factor analysis of the 18 items of the *DSM-IV* ADHD Symptom Scales from the CAARS-Observer and CAARS-Self forms. Self and observer data were subjected separately to principal factors analyses (communalities = multiple *R*-square) with varimax rotations. Based on the Kaiser criterion (Kaiser, 1960), only factors accounting for variance equivalent to that of one original variable should be retained for interpretation. For both sets of ratings, four factors with eigenvalues above 1.0 were extracted from the 18 *DSM-IV* ADHD symptom items (see Figure 3). However, according to the scree criterion (Cattell, 1966), factors extracted beyond the first two factors in both analyses accounted for too little additional independent variance to be retained for interpretation (i.e., four and three percent respectively for self- and observer-ratings; Figure 3). Therefore, the two-factor solutions for both sets of ratings were rotated (factor loadings for both analyses are presented in Table 2).¹ As may be seen in Figure 3 and Table 2, results of the separate factor analyses of observer- and self-ratings of the 18-item *DSM-IV* CAARS (Conners, et al., 1999b) Symptom Scales were very similar. Both analyses generated clear, two-dimensional symptom structures with items reflecting *DSM-IV* inattentive symptoms emerging together on the first factor and items representing *DSM-IV* hyperactive and impulsive symptoms loading together on a second factor. The two-dimensional factor structure extracted using CAARS-O scores on the 18 *DSM-IV* symptom items accounted for approximately 54 percent of total variance in observer-ratings. Moreover, the two dimensions extracted with these 18-items using CAARS-S data accounted for approximately 46 percent of variance in self-ratings.

¹ A review of considerations regarding how many factors should be retained is presented in Appendix H.

Where the issue of factor cross-loading was concerned, Lahey et al. (1988) noted variables with loadings $\geq .35$ on more than one factor "may not be descriptive of only one maladaptive dimension" (Lahey et al., 1988, p. 332). Two items from the observer-ratings loaded high on both factors (i.e., inattention symptom eight, "appears distracted when things are going on around him/her"; and restlessness/overactivity symptom seven, "gives answers to questions before the questions have been completed"). Moreover, three self-rated items loaded high on both factors (i.e., inattentive symptom three, "has trouble listening to what other people are saying"; inattentive symptom eight, "appears distracted when things are going on around him/her"; and restlessness/overactivity item four, "gets rowdy or boisterous during leisure activities").

Where the statistical significance of factor loadings was concerned, issues of sample size and power are critical for estimating which factor loadings are statistically significant (Hair et al., 1998). Based on a sample size of 80 for observer- and self-ratings, alpha (α) levels of .05, minimum acceptable power of 80 percent, and standard errors assumed twice those of conventional correlation coefficients (two-tailed test), factor loadings of $\geq .63$ for self and observer forms were considered statistically significant (StatSoft, 1998).

Hypothesis 1b was tested using two separate MANOVAs with CAARS-S:L and CAARS-O:L data to analyze overall group differences on self- and observer-ratings of empirically derived symptom domains (i.e., Inattention Memory Problems factor, Hyperactivity/Restlessness factor, Impulsivity/Emotional Lability factor, and Problems with Self-Concept factor). As expected, the overall MANOVA using self-ratings revealed significant differences across the three groups in these domains of secondary functional impairment, $F(8, 148) = 5.52, p = .000004$, Wilk's Lambda = .59. Follow-up univariate

analyses of variance (ANOVAs) were conducted to determine which of the factors reflecting the different domains of symptom impairment accounted for the overall significant MANOVA (see Table 3). As predicted, univariate analyses revealed significant group effects for the Inattention/Memory Problems factor, $F(2, 77) = 16.37, p = .000001$, the Hyperactivity/Restlessness factor, $F(2, 77) = 6.22, p = .0031$, the Impulsivity/Emotional Lability factor, $F(2, 77) = 4.89, p = .0100$, and the Problems with Self-Concept factor, $F(2, 77) = 6.32, p = .0029$. Post hoc LSD analyses¹ comparing the three groups on each factor revealed that the ADHD group reported significantly greater impairment than did the LD and clinic-referred control groups on the Inattention/Memory Problems and Problems with Self-Concept factors. However, contrary to expectations, in part, the ADHD group reported significantly more difficulty than the LD group on the Hyperactivity/Restlessness and Impulsivity/Emotional Lability factors, but ADHD adults did not report significantly more difficulty on these factors than did the clinic-referred control group.

Where observer-ratings of symptom impairment in these empirically derived domains were concerned, as predicted, the overall MANOVA revealed a significant effect for group status, $F(8, 148) = 2.22, p = .035$, Wilk's Lambda = .80. Follow-up univariate analyses of variance (ANOVAs) were conducted to determine which of the four factors reflecting the different symptom domains accounted for the overall significant MANOVA (see Table 4). As predicted, univariate analyses revealed significant group effects for the Inattention/Memory Problems factor, $F(2, 77) = 4.33, p = .0166$, and the Hyperactivity/Restlessness factor, $F(2, 77) = 3.50, p = .0351$. However, contrary to expectations,

¹ A conservative alpha level of .009 was used for the LSD analyses comparing specific groups on symptom impairment to adjust for the number of comparisons performed.

univariate analyses revealed non-significant group effects for the Impulsivity/Emotional Lability factor, $F(2, 77) = 2.77, p = .0689$, and the Problems with Self-Concept factor, $F(2, 77) = .07, p = .9303$. Post hoc LSD analyses¹ comparing the three groups on the Inattention/Memory Problems and Hyperactivity/ Restlessness factors revealed that observers rated ADHD adults as exhibiting significantly greater impairment than LD adults, but not clinic-referred control adults.

What Domains of Executive Dysfunction Are Involved in Adult ADHD?

Hypothesis 2 was tested via principle components analysis (PCA) of data from 10 standardized, neuropsychological measures of executive functioning. The neuropsychological measures included in the PCA were first analyzed using a multivariate analysis of variance (MANOVA) to test overall group differences when considering all 10 variables collectively. This analysis revealed significant group differences in neurocognitive functioning across the three groups (ADHD, LD, or clinic-referred control), $F(20, 136) = 2.56, p = .0008$; Wilk's Lambda = .53. Follow-up univariate analyses of variance (ANOVAs) were conducted to determine which of the 10 variables accounted for the overall significant MANOVA (see Table 5). Univariate analyses revealed significant effects ($p < .05$) for group status for eight of the 10 neuropsychological measures. Only Percent Perseverative Errors from the WCST, $F(2,77) = 1.93, p = .15$, and Digits Forward from the WAIS-III, $F(2,77) = 1.48, p = .23$, showed non-significant effects for group status. For the remaining eight measures for which

¹ A conservative alpha level of .009 was used for the LSD analyses comparing specific groups on symptom impairment to adjust for the number of comparisons performed.

univariate F values were significant, post hoc analyses (LSD¹) were performed to determine which groups showed significant differences. Table 5 reveals that the ADHD group performed significantly less well than the LD and clinic-referred control groups on four measures from the Conners CPT (i.e., Hits Percentile, Commission Errors, Overall d -prime, and Omission Errors) and one measure from the PASAT (i.e., Total Correct Responses). Table 5 also reveals that the ADHD group performed significantly less well than the clinic-referred control group on two measures from the WAIS-III (Working Memory Index and Processing Speed Index) and one measure from the WMS-III (Auditory Immediate Index).

To preliminarily address the question of whether the neurocognitive executive control deficits exhibited by adults with ADHD are unidimensional or multidimensional phenomena, the 10 EF measures were subjected to principal components factor analysis with varimax rotations. The results of the principle components analysis of the 10 EF variables are presented in Table 6. Three factors were extracted with eigenvalues above 1.00, and this three-factor solution was rotated. The rotated solution revealed a clear three-dimensional structure for the 10 executive control measures. Specifically, tasks requiring effortful verbal processing (Working Memory Index, WAIS-III; Digits Forward Total Score, WAIS-III; and PASAT Total Correct) loaded together on a factor termed *Effortful Verbal Working Memory* that accounted for 23 percent of the total variance in scores. Moreover, tasks requiring effortful maintenance of readiness to continue, or stop, responding (Overall d -prime, Total Omission Errors, Total Commission Errors, and Hits Percentile, all from the Conners CPT), loaded together on a factor termed *Effortful Intention* that accounted for 28

¹ A conservative alpha level of .005 was used for the post hoc LSD analyses to adjust for the number of comparisons performed.

percent of the total variance in scores. Finally, tasks requiring participants to quickly and efficiently process, remember, and strategically utilize (on the task at hand) novel verbal or non-verbal information (Auditory Immediate Index, WMS-III; Percent Perseverative Errors, WCST; and Processing Speed Index, WAIS-III), loaded together on a factor termed *Effortful Learning* that accounted for 17 percent of the total variance in scores. Collectively, these three factors accounted for 68 percent of the total variance in scores on the 10 EF variables.

As noted in the Procedures section above, mean composite scores on each factor for all participants were calculated by (a) converting data for each variable to standard score format ($M=100$; $SD=15$) when not already recorded as such, (b) summing standard scores for variables that loaded most strongly on each of the factors, and (c) dividing by the number of such variables. Mean composite scores for each factor were utilized in the analyses regarding discriminant validity of ADHD and in the discriminant function analyses reported below.

Does ADHD in Adults Show Discriminant Validity?

Hypothesis 3a was tested via MANOVA to examine group differences considering all three empirically derived EF factors collectively. As expected, the MANOVA revealed significant differences across the three groups in neurocognitive executive functioning, $F(6, 150) = 5.86$, $p = .00002$, Wilk's Lambda = .66. Follow-up univariate analyses of variance (ANOVAs) were conducted to determine which of the three EF factors accounted for the overall significant MANOVA (see Table 6). Univariate analyses revealed significant group effects for the Working Memory factor, $F(2, 77) = 6.13$, $p = .0034$, the Sustained Attention factor, $F(2, 77) = 12.27$, $p = .00002$, and the Effortful Learning factor, $F(2, 77) = 7.61$, $p = .001$. Post hoc LSD analyses were performed to determine which groups showed significant

differences on each factor.¹ Table 7 reveals that the ADHD group performed significantly less well than the clinic-referred control group, but not the LD group, on the Working Memory and Effortful Learning factors. Moreover, Table 7 also shows that the ADHD group performed significantly less well than the LD and clinic-referred control groups on the Effortful Intention factor.

Hypotheses 3b, 3c, and 3d were tested using a MANOVA to analyze overall group differences on measures of cognitive ability requiring lower degrees of executive control, academic achievement, and delayed verbal memory. As expected, the MANOVA revealed significant differences across the three groups in these domains of secondary functional impairment, $F(14, 142) = 2.58, p = .002$, Wilk's Lambda = .64. Follow-up univariate analyses of variance (ANOVAs) were conducted to determine which of the measures of secondary functional impairment accounted for the overall significant MANOVA (see Table 8). As predicted, for the measures of cognitive ability purportedly requiring lower levels of executive control, a univariate analysis revealed a non-significant group effect for the Verbal Comprehension Index (VCI), $F(2, 77) = .72, p = .49$. However, contrary to expectations, a significant ANOVA was obtained for the Perceptual Organization Index (POI), $F(2, 77) = 3.23, p = .045$. Nonetheless, a post hoc LSD analysis comparing the three groups on mean POI scores revealed that no between group differences reached significance at the

¹ A conservative alpha level of .01 was used for these post hoc LSD analyses to adjust for the number of comparisons performed.

conservative alpha level of .009.¹ Yet, a trend was noted on the LSD test in the comparison of the ADHD and LD groups on the POI, $p = .023$.

Contrary to expectations, univariate analyses revealed no significant group effects for academic achievement in reading (mean Broad Reading standard score; WJ-R), $F(2, 77) = 1.81, p = .17$, math (mean Broad Math standard score; WJ-R), $F(2, 77) = 1.65, p = .199$, or knowledge (mean Broad Knowledge standard score; WJ-R), $F(2, 77) = 1.63, p = .203$. However, consistent with expectations, a significant ANOVA was obtained for writing achievement (mean Broad Written Language standard score; WJ-R), $F(2, 77) = 3.70, p = .029$. A post hoc LSD comparing the three groups on mean Broad Written Language standard scores revealed a significant difference between the LD and clinic-referred control groups ($\alpha = .009$) but a non-significant difference between the ADHD group and the two non-ADHD groups.

As predicted, a univariate analysis revealed a significant group effect for delayed recall of recently acquired verbal material (mean Auditory Delayed Index score [ADI]; WMS-III), $F(2, 77) = 3.95, p = .023$. However, a post hoc LSD comparing the three groups on mean ADI scores revealed that no between group differences reached significance at the conservative alpha level of .009. Nonetheless, trends were noted on the LSD test in comparisons of the ADHD and LD groups on the ADI, $p = .016$, and the ADHD and clinic-referred control groups on the ADI, $p = .031$.

Hypothesis 3e was tested via a 2 x 2 chi-square (χ^2) analysis. Given that the 2 x 2 tables used to estimate the χ^2 statistic for this comparison contained small observed

¹ A conservative alpha level of .009 was used for the LSD analyses comparing specific groups on secondary functional impairment to adjust for the number of comparisons performed.

frequencies (some expected frequencies ≤ 10), Yates' corrected χ^2 statistic was used to make the estimation more conservative (Hayes, 1981). Contrary to expectation, this analysis revealed that the ADHD group did not present with significantly more comorbid psychopathology than the LD group, $\chi^2 (1) = .84, p = .36$ (see Table 9). Forty percent of the ADHD group had comorbid psychopathology (i.e., carried at least one additional Axis I diagnosis) while 25 percent of the LD group met criteria for another diagnosis (i.e., in addition to the original ADHD or LD diagnosis that served as the basis for group membership). Too few Axis II disorders were present to examine the relationship between the diagnosis of ADHD and comorbid personality disorders.

Do Subtypes of Adult ADHD Show Discriminant Validity?

In this section, results of analyses are reported that tested a series of hypotheses regarding the *DSM-IV* subtypes of ADHD (i.e., Combined and Inattentive Types)¹. These analyses were similar to those examined above with the three primary groupings (ADHD, LD, and clinic-referred control groups), but in the subtypes analyses, the groups were comprised of adults meeting criteria for ADHD-Combined Type (ADHD-C group), adults meeting criteria for ADHD-Inattentive Type (ADHD-I group), and as above, adults not meeting criteria for any Axis I or II diagnosis upon completion of their clinical evaluation (clinic-referred control group). These hypotheses were tested to examine whether *DSM-IV* subtypes of ADHD show discriminant validity in domains of executive and functional impairment among clinic-referred adults.

¹ No adults were identified by research diagnosis criteria (see Appendix G) in this sample who met criteria for ADHD-Predominately Hyperactive-Impulsive Type.

Hypothesis 4a was tested via MANOVA to examine overall group differences considering all three empirically derived EF factors collectively. As expected, the MANOVA revealed significant differences across the three groups (ADHD-C, ADHD-I, and clinic-referred control) in neurocognitive executive functioning, $F(6, 100) = 3.98, p = .0013$, Wilk's Lambda = .65. Follow-up univariate analyses of variance (ANOVAs) were conducted to determine which of the three EF factors accounted for the overall significant MANOVA (see Table 10). Univariate analyses revealed significant group effects for the Verbal Working Memory factor, $F(2, 52) = 5.57, p = .0064$, the Sustained Intention factor, $F(2, 56) = 8.12, p = .0008$, and the Effortful Learning factor, $F(2, 77) = 5.66, p = .0060$. Post hoc LSD analyses were performed to determine which groups showed significant differences on each factor.¹ Table 10 reveals that the ADHD-C and ADHD-I groups performed significantly less well than the clinic-referred control group on the Verbal Working Memory, Sustained Intention, and Effortful Learning factors. However, Table 10 also indicates that no significant differences were found between the ADHD subgroups in performance on the EF factors.

Hypotheses 4b, 4c, and 4d were tested using a MANOVA to analyze overall group differences on lower EC demand measures of cognitive ability, measures of academic achievement, and a measure of delayed verbal memory. Contrary to expectations, the MANOVA did not reveal a significant effect for group status when lower EC demand cognitive measures, measures of academic achievement, and a measure of delayed verbal memory were considered collectively, $F(14, 92) = 1.11, p = .363$, Wilk's Lambda = .73 .

¹ A conservative alpha level of .0175 was used for these post hoc LSD analyses to adjust for the number of comparisons performed.

Similar to the examination of Hypothesis 3e reported above, Hypothesis 4e was tested using two separate MANOVAs with CAARS-S:L and CAARS-O:L data to analyze overall group differences on self- and observer-ratings of secondary functional impairments in adaptive memory (Inattention Memory Problems factor), internal restlessness (Hyperactivity/Restlessness factor), emotional stability (Impulsivity/Emotional Stability factor), and self-concept (Problems with Self-Concept factor). As expected, the overall MANOVA using self-ratings revealed significant differences across the three groups in these domains of secondary functional impairment, $F(8, 98) = 3.84, p = .0006$, Wilk's Lambda = .58. Follow-up univariate analyses of variance (ANOVAs) were conducted to determine which of the factors reflecting the different domains of secondary functional impairment accounted for the overall significant MANOVA (see Table 11). As predicted, univariate analyses revealed significant group effects for the Inattention/Memory Problems factor, $F(2, 52) = 4.24, p = .0198$, the Hyperactivity/Restlessness factor, $F(2, 52) = 4.65, p = .0139$, the Impulsivity/Emotional Stability factor, $F(2, 52) = 6.85, p = .0023$, and the Problems with Self-Concept factor, $F(2, 52) = 4.03, p = .0236$. Post hoc LSD analyses¹ comparing ADHD-C, ADHD-I, and clinic-referred control groups in each domain of secondary impairment revealed that contrary to expectations, in part, the ADHD-I group reported significantly greater impairment than did the clinic-referred control group on the Inattentive/Memory Problems factor, but neither of these groups were significantly different from the ADHD-C group on this factor. Moreover, as was partly consistent with predictions for self-rated secondary impairment, ADHD-C adults reported significantly greater

¹ A conservative alpha level of .0125 was used for the LSD analyses comparing specific groups on secondary functional impairment to adjust for the number of comparisons performed.

difficulty with internal restlessness (Hyperactivity/Restlessness factor) than did the ADHD-I group. Yet, ADHD-C and control adults were not significantly different in self-rated overactivity and restlessness. Consistent with expectations, the ADHD-C group reported significantly greater difficulty with emotional control and impulsivity than did either the ADHD-I or control groups. Finally, contrary to expectations, ADHD-C, ADHD-I, and control adults did not report significantly different levels of difficulty with poor self-concept.

Where observer-ratings of secondary functional impairments in these domains were concerned, contrary to predictions, the overall MANOVA did not reveal a significant effect for group status, $F(8, 98) = 1.85, p = .076, \text{Wilk's Lambda} = .75$.

Hypothesis 4f was tested via a 2 x 2 chi-square (χ^2) analysis. As was the case when comparing ADHD and LD groups on number of comorbid diagnoses (reported above), given that the 2 x 2 tables used to estimate the χ^2 statistic for the comparison of ADHD-C and ADHD-I groups contained small observed frequencies, with some expected frequencies ≤ 10 , Yates' corrected χ^2 statistic was used again here to make the approximation more conservative (Hayes, 1981). Contrary to expectation, the χ^2 comparing ADHD-C and ADHD-I groups on number of comorbid affective disorders was not significant, $\chi^2(1) = .03, p = .87$ (see Table 9). Also as reported in Table 9, ADHD-C and ADHD-I groups were not significantly different on number of comorbid anxiety disorder diagnoses, $\chi^2(1) = .03, p = .87$. In addition, the ADHD-C group was not found to have received significantly more substance use disorder diagnoses than the ADHD-I group. Overall, 45 percent ($n=9$) of the ADHD-C adults, and 36 percent ($n=5$) of the ADHD-I adults, carried at least one additional Axis I diagnosis. As was the case when comparing the overall ADHD and LD groups, too

few Axis II disorders were present to examine the relationship between *DSM-IV* subtypes of ADHD and comorbid personality disorders.

Do Measures of Executive Dysfunction Show Adequate Diagnostic Utility?

ADHD vs. Non-ADHD

Hypothesis 5a was tested via several separate discriminant function analyses (DFAs) with the overall *ADHD and non-ADHD* groups using composite scores from the three empirically derived executive functioning (EF) factors reported in Table 6. The three DFAs conducted using the separate EF factors identified optimal composite standard score¹ cutoffs of ≤ 97 for the Verbal Working Memory factor, ≤ 98 for the Sustained Intention factor, and ≤ 97 for the Effortful Learning factor. Table 12 reveals that for each factor, the proportion of participants scoring below the cutoff scores who were correctly classified as ADHD (sensitivity) was relatively low and ranged from 54 to 60 percent. These sensitivity values resulted in high false negative rates that ranged from 40 to 46 percent. However, the proportions of non-ADHD participants who obtained scores below these cutoff values (false positive rates) for the Working Memory, Sustained Intention, and Effortful Learning factors were comparatively lower at 27, 20, and 16 percent, respectively. Moreover, these relatively low rates for false positive diagnoses among the non-ADHD adults indicate that the separate composite scores correctly identified 73, 80, and 84 percent of participants not diagnosed with ADHD (specificity).

Where positive and negative predictive power (PPP and NPP) were concerned (again, positive and negative predictive values represent the probability that a participant

¹ Given that some standard scores used to identify the EF factors were derived exclusively from scores in this sample, mean scores of 100 do not reflect an “average” level of performance.

does or does not meet criteria for a diagnosis given that a test classifies the participant as meeting or not meeting criteria for the diagnosis; Kessel & Zimmerman, 1993), it is important to note that although an initial examination of these more clinically meaningful indices as reported in Table 12 suggested that the factors performed somewhat better in terms of NPP than PPP, further analysis revealed that the factors showed notably better PPP than NPP given the base rates of ADHD (44 percent) and non-ADHD (56 percent) in this sample. Specifically, an index of the degree to which each factor successfully identified ADHD participants as having the disorder beyond the rate accounted for by the base rate of ADHD in the sample was derived by subtracting the base rate of ADHD from the value for PPP (e.g., PPP for Effortful Learning factor [73 percent] – base rate of ADHD [44 percent] = improvement in positive prediction beyond base rate [29 percent]). When this simple calculation was performed for each factor, results indicated improvements in positive prediction beyond base rate of 17, 26, and 29 percent, for the Working Memory, Sustained Intention, and Effortful Learning factors, respectively. However, computation of an index showing the degree to which the EF factors successfully identified non-ADHD participants as not having the disorder beyond the rate accounted for by the prevalence of non-ADHD in the sample (e.g., NPP for Effortful Learning factor [70 percent] – prevalence of non-ADHD [56 percent] = improvement in negative prediction beyond that accounted for by the prevalence of non-ADHD [14 percent]) revealed lower rates of accuracy for negative prediction. Specifically, results of this NPP vs prevalence analysis indicated improvements in negative prediction beyond prevalence of non-ADHD of only 11, 16, and 14 percent, for the respective factors. Therefore, levels of PPP for the 3 EF factors when evaluated separately were generally adequate, averaging approximately 25 percent higher than the

base rate of ADHD in this sample. However, the NPP rates were, on average, only 14 percent higher than the prevalence of non-ADHD adults in this sample. These findings suggest that, in general, when the EF factors identified a participant as having ADHD, there was a relatively good chance that he/she did actually meet criteria for the disorder. However, the findings also indicated that the odds of not having the diagnosis when the EF factors identified one as non-ADHD, were comparatively lower.

Nonetheless, as reported in Table 12, the χ^2 tests were significant for all of the classification tables generated in the separate DFAs with each EF factor. Moreover, Table 12 also shows that kappas ranged from a low of 28 percent (Working Memory factor) to a high of 41 percent (Sustained Intention factor) for the degree to which observed agreement exceeded chance agreement. In addition, calculation of Press' Q statistic generated values of 7.20 ($p < .01$) for the Working Memory factor, 14.45 ($p < .001$) for the Sustained Intention factor, and 14.45 ($p < .001$) for the Effortful Learning factor. These findings indicated that when taken alone, each EF factor generated overall correct classifications for ADHD and non-ADHD adults that were statistically better than chance after adjusting for sample size and number of groups.

However, a further DFA was conducted with ADHD and non-ADHD adults using all three EF factors combined to determine if positive and negative predictive power and classification accuracy would improve. Table 12 reveals that the proportion of participants whose average canonical score (i.e., based on a linear combination of factors; average canonical score = the sum of canonical scores [factor composite x raw canonical coefficient for that factor] / number of factors; compared to an optimal cutoff [constant]; see Method section above) fell below the cutoff (indicating that the combined factors classified him/her

as ADHD) who were correctly classified as ADHD (sensitivity) was notably improved at 69 percent. Although this sensitivity value was improved as compared to that produced by any of the EF factors in isolation, it resulted in three of 10 ADHD adults being misclassified as non-ADHD (false negatives). Interestingly, use of the combined EF factors did not produce a notable increase in specificity as compared to use of the separate factors, but again, approximately 80 percent of the non-ADHD adults were correctly designated as non-ADHD and false positive diagnoses remained acceptable at 18 percent. Moreover, where PPP and NPP were concerned, Table 12 suggests that NPP exceeded PPP in classifying ADHD and non-ADHD adults, but again, the improvement in positive prediction beyond base rate of ADHD in this sample was 31 percent for this analysis, whereas negative prediction exceeded prevalence of non-ADHD by 21 percent. Therefore, PPP exceeded NPP in this analysis. Again, this latter finding suggests that when a participant was designated ADHD by his/her performance on the combined EF factors, there was a relatively strong likelihood that he/she actually met criteria for ADHD. However, when a participant's EF performance resulted in his/her assignment to the non-ADHD group, odds were somewhat lower that he/she actually did not meet criteria for the diagnosis. It should also be noted here that the Sustained Intention factor demonstrated greatest discriminatory power, the Effortful Learning factor showed slightly less discriminatory power, and the Working Memory factor demonstrated least discriminatory power, in separating the ADHD and non-ADHD groups.

In evaluating the statistical significance of the classification based on the combined EF factors for the ADHD and non-ADHD groups, the χ^2 test was significant as reported in Table 12. Moreover, Table 12 shows that use of the combined EF factors resulted in notable improvement in the degree to which observed agreement exceeded chance agreement (kappa

= 51). In addition, the value for Press' Q statistic was 22.05, indicating that the performance of ADHD and non-ADHD adults on the EF tests that comprised the three empirically derived factors generated an overall level of agreement between test performance and diagnostic algorithm (overall correct classifications = 76 percent) that was significantly better than chance at $p < .001$ after adjusting for sample size and number of groups.

However, given that DFA capitalizes on chance variation in a sample when calculating classification coefficients, a jackknife validation procedure (Lachenbruch, 1967) using the combined EF factors was utilized to classify each participant after deriving classification functions to which his/her data did not contribute. Table 12 reveals that sensitivity was notably lower when the jackknife procedure was used, resulting in an increase in false negatives from 31 to 40 percent. However, just as use of the combined EF factors did not produce a notable increase in specificity as compared to use of the separate factors, use of the jackknife procedure did not produce a meaningful decrease in specificity. Specifically, 80 percent of the non-ADHD adults were correctly designated as non-ADHD and false positive diagnoses remained acceptable at 20 percent upon use of the jackknife validation procedure. Moreover, positive and negative predictive power remained acceptable, with positive prediction beyond base rate of ADHD being 26 percent, and negative prediction beyond prevalence of non-ADHD being 16 percent. In addition, although the χ^2 test for the classification results of the validation procedure remained significant ($p = .0002$), the degree to which observed agreement exceeded chance showed a notable decrease (i.e., kappa dropped from 51 to 41). Nonetheless, the value for Press' Q statistic for the results of the jackknife procedure was 14.45, indicating that for the ADHD and non-ADHD groups, the overall level of agreement between test performance (EF

factors) and diagnostic algorithm (overall correct classifications = 71 percent) remained statistically significant at $p < .001$ after adjusting for sample size and number of groups.

ADHD vs. LD

Hypothesis 5b was tested via several separate discriminant function analyses (DFAs) with the *ADHD and LD* groups using composite scores from the three empirically derived executive functioning (EF) factors. The three DFAs conducted using the separate EF factors identified optimal composite standard score¹ cutoffs of ≤ 106 for the Verbal Working Memory factor, ≤ 104 for the Sustained Intention factor, and ≤ 106 for the Effortful Learning factor. Table 13 reveals that for each factor, the proportion of participants scoring below the cutoff scores who were correctly classified as ADHD (sensitivity) was adequate and ranged from 77 percent (Sustained Intention factor) to 83 percent (Effortful Learning factor). These sensitivity values resulted in tolerable false negative rates of 20, 23, and 17 percent for the Working Memory, Sustained Intention, and Effortful Learning factors, respectively. However, the proportions of LD participants who obtained scores below these cutoff values (false positive rates) for the respective factors were markedly higher at 54, 54, and 79 percent, respectively. Moreover, these very high rates for false positive diagnoses among the LD adults indicated that the separate composite scores correctly identified only 46, 46, and 21 percent of participants not diagnosed with ADHD (specificity).

Where positive and negative predictive power (PPP and NPP) were concerned, it is important to note that although an initial examination of these more clinically meaningful indices as reported in Table 13 suggested that the factors performed somewhat better in

¹ Given that some standard scores used to identify the EF factors were derived exclusively from scores in this sample, mean scores of 100 do not reflect an “average” level of performance.

terms of PPP than NPP, further analysis revealed that the factors showed notably better NPP than PPP given the base rates of ADHD (59 percent) and LD (41 percent) in these analyses. Specifically, results of a PPP vs. base rate of ADHD analysis indicated improvements in positive prediction beyond base rate of only 9, 9, and 1 percent, for the Working Memory, Sustained Intention, and Effortful Learning factors, respectively. However, a NPP vs prevalence of LD analysis indicated improvements in negative prediction beyond prevalence of LD of 20, 17, and 4 percent, for the respective factors. Therefore, levels of PPP for the 3 EF factors when evaluated separately were unacceptably low, averaging approximately 6 percent higher than the base rate of ADHD in these analyses. However, the NPP rates were, on average, approximately 14 percent higher than the prevalence of LD adults in these analyses. These findings suggest that, in general, there was a 68 percent chance that a participant identified as meeting criteria for ADHD actually met criteria for the disorder, but even this moderate level of accurate positive prediction may have arisen as an artifact of the relatively high base rate of ADHD in these analyses. In contrast, when EF test performance indicated that a participant did not meet criteria for ADHD (i.e., and thus, that he/she met criteria for an LD diagnosis), there was a relatively good chance that he/she met criteria for LD as opposed to ADHD.

Nonetheless, as reported in Table 13, only for the Verbal Working Memory factor did the χ^2 test reach significance. Moreover, although the degree to which observed agreement exceeded chance agreement for the Verbal Working Memory and Sustained Intention factors was relatively low (as indicated in kappas of 27 and 24, respectively), classification based on the Effortful Learning factor was essentially equal to chance (kappa = 4). In addition, calculation of Press' Q statistic generated values of 6.12 ($p < .05$) for the

Working Memory factor, 4.90 ($p < .05$) for the Sustained Intention factor, and 1.37 (ns) for the Effortful Learning factor. These findings indicated that when taken alone, only the Working Memory and Sustained Intention factors generated overall correct classifications for ADHD and LD adults that were statistically better than chance after adjusting for sample size and number of groups.

However, a further DFA was conducted with ADHD and LD adults using all three EF factors combined to determine if positive and negative predictive power and classification accuracy would improve. Table 13 reveals that the proportion of participants whose average canonical score fell below the cutoff (indicating that the combined factors classified him/her as ADHD) who were correctly classified as ADHD (sensitivity) was consistent with values obtained when the factors were used in isolation (i.e., 80 percent). However, use of the combined EF factors produced a notable increase in specificity as compared to use of the separate factors, but again, approximately 42 percent of the non-ADHD adults were incorrectly designated as ADHD. Nonetheless, where PPP and NPP were concerned, Table 13 suggests that PPP exceeded NPP in classifying ADHD and LD adults, but again, the improvement in positive prediction beyond base rate of ADHD in this analysis was 15 percent, whereas negative prediction exceeded prevalence of LD by 26 percent. Therefore, NPP exceeded PPP in this analysis from the perspective of base rates of the groups in the sample. Again, this latter finding suggests that when a participant was designated LD by his/her performance on the combined EF factors, there was a relatively strong likelihood that he/she actually met criteria for LD. It should also be noted here that the Working Memory factor demonstrated greatest discriminatory power, the Sustained

Intention factor showed slightly less discriminatory power, and the Effortful Learning factor demonstrated least discriminatory power, in separating the ADHD and LD groups.

In evaluating the statistical significance of the classification based on the combined EF factors for the ADHD and LD groups, the χ^2 test was significant as reported in Table 13. Moreover, Table 13 shows that combined use of the EF factors resulted in notable improvement in the degree to which observed agreement exceeded chance agreement (kappa = .39). In addition, the value for Press' Q statistic was 10.59, indicating that the performance of ADHD and LD adults on the EF tests that comprised the three empirically derived factors generated an overall level of agreement between test performance and actual diagnoses (overall correct classifications = 71 percent) that was significantly better than chance at $p < .005$ after adjusting for sample size and number of groups.

However, the jackknife validation procedure (Lachenbruch, 1967) using the combined EF factors was utilized to classify each participant (ADHD or LD) after deriving classification functions to which his/her data did not contribute. Table 13 reveals that sensitivity actually increased from 80 to 83 percent when the jackknife procedure was used, resulting in a decrease in false negatives from 20 to 17 percent. Moreover, the jackknife procedure only a slight decrease in specificity (i.e., from 58 to 54 percent), resulting in false positive diagnoses of 46 percent. Moreover, positive and negative predictive power remained acceptable, with positive prediction beyond base rate of ADHD being 14 percent, and negative prediction beyond prevalence of LD being 27 percent. In addition, the χ^2 test for the classification results of the jackknife procedure remained significant ($p = .003$), and the degree to which observed agreement exceeded chance showed good consistency (i.e., kappa dropped only one percentage point, from 39 to 38). Furthermore, the value for Press'

Q statistic for the results of the jackknife procedure was identical (10.59) to that obtained in non-validation combined DFA, indicating that for the ADHD and LD groups, the overall level of agreement between test performance (EF factors) and actual diagnoses (overall correct classifications = 71 percent) remained statistically significant at $p < .001$ after adjusting for sample size and number of groups.

ADHD vs. Clinic-Referred Control

Hypothesis 5c was tested via several separate discriminant function analyses (DFAs) with the *ADHD and clinic-referred control* groups, again using composite scores from the three empirically derived executive functioning (EF) factors. The three DFAs conducted using the separate EF factors identified optimal composite standard score¹ cutoffs of ≤ 108 for the Verbal Working Memory factor, ≤ 106 for the Sustained Intention factor, and ≤ 105 for the Effortful Learning factor. Table 14 reveals that for each factor, the proportion of participants performing below the cutoff scores who were correctly classified as ADHD (sensitivity) was good and ranged from 80 percent (Sustained Intention and Effortful Learning factors) to 91 percent (Sustained Intention factor). These sensitivity values resulted in tolerable false negative rates of 9, 20, and 20 percent for the Working Memory, Sustained Intention, and Effortful Learning factors, respectively. However, the proportions of clinic-referred control participants who obtained scores below these cutoff values (false positive rates) for the respective factors were markedly higher at 52, 48, and 62 percent, respectively. Moreover, these high rates for false positive diagnoses among the clinic-

¹ Again here, given that some standard scores used to identify the EF factors were derived exclusively from scores in this sample, mean scores of 100 do not reflect an “average” level of performance.

referred control adults indicated that the separate composite scores correctly identified only 48, 52, and 38 percent of participants not diagnosed with ADHD (specificity).

Where positive and negative predictive power (PPP and NPP) were concerned, it is important to note that as was the case in the previous sets of DFAs reported above, although an initial examination of these more clinically meaningful indices as reported in Table 14 suggested that the factors performed somewhat better in terms of PPP than NPP, again, further analysis revealed that the factors showed markedly better NPP than PPP given the base rates of ADHD (63 percent) and clinic-referred control (37 percent) for these analyses. Specifically, results of a PPP vs. base rate of ADHD analysis indicated improvements in positive prediction beyond base rate of only 11, 11, and five percent, for the Working Memory, Sustained Intention, and Effortful Learning factors, respectively. However, a NPP vs prevalence of clinic-referred control analysis indicated improvements in negative prediction beyond prevalence of clinic-referred control adults of 40, 24, and 16 percent, for the respective factors. Therefore, levels of PPP for the 3 EF factors when evaluated separately were relatively low, providing an average improvement of 9 percent over base rate of ADHD for these analyses. However, the NPP rates were, on average, approximately 27 percent higher than the prevalence of clinic-referred control adults in these analyses. These findings suggest that, in general, although there was a relatively strong chance that a participant identified as meeting criteria for ADHD actually met criteria for the disorder, much of the accuracy in positive prediction likely arose as an artifact of the relatively high base rate of ADHD in these analyses with ADHD and clinic-referred control adults. In contrast, when EF test performance indicated that a participant did not meet criteria for

ADHD (i.e., and thus, that he/she had not received a clinical diagnosis), there was a relatively good chance that he/she had not received a clinical diagnosis.

Nonetheless, as reported in Table 14, the χ^2 test reached significance for the Verbal Working Memory and Sustained Intention factors, but not for the Effortful Learning Factor. Moreover, although the degree to which observed agreement exceeded chance agreement for the Verbal Working Memory and Sustained Intention factors was adequate (as indicated in kappas of 42 and 33, respectively), classification based on the Effortful Learning factor was very low (kappa = 13). In addition, calculation of Press' Q statistic generated values of 14.00 ($p < .001$) for the Working Memory factor, 8.64 ($p < .005$) for the Sustained Intention factor, and 2.86 (ns) for the Effortful Learning factor. These findings indicated that when taken alone, only the Working Memory and Sustained Intention factors generated overall correct classifications for ADHD and clinic-referred control adults that were statistically better than chance after adjusting for sample size and number of groups.

However, as was the case for the classifications reported above, a further DFA was conducted with ADHD and clinic-referred control adults using all three EF factors combined to determine if positive and negative predictive power and classification accuracy would improve. Table 14 reveals that the proportion of participants whose average canonical score fell below the cutoff (indicating that the combined factors classified him/her as ADHD) who were correctly classified as ADHD (sensitivity) was consistent with values obtained when the factors were used in isolation (i.e., 83 percent). However, use of the combined EF factors produced a notable increase in specificity as compared to use of the separate factors. Specifically, the proportion of clinic-referred control adults that who obtained a canonical mean score below the cutoff value (false positive diagnosis) was 33 percent. This relatively

high rate of false positive diagnoses indicated that participant's performance on the combined EF factors correctly identified 67 percent of the clinic-referred control adults as not meeting criteria for ADHD. Nonetheless, where PPP and NPP were concerned, Table 14 suggests that PPP exceeded NPP in classifying ADHD and clinic-referred control adults, but again, the improvement in positive prediction beyond base rate of ADHD in this analysis was 18 percent, whereas negative prediction exceeded prevalence of clinic-referred control by 33 percent. Therefore, NPP exceeded PPP in this analysis from the perspective of base rates of the groups in the sample. Again, this latter finding suggests that when a participant was designated clinic-referred control by his/her performance on the combined EF factors (NPP = 70 percent), there was a relatively strong likelihood that he/she actually belonged to the clinic-referred control group. Importantly, the same conclusion may be drawn for PPP and the ADHD group, as well, but for different reasons. That is, there was a generally high probability that a participant identified as ADHD by the combined factors actually met criteria for ADHD (PPP = 81 percent), but this high PPP may be an artifact of the high base rate of ADHD in this analysis, rather than a result of the ability of the EF tests to accurately diagnosis those meeting criteria for ADHD. Such was not the case for the clinic-referred control group. The low base rate of 37 percent for clinic-referred controls in this analysis indicates that the base rate of control adults likely does not account for the finding showing relatively good NPP. It should also be noted here that the Working Memory factor showed strong discriminatory power, the Sustained Intention factor showed moderate discriminatory power, and the Effortful Learning factor showed poor discriminatory power, in separating the ADHD and clinic-referred control groups.

In evaluating the statistical significance of the classification based on the combined EF factors for the ADHD and clinic-referred control groups, the χ^2 test was significant as reported in Table 14. Moreover, Table 14 shows that combined use of the EF factors resulted in marked improvement in the degree to which observed agreement exceeded chance agreement ($kappa = .50$). In addition, the value for Press' Q statistic was 16.07, indicating that the performance of ADHD and clinic-referred control adults on the EF tests that comprised the three empirically derived factors generated an overall level of agreement between test performance and actual diagnoses (overall correct classifications = 77 percent) that was significantly better than chance at $p < .001$ after adjusting for sample size and number of groups.

However, the jackknife validation procedure (Lachenbruch, 1967) using the combined EF factors was utilized to classify each participant (ADHD or clinic-referred control) after deriving classification functions to which his/her data did not contribute. Table 15 reveals that sensitivity decreased slightly, from 83 to 80 percent when the jackknife procedure was used, resulting in small increase in false negatives from 17 to 20 percent. Moreover, the jackknife procedure resulted in a noteworthy decrease in specificity (i.e., from 67 to 57 percent), resulting in false positive diagnoses of 43 percent. Moreover, positive and negative predictive power remained acceptable, with positive prediction beyond base rate of ADHD being 13 percent, and negative prediction beyond prevalence of clinic-referred control being 26 percent. In addition, although the χ^2 test for the classification results of the jackknife procedure remained significant ($p = .005$), and the degree to which observed agreement exceeded chance decreased from a strong 50 percent to a moderate level of 38 percent. Furthermore, the value for Press' Q statistic for the results of the jackknife

procedure was 10.29, indicating that for the ADHD and clinic-referred control groups, the overall level of agreement between test performance (EF factors) and actual diagnoses (overall correct classifications = 71 percent) remained statistically significant at $p < .005$ after adjusting for sample size and number of groups.

DISCUSSION

Symptom Dimensions in Adult ADHD

The results of the exploratory factor analyses of observer- and self-ratings of *DSM-IV* ADHD symptomatology in the current study provided strong evidence that the core symptoms of the disorder in adults are two-dimensional in that a clear inattention dimension was easily distinguished from a strong hyperactivity/impulsivity dimension. Therefore, data from this clinic-referred sample of adults with attentional complaints strongly suggest that the defining symptoms of ADHD, as expressed by adults, do not fall along one broad restlessness/inattentive/impulsive dimension (as in *DSM-III-R*) nor separate dimensions of inattention, hyperactivity, and impulsivity as suggested by findings from the CAARS development study (Conners et al., 1999a). Indeed, in the findings from this study, items reflecting impulsivity loaded as high on the hyperactive/impulsive factor as did the symptoms of restlessness/overactivity. Interestingly, where the impulsive items were concerned, the two items reflecting aspects of verbal impulsivity loaded significantly on the hyperactivity/impulsivity factor, whereas the item reflecting impatience (H/I symptom eight) did not, and this pattern was found with both the self- and observer-ratings. The latter finding is consistent with clinical observations that many adults with ADHD have difficulty inhibiting statements they later regret.

The finding that ADHD symptoms in adults are two-dimensional was strengthened by the finding that separate factor analyses of the 18 *DSM-IV* symptoms included on the CAARS-S and CAARS-O forms generated virtually identical two-dimensional solutions. As was found by Lahey et al. (1988) in their study with clinic-referred children with ADHD, results in the current study revealed that items describing problems with focused attention,

distractibility, difficulty following through, forgetfulness, avoidance of mentally demanding tasks, and disorganization, loaded most strongly on an inattention factor. In contrast, items descriptive of problems with sitting still, staying seated, excessive talking, and socially impulsive behavior (i.e., "interrupts others when they are working or busy"; "gives answers to questions before they have been completed"), loaded most strongly on a second factor. Overall, both hyperactive and impulsive symptoms showed strong relationships with a single restlessness/impulsivity factor, with two of three impulsive, and five of six restlessness/overactivity, symptoms for observers showing statistically significant loadings on that factor. Thus, based on results from this clinic-referred adult sample, problems with restlessness/overactivity and impulsivity appear to form a unitary dimension of symptom impairment in adult ADHD as has been found in most studies with children (e.g., Bauermeister et al., 1992; DuPaul et al., 1997; Lahey et al., 1988; Lahey et al., 1994a). Moreover, based on empirical guidelines set forth by Guadagnoli & Velicer (1988),¹ the strength of loadings on the separate attention problems and restlessness/impulsivity dimensions reveal high "component saturation" (i.e., "absolute magnitude" of loadings is high), suggesting they are reliable factors (p. 265).

However, it is important to note that if ADHD as expressed in adults involves other dimensions of impairment not reflected in the 18 symptoms included in the *DSM-IV* definition of the disorder, those dimensions could not be reflected in the results of the factor analyses reported here. For example, none of the items included in these factor analyses

¹ Based on their Monte Carlo study, these authors assert that factors with four or more loadings above .60 in absolute value, are likely reliable, even if the subject-to-variable ratio is considerably smaller than popular guidelines (e.g., five participants per variable) would indicate.

clearly reflected potentially important symptoms of sluggishness, sleepiness, and/or underarousal that are reported by a noteworthy minority of adult patients presenting with attentional complaints. From a neurocognitive perspective, it seems reasonable that compromised alerting mechanisms in the brain (e.g., the ascending Noradrenergic reticular system) could produce symptoms similar to some of the inattentive symptoms seen in ADHD patients. Indeed, one seminal study examining ADHD symptom dimensions in children conducted an exploratory factor analysis using items reflecting symptoms of underarousal, inattention, hyperactivity, and impulsivity (Lahey et al., 1988). Interestingly, that factor analysis yielded inattentive and hyperactive/impulsive factors, as well as a factor descriptive of underarousal (sluggishness, drowsiness, and problems following instructions). The possibility that dimensions of symptom impairment other than hyperactivity, impulsivity, and inattention, may be involved in adult expressions of ADHD should be explored in future research with clinical samples of adults.

Empirically-Derived Domains of Symptom Impairment

As noted above, only one large scale study has empirically examined potential domains of symptom impairment that may be involved in adult expressions of attentional problems (Conners et al., 1999a). To date, this is the first study to evaluate the discriminant validity of the domains of symptom impairment identified by that study (Conners et al.) in a clinic-referred sample of adults. Importantly, the findings here do not support the hypothesis that symptoms of restlessness, or hyperactivity, and those of impulsivity load on separate factors among clinic-referred adults with attentional complaints. However, the findings from this sample clearly supported the discriminant validity of the inattention/memory problems and hyperactivity/restlessness factors extracted in the study by Conners et

al. (1999a). Specifically, both self- and observer-ratings indicated that adults with ADHD exhibit significantly greater difficulty with symptoms comprising these symptom domains (i.e., inattention/memory problems and hyperactivity/restlessness) than clinic-referred adults ultimately diagnosed with learning disorders.

However, only on the self-ratings did the inattention/memory problems factor distinguish ADHD adults from both LD and clinic-referred control adults. Interestingly, where the impulsivity/emotional lability and problems with self-concept factors were concerned, self-ratings distinguished adults with ADHD from those with LD on the former dimension, and from both LD and control adults on the latter dimension. However, observer-ratings did not distinguish the three groups on either of the last two dimensions. These findings may indicate that adults with ADHD are able to better manage external expressions of internal impulses, rapid swings in one's emotional state, and feelings of personal inadequacy, than are children with the disorder. Thus, such difficulties would be less evident to observer raters than the effects of lapses in day-to-day memory functioning (e.g., forgetting where the car is parked; missing crucial appointments; realizing he/she forgot the tickets to the football game at the gate; failing to remember a parent's or spouses' birthday), or verbal learning problems (e.g., inevitably forgetting items on a grocery list; missing critical pieces of verbal directions to some location). Even high functioning adults with ADHD may have difficulty hiding these symptoms from those with whom they interact frequently. The same reasoning may apply somewhat to the discrepancy between self- and observer-raters on the hyperactivity/restlessness factor.

It is also interesting to note that only for self- and observer ratings of inattention/memory problems did the mean approach 2 SDs above the normative mean (i.e., T-score

≥70). This finding may reflect the relative high functioning of this clinic-referred sample as compared to the overall population of adults with ADHD. If this interpretation is accurate, as will need to be evaluated in future studies with samples showing greater impairment, it may also support the notion that problems with inattention and difficulties with adaptive memory represent the realm in which ADHD adults tend to experience greatest difficulty. This notion is supported by the finding that this symptom dimension accounted for 68 percent of the explained variance in the final factor solution adopted by Conners and colleagues in their exploratory factor analytic study (Conners et al., 1999a). Moreover, the findings from the neuropsychological measures discussed below, as well as the bulk of neuropsychological findings from studies with ADHD adults, suggest that inattention and verbal memory problems may be two sides of the same coin that symbolizes the realm of greatest symptom impairment in adult expressions of attention disorders.

Domains of Neurocognitive Executive Dysfunction in Adult ADHD

Relative to clinic-referred control adults who received no diagnosis upon completion of their clinical assessment, ADHD adults showed significantly weaker performance on eight of 10 neuropsychological measures of executive functioning. Specifically, ADHD adults performed significantly less well than control adults on measures of verbal learning and memory (i.e., Auditory Immediate and Delayed Indices from the WMS-III), verbal working memory (i.e., total correct responses from the PASAT; and Working Memory Index from the WAIS-III), complex psychomotor processing speed (i.e., Processing Speed Index from the WAIS-III), effortful response inhibition (i.e., commission errors from the Conners CPT), sustained attention (i.e., total omission errors and overall hits percentile from the Conners CPT), and perceptual sensitivity (i.e., overall d' prime from the Conners CPT).

ADHD adults in this study did not exhibit significantly weaker performance than clinic-referred control adults in cognitive flexibility (i.e., percent perseverative errors from the WCST-CV2) or serial digit learning (i.e., Digits Forward from the WAIS-III).

Overall, these findings are consistent with the neuropsychological literature examining cognitive functioning in adult ADHD. However, given that no consensus has yet been developed on which aspects of executive functioning are tapped by which measures, and in turn, which domains of executive functioning represent realms of greatest functional impairment for adults with ADHD, a principle components analysis of the 10 measures used in this study was conducted. As indicated above, three clear dimensions of neurocognitive executive functioning were extracted (Table 6), including a Verbal Working Memory factor, a Sustained Intention factor, and an Effortful Learning factor.

The most powerful of these factors was the Sustained Intention factor, and the d' prime index from the Conners CPT showed the highest loading on this factor. Moreover, this factor provided greatest discrimination between the ADHD and overall non-ADHD groups in this sample. Importantly, although the extraction of this factor was not wholly expected, given that errors of commission and omission are typically believed to represent separate neuropsychological constructs, the fact that they emerged together is not entirely unexpected. Indeed, this factor could be re-named the “Conners CPT factor,” for all four measures from that test loaded on this factor, and no other variable from any other test did so. Moreover, as reviewed above, Denckla (1996a, 1996b) suggested that the term *sustained intention* may better represent the type of executive control deficits exhibited by ADHD children and adults than the notion of *sustained attention*. Sustained intention involves effortfully maintaining a state of continual preparedness to respond to something in the

environment. When the conditions monitored by the organism do not provide inherently rewarding stimulation, executive control processes necessarily become involved to govern the vector on which attentional energies are expended (right anterior prefrontal—posterior parietal attentional network; Posner & Raichle, 1997) and to maintain a state of neural excitation in the motor mechanisms that determine speed of response and/or inhibition of an ongoing response (orbitofrontal subcortical circuit; Cummings, 1993). The Conners CPT places relatively strong demands on, at least, these two executive control mechanisms, and thus, represents a good measure of sustained attention as discussed by Denckla (1994, 1996a). Importantly, as indicated in Table 7, mean composite scores on this factor provided strong discrimination between the ADHD and non-ADHD adults in this sample. However, as expected, the LD and clinic-referred control groups did not show significant differences on this factor.

The second powerful factor to emerge from the principle components analysis was the Verbal Working Memory factor. This factor was expected to emerge, and it too, discriminated among ADHD and non-ADHD adults in this sample. Yet again, the LD and clinic-referred control groups did not perform differently on this factor. These findings regarding verbal memory functioning among clinic-referred ADHD adults are consistent with the bulk of neuropsychological findings with ADHD adults reported above. However, the emergence of a factor that involved both verbal and non-verbal aspects of *on-the-spot* learning, or efficiency of *here-and-now* encoding, integration, and utilization of novel verbal and spatial information on tasks that included rote verbal memory, effortful encoding of, and access to, verbal memory (as found by Holdnack et al, 1995), complex psychomotor speed, and cognitive flexibility, on variables as seemingly disparate as the Auditory Immediate

Index (WMS-III), the Processing Speed Index (WAIS-III), and the percent perseverative errors score (WCST), was altogether unexpected. However, in light of the empirical data, as well as current notions of the role that executive cognitive control processes likely play in child and adult variants of ADHD, it makes intuitive sense that tasks involving the rapid acquisition of, integration of, and utilization of, novel information from the environment in the effortful performance of an unpracticed task, should represent a challenge for ADHD patients. Moreover, the extraction of this latter factor, if replicated in future studies of ADHD in adults, will provide support for the existence of content independent, transmodality, executive control systems in the human brain. These executive control systems likely serve the diffuse modulatory purpose of governing and directing the allocation of one's cognitive resources, determining the vector on which those resources are expended, and monitoring and maintaining a state of readiness in separate neural regions responsible for data processing and motor response, making it possible for the organism to adapt to novel challenges in the environment.

Discriminant Validity of Adult ADHD on Measures of Secondary Impairment

Several neuropsychological measures supported the discriminant validity of the disorder among clinic referred adults, yet a few did not. For example, as was consistent with the findings from all neuropsychological studies of adult ADHD reviewed above, ADHD patients in this study did not perform significantly less well than non-ADHD adults on the measure from the WCST, despite numerous studies showing that ADHD children often perform poorly on this test relative to controls (e.g., Chelune et al., 1986). This finding may suggest that frontal lobe structures involved in performance of the WCST (i.e., dorsolateral prefrontal cortex; Berman, Ostrem, Randolph, Gold, Goldberg, Coppola, et al., 1995) may

mature at later developmental intervals among those with ADHD (Holdnack et al., 1995). On balance, findings with ADHD children, adolescents, and adults strongly support a developmental lag hypothesis for frontal structures and frontal-subcortical circuits (Rubia, Overmeyer, Taylor, Brammer, Williams, Simmons, et al., 2000; Slattery et al., 2001). Nonetheless, it is possible that a maturational lag in frontal regions contributes to childhood expressions of the disorder *and* that frontal dysfunction remains involved in adult variants of the disorder. As noted by Holdnack et al., frontal regions, or frontal subcortical circuits, governing aspects of executive functioning not involved in WCST performance are likely compromised in adult ADHD (anterior cingulate and/or orbitofrontal regions). For example, the right anterior and left posterior cingulate areas show strong activation during PASAT performance (Deary, Ebmeier, MacLeod, & Dougall, 1994). Moreover, a network of brain areas appear to work in concert to mediate short-term storage, retrieval, and utilization of novel verbal information (verbal working memory tasks), including regions in the dorsolateral prefrontal, anterior cingulate, posterior parietal, and extrastriate cortices (Jonides, Schumacher, Smith, Koeppe, Awh, Reuter-Lorenz, et al., 1998). The significantly weaker performance of the ADHD adults as compared to clinic-referred control adults in this sample on the Verbal Working Memory factor (WMI, Digits Forward subtest, and total correct PASAT) suggests that abnormal development of these brain regions may play an important role in the day-to-day functional impairments experienced by adults with the disorder. The specific nature of the dysfunction in these regions in adult developmental manifestations of ADHD needs to be clarified in further research.

Nonetheless, the fact that ADHD and non-ADHD adults in the current study showed significant differences in level of performance on all three executive functioning factors

extracted here, supports the discriminant validity of ADHD in adults as defined under *DSM-IV*. Moreover, the fact that ADHD and LD adults showed significant differences on the Sustained Intention factor, despite the co-occurrence of executive control problems known to occur in both groups of patients (e.g., Pennington et al., 1996), supports the discriminant validity of the overall category among clinic-referred adults. In contrast, the complete absence of statistically significant differences between the two subtypes of the disorder under *DSM-IV* suggests that these subtypes may lack discriminant validity.

Although the exploratory factor analysis of self- and observer-ratings of items reflecting the 18 *DSM-IV* symptoms of ADHD extracted two clear symptom dimensions, further analyses examining the discriminant validity of inattentive (ADHD-I) and combined (inattentive and hyperactive/impulsive; ADHD-C) groups found no evidence that these subtypes differ in any domain of executive or functional impairment. However, the small sizes of the subgroups in this sample may have resulted in too little statistical power to detect differences in these domains if the effect of ADHD subtype in adults is small to moderate. Nonetheless, it is interesting to note that these findings are generally consistent with the findings of one large epidemiological study with children in which little evidence of an inattentive only subtype of ADHD emerged (August & Garfinkel, 1993). Moreover, arguing against the notion of too little statistical power in the subtype analyses in this study were the findings that ADHD-C and ADHD-I subgroups differed significantly from clinical-referred control adults in all three domains of neurocognitive executive functioning (EF) identified here, but they did not differ from one another in any EF domain (i.e., in verbal working memory, sustained intention, or effortful learning domains). The findings from the discriminant function analyses (DFAs) with the ADHD subtypes were also consistent this

latter point in that the two subtypes were completely indistinguishable on the measures of neurocognitive EF (i.e., these analyses classified all 35 ADHD adults in the ADHD-C subgroup). If the populations of hyperactive/inattentive and purely inattentive populations of ADHD adults truly differed in executive dysfunction (and the n's were too small to detect that difference here, as may well be the case), one would expect that at least a small number of the 14 inattentive only adults would be classified separately than the remainder of the overall ADHD group.

Findings from previous neuropsychological studies with ADHD adults speak to the nature of the differences in verbal memory functioning that adults with the disorder may experience (Holdnack et al., 1995). Specifically, it is interesting to note that in the study conducted by Holdnack and colleagues, ADHD adults received significantly lower semantic and serial clustering scores on the CVLT, indicating that as a group, they did not benefit from the memory strategies that appeared to help non-clinical adults recall more information. However, these investigators note that rather than not using semantic clustering at all, ADHD adults exhibited inconsistent use of a semantic clustering strategy, and thus, derived only limited benefit from this strategy across trials. However, it is also interesting to note that ADHD and non-clinical adults did not differ in terms of retention effects, indicating that despite initial difficulties in either encoding or immediate retrieval, ADHD adults had little difficulty retaining, and later retrieving, verbal information once it was acquired. Furthermore, follow-up analyses revealed that ADHD adults showed a clear pattern of poorer performance on the first list learning task on the CVLT but better performance on the second such task (interference task). Holdnack et al. note that this pattern is unusual, for the two tasks are essentially the same, and typically, adults build-up

some semantically-related interference which is exhibited when performing the interference task. ADHD adults showed no semantically-related interference, perhaps because they inconsistently applied a semantic clustering strategy, or perhaps because the novelty of the task was eliminated by the time the interference task was administered. This latter hypothesis offered by Holdnack et al., speaks to the aspects of executive control potentially involved in performance of the CVLT. Under this hypothesis, ADHD adults would have had sufficient time to reallocate the cognitive resources necessary to perform the task by the time the interference task was given.

Importantly, this hypothesis may also explain why some previous studies reported that ADHD adults performed significantly less well on Trails A than on Trails B (Holdnack et al.; Johnson et al., 2001). At first glance, these findings on the Trails test seem odd, because Trails B carries a notably higher cognitive demand than Trails A given the somewhat higher demands placed on working memory in performance of Trails B. However, under the *task novelty* hypothesis, ADHD adults performed better on Trails B, as well as the interference trial of the CVLT, because these tasks were administered after these adults had already transferred the information required merely to perform the task (i.e., the task instructions) into a longer-term form of verbal memory storage, freeing sufficient on-line memory resources for the actual performance of these tasks that came later in time.

Nonetheless, as noted by Lovejoy et al. (1999), findings in the present study showing significant differences in neurobehavioral test performance between ADHD, LD, and clinic-referred control adults do not ensure the clinical relevance of these results. This observation seems particularly accurate in light of the statistical truism that average test scores across groups may differ significantly when only a small proportion of participants in one group performed poorly (Barkley &

Grodzinsky, 1994). Therefore, the diagnostic utility of the empirically derived EF factors was examined in several discriminant function analyses (DFAs) to assess the clinical significance of findings from this study.

Diagnostic Utility of Measures of Neurocognitive Executive Dysfunction in Adult ADHD

As evident in Tables 12, 13, and 14, the three empirically-derived EF factors provided tolerable positive and negative predictive power in the current sample. Moreover, the overall correct classifications were statistically better than chance classifications when assigning participants to either ADHD or non-ADHD groups, ADHD or LD groups, or ADHD or clinic-referred control groups. Moreover, this is the first study with ADHD adults to utilize a validation procedure to test the reliability and potential generalizability of the classification coefficients derived using the discriminant function analysis. The classification coefficients proved to be relatively robust based on the leave-one-out jackknife validation procedure (Lachenbruch, 1967). For each of the three groupings, the overall classification rates remained statistically better than chance. This is particularly meaningful given that the task of classifying clinic-referred adults into appropriate categories is more difficult than discriminating ADHD and non-clinical control adults.

Study Limitations

The findings of this study may be limited by the degree to which the sample represented the population of adults meeting criteria for ADHD. For example, adults in the current sample were fairly young (mean age = 23.61, SD = 5.26), few were married, and many were undergraduate or graduate students. Moreover, the sample was generally high functioning, with a mean FSIQ of 111 (SD = 12.39). However, it is important to note that despite the high functioning nature of this sample, the mild-moderate neurocognitive

impairments exhibited by ADHD adults in this study are consistent with the level of impairment reported in several other neuropsychological studies with ADHD adults (Biederman et al., 1993; Jenkins et al., 1998; Riordan et al., 1999; Walker et al., 2000). In addition, the lack of significant findings regarding the discriminant validity of the subtypes of ADHD (i.e., ADHD-Predominately Inattentive Type and ADHD-Combined Type in this study) should be carefully examined in future studies with larger samples of clinic-referred adults and that utilize measures perhaps more sensitive to subtle differences in neurocognitive functioning between the subtypes (e.g., slow cognitive tempo among ADHD-I patients; McBurnett, Pfiffer, & Frick, 2001).

Conclusions

Overall, the results of the current study support the discriminant validity of the ADHD classification for adults as defined in *DSM-IV*. However, little to no support was found for the existence of separate subtypes of *DSM-IV* ADHD. Importantly, measures of symptom impairment suggest the existence of two broad domains consistent with those delineated in *DSM-IV*. Moreover, measures of neuropsychological functioning suggest at least three broad domains of neurocognitive dysfunction in adult variants of attention problems, including a verbal working memory domain, a sustained intention domain, and an effortful learning domain. In addition, composite scores in these domains of executive functioning generated correct classifications that were significantly better than chance when classifying clinic-referred adults that (a) did and did not meet criteria for ADHD, (b) met criteria for ADHD or a learning disability, and (c) met criteria for ADHD or no clinical diagnosis. Classification results proved to be robust when tested using a jackknife (leave-one-out) validation procedure. Finally, results of this study provide general support for the

developmental lag hypothesis of frontal-subcortical functioning in ADHD when considered vis-à-vis child ADHD data, but findings also support the notion that ADHD in adults is associated with continuing dysfunction in specific neuroanatomical circuits and networks believed to subserve executive attentional functions (e.g., dorsolateral prefrontal-subcortical; anterior cingulate-subcortical; orbitofrontal-subcortical).

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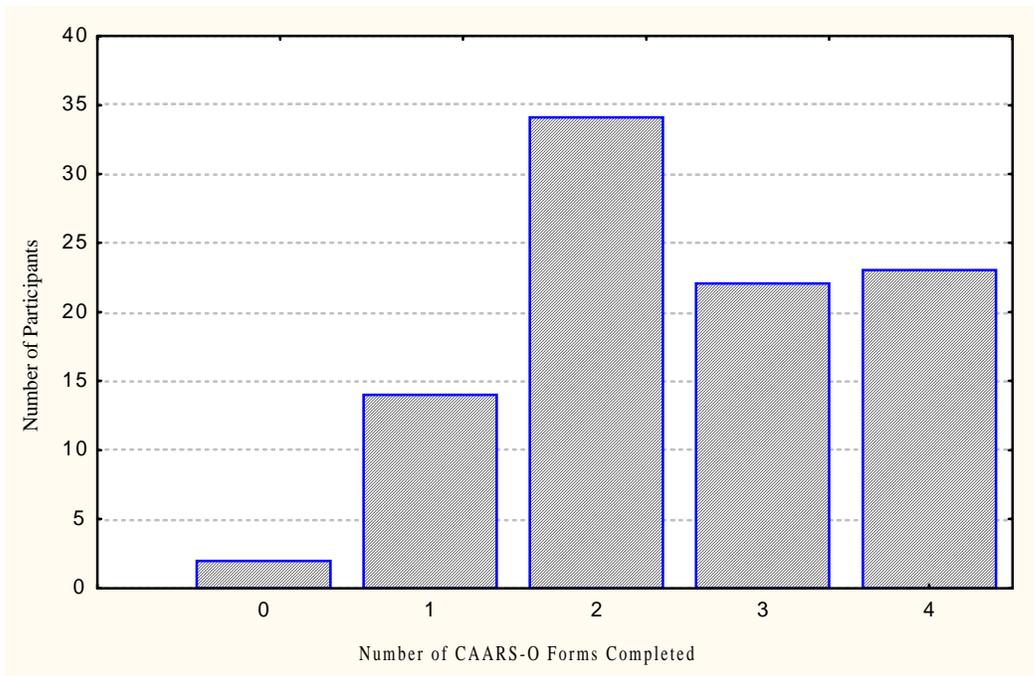


Figure 1: Number of Participants for Whom 0 – 4 CAARS-O Forms Were Completed

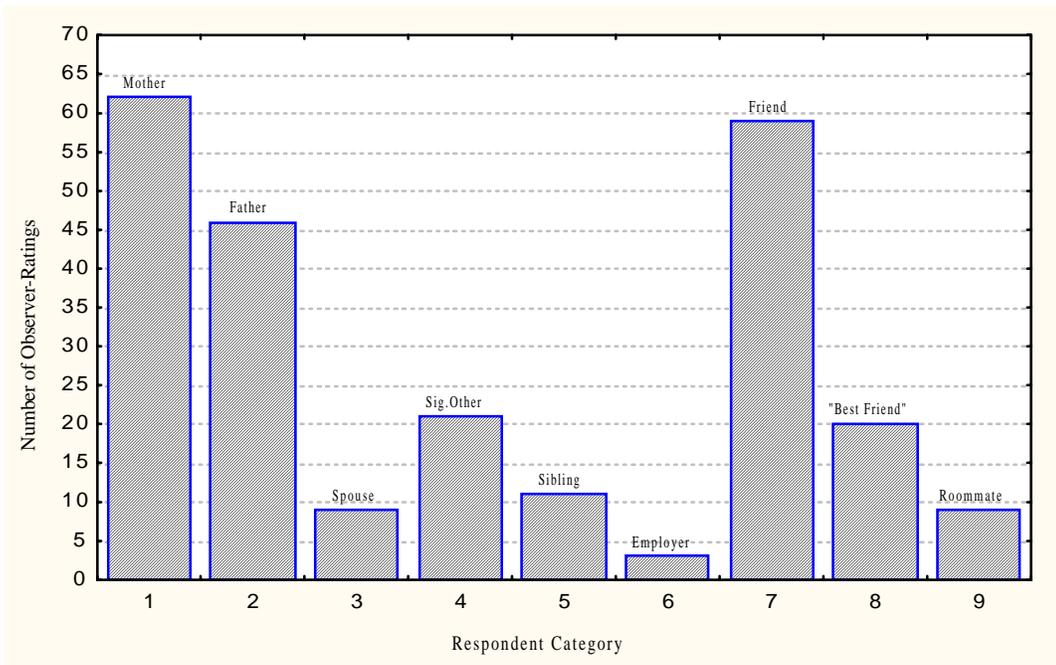


Figure 2. Total Number of CAARS-O Respondents By Category

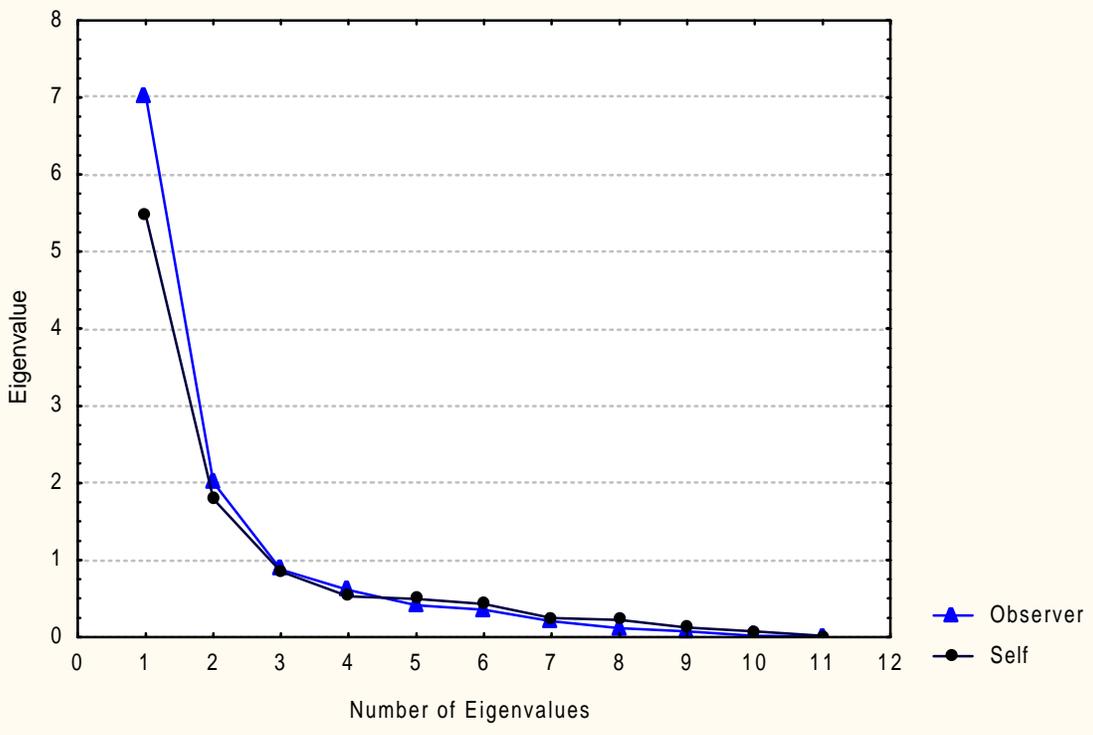


Figure 3. Plot of Eigenvalues for Exploratory Factor Analyses of Observer- and Self-Ratings on 18 DSM-IV ADHD Symptom Items from the CAARS

Table 1
Demographics Data

	ADHD n=35		LD n=24		Clinical Control n=21		<i>F</i> (2,77) ^a
Sex (male/female) ^b	19/16		12/12		11/10		
	Mean	(SD)	Mean	(SD)	Mean	(SD)	
Age	24.59	(6.3)	23.48	(4.8)	22.16	(3.3)	1.43
Years of Education	15.01	(1.6)	15.68	(1.2)	15.59	(2.5)	1.22
FSIQ (WAIS-III)	106.37	(11.8)	114.38	(12.0)	114.76	(11.7)	4.70 *
VIQ (WAIS-III)	107.94	(13.3)	113.38	(10.5)	114.10	(10.8)	2.33
PIQ (WAIS-III)	103.80	(12.7)	113.00	(14.3)	112.00	(13.0)	4.30 *

Note. ADHD = Attention-Deficit/Hyperactivity Disorder; LD = Learning Disorder; WAIS-III = Wechsler Adult Intelligence Test, Third Edition; FSIQ = Full Scale Intelligence Quotient; VIQ = Verbal IQ; PIQ = Performance IQ.

^a $\alpha = .05$ for all comparisons on demographics variables.

^b Chi-square analysis (3 x 2, group x sex) n.s.

* $p < .05$

Table 2
Factor Loadings for CAARS Observer- and Self-Ratings of *DSM-IV* Symptoms of ADHD

CAARS Items Representing <i>DSM-IV</i> ADHD Symptoms	Observer Ratings (n=80)		Self Ratings (n=80)	
	Inattention Factor	Restlessness - Impulsivity Factor	Inattention Factor	Restlessness - Impulsivity Factor
Inattention				
(1) Makes careless mistakes or has trouble paying close attention to details	.63*	.20	.52	.31
(2) Trouble keeping attention focused when working or at leisure	.72*	.18	.59	.25
(3) Has trouble listening to what other people are saying	.62	.22	.55	.39
(4) Has trouble finishing job tasks or schoolwork	.76*	.06	.73*	.15
(5) Has problems organizing tasks and activities	.78*	.05	.79*	-.04
(6) Doesn't like academic studies/work projects where effort at thinking a lot is required	.72*	.14	.42	.29
(7) Loses things necessary for tasks or activities (e.g., to-do lists, pencils, books, or tools)	.73*	.18	.68*	.03
(8) Appears distracted when things are going on around him/her	.73*	.36	.49	.45
(9) Is forgetful in daily activities	.73*	.31	.81*	.06
Restlessness/Overactivity				
(1) Fidgets with hands or feet or squirms in seat	.28	.76*	.26	.53
(2) Leaves seat when not supposed to	.25	.78*	.16	.61
(3) Is restless or overactive	.31	.74*	.11	.76*
(4) Gets rowdy or boisterous during leisure activities	.32	.47	.35	.57
(5) Is always on the go	-.17	.69*	.09	.54
(6) Talks too much	.02	.71*	-.22	.69*
Impulsivity				
(7) Gives answers to questions before the questions have been completed	.42	.66*	.20	.68*
(8) Has trouble waiting in line or taking turns with others	.30	.53	.27	.54
(9) Interrupts others when they are working or busy	.21	.68*	.27	.68*

* Statistically significant factor loadings ($\geq .63$; $p < .05$).

Table 3
Differences in Self-Ratings Across ADHD, LD, and Clinic-Referred Control Groups
in Empirically Derived Symptom Domains¹

Symptom Domain	ADHD ² n=35 (m=19; f=16)		LD ³ n=24 (m=12; f=12)		Control ⁴ n=21 (m=11; f=10)		<i>F</i> (df = 2,77)	<i>p</i>
	Mean	SD	Mean	SD	Mean	SD		
Inattention/Memory Problems Factor ⁵	69.14 ^a	(10.55)	53.92 ^b	(10.13)	61.43 ^b	(9.21)	16.37	<.0000
Hyperactivity/Restlessness Factor ⁶	60.94 ^a	(9.45)	51.21 ^b	(11.32)	58.43	(11.33)	6.22	.0031
Impulsivity/Emotional Lability Factor ⁷	58.34 ^a	(13.16)	49.21 ^b	(11.58)	51.48	(8.93)	4.89	.0100
Problems with Self-Concept Factor ⁸	60.91 ^a	(10.65)	52.67 ^b	(10.49)	52.53 ^b	(10.47)	6.32	.0029

¹ Mean scores for each group (arranged horizontally) with same superscripts, or no superscript, are not significantly different at $p < .0085$ based on Fisher's LSD procedure for post hoc analyses.

² ADHD = Attention-Deficit/Hyperactivity Disorder Group.

³ LD = Learning Disorders Group.

⁴ Control = clinic-referred control group (adults receiving no diagnosis upon completion of their evaluation).

⁵ **Inattention Memory Problems Factor** = Mean T-scores (M=50; SD=10) on this factor from the Conners Adult ADHD Rating Scale - Self: Long Version (CAARS-S:L).

⁶ **Hyperactivity/Restlessness Factor** = Mean T-scores (M=50; SD=10) on this factor from the CAARS-S:L.

⁷ **Impulsivity/Emotional Lability Factor** = Mean T-scores on this factor from the CAARS-S:L.

⁸ **Problems with Self-Concept Factor** = Mean T-scores on this factor from the CAARS-S:L.

Table 4
Differences in Observer-Ratings Across ADHD, LD, and Clinic-Referred Control
Groups in Empirically Derived Symptom Domains¹

Symptom Domain	ADHD ² n=35 (m=19; f=16)		LD ³ n=24 (m=12; f=12)		Control ⁴ n=21 (m=11; f=10)		<i>F</i> (df = 2,77)	<i>p</i>
	Mean	SD	Mean	SD	Mean	SD		
Inattention/Memory Problems Factor ⁵	67.97 ^a	(11.45)	59.61 ^b	(12.03)	61.98	(9.99)	4.33	.0166
Hyperactivity/Restlessness Factor ⁶	61.17 ^a	(10.67)	52.91 ^b	(12.94)	59.42	(13.05)	3.50	.0351
Impulsivity/Emotional Lability Factor ⁷	55.57	(12.51)	49.70	(10.28)	49.89	(8.38)	2.77	.0689
Problems with Self-Concept Factor ⁸	58.64	(12.24)	58.26	(11.88)	59.58	(11.64)	.07	.9303

¹ Mean scores for each group (arranged horizontally) with same superscripts, or no superscript, are not significantly different at $p < .0125$ based on Fisher's LSD procedure for post hoc analyses.

² ADHD = Attention-Deficit/Hyperactivity Disorder Group.

³ LD = Learning Disorders Group.

⁴ Control = clinic-referred control group (adults receiving no diagnosis upon completion of their evaluation).

⁵ **Inattention Memory Problems Factor** = Mean T-scores (M=50; SD=10) on this factor from the Conners Adult ADHD Rating Scale - Observer: Long Version (CAARS-O:L).

⁶ **Hyperactivity/Restlessness Factor** = Mean T-scores (M=50; SD=10) on this factor from the CAARS-O:L.

⁷ **Impulsivity/Emotional Lability Factor** = Mean T-scores on this factor from the CAARS-O:L.

⁸ **Problems with Self-Concept Factor** = Mean T-scores on this factor from the CAARS-O:L.

Table 5
Differences Across ADHD, LD, and Clinic-Referred Control Groups
on Neuropsychological Measures of Executive Functioning¹

Executive Functioning (EF) Measure	ADHD ² n=35 (m=19; f=16)		LD ³ n=24 (m=12; f=12)		Control ⁴ n=21 (m=11; f=10)		F Value (df = 2,77)	p
	Mean	SD	Mean	SD	Mean	SD		
WM Index ⁵	100.37 ^a	(13.00)	105.75	(11.87)	112.24 ^b	(14.72)	5.39	.0064
% Persever. Errors ⁶	96.85	(15.61)	97.52	(19.86)	105.44	(14.32)	1.93	.1515
Auditory Immediate ⁷	96.54 ^a	(14.62)	104.01	(12.42)	107.70 ^b	(11.95)	5.12	.0082
Hits Percentile ⁸	78.54 ^a	(17.50)	58.43 ^b	(24.06)	62.01 ^b	(22.95)	7.70	.0009
Digits Forward ⁹	9.83	(1.98)	10.75	(2.64)	10.80	(2.86)	1.48	.2341
Commission Errors ¹⁰	16.16 ^a	(7.94)	11.71 ^b	(5.43)	11.41 ^b	(6.44)	4.37	.0159
Processing Speed Index ¹¹	95.86 ^a	(12.27)	100.17	(11.22)	105.64 ^b	(12.14)	4.44	.0159
PASAT Correct Responses ¹²	115.03 ^a	(32.95)	140.35 ^b	(34.17)	151.99 ^b	(38.16)	8.35	.0005
Overall <i>d</i> -prime ¹³	2.59 ^a	(.80)	3.28 ^b	(.54)	3.33 ^b	(.85)	9.16	.0003
Omission Errors ¹⁴	94.15 ^a	(14.21)	105.09 ^b	(12.26)	109.96 ^b	(10.44)	11.41	<.0000

¹ Mean scores for each group (arranged horizontally) with same superscripts, or no superscript, are not significantly different at $p < .005$ level based on Fisher's least significant difference procedure (LSD) for post hoc analyses.

² **ADHD** = Attention-Deficit/Hyperactivity Disorder group.

³ **LD** = Learning Disorders group.

⁴ **Control** = Clinic-Referred Control group (adults receiving no diagnosis upon completion of evaluation).

⁵ **WM Index** = Working Memory Index from WAIS-III.

⁶ **% Persever. Errors** = Percent Perseverative Errors age and education adjusted standard score (M=100, SD=15), Wisconsin Card Sorting Test-Computerized Version, 2nd edition (WCST-CV2).

⁷ **Auditory Immediate** = Auditory Immediate Index (M=100, SD=15), Wechsler Memory Scale, 3rd edition (WMS-III).

⁸ **Hits Percentile** = Mean group percentile (indicates proportion of participant's age group from the normative sample who performed better in terms of total number of hits), Conners Continuous Performance Test (Conners CPT).

⁹ **Digits Forward** = total digits forward raw score, Digit Span Subtest (WAIS-III).

¹⁰ **Commission Errors** = total number of commission errors (i.e., trials in which patient responded to a non-target stimulus; Conners CPT).

¹¹ **Processing Speed Index** = Processing Speed Index score (M = 100; SD = 15; WAIS-III).

¹² **PASAT Correct Responses** = total number of correct responses (PASAT).

¹³ **Overall *d*-prime** = Signal Detection Theory index of overall perceptual sensitivity (reflects degree to which patients successfully discriminated perceptual features of target and non-target stimuli; Conners CPT).

¹⁴ **Omission Errors** = number of trials in which patient failed to respond to a target stimulus (Conners CPT); Raw data for **Omission Errors** violated assumptions of MANOVA/ANOVA due to significant heterogeneity of variances across groups (Hartley F -Max = 7.23, $p = .0001$). Subsequently, the Box-Cox power transformation was applied to this variable, resulting in a post-transformation Hartley F -Max of 1.85 ($p = .320$). Transformed values were converted to standard scores (M=100; SD=15) prior to analysis to aid interpretation of group differences. Data for no other EF variable violated the homogeneity of variances assumption.

Table 6
Results of Principle Components Analysis
of 10 Neuropsychological Variables of Executive Functioning¹

	Verbal Working Memory Factor	Effortful Intention/Inhibition Factor	Effortful Learning Factor
Working Memory Index ²	.86 *	.14	.28
Percent Perseverative Errors ³	.21	-.13	.67 *
Auditory Immediate Index ⁴	.02	.14	.77 *
Hits Percentile ⁵	-.29	-.74 *	-.17
Digits Forward ⁶	.88 *	.03	-.01
Commission Errors ⁷	-.06	-.79 *	.11
Processing Speed Index ⁸	.36	.18	.57
PASAT Correct Responses ⁹	.70 *	.20	.29
Overall <i>d</i> -prime ¹⁰	.09	.94 *	-.05
Omission Errors ¹¹	.02	.76 *	.31

¹ Variables with component loadings printed in bold in the same column loaded on the same factor.

² **Working Memory Index** = Working Memory Index from WAIS-III.

³ **Percent Perseverative Errors** = Percent Perseverative Errors age and education adjusted standard score (M=100, SD=15), Wisconsin Card Sorting Test-Computerized Version, 2nd edition (WCST-CV2).

⁴ **Auditory Immediate Index** = Auditory Immediate Index, Wechsler Memory Scale, 3rd edition (WMS-III).

⁵ **Hits Percentile** = Mean group percentile (indicates proportion of participant's age group from the normative sample who performed better in terms of total number of hits), Conners Continuous Performance Test (Conners CPT).

⁶ **Digits Forward** = total digits forward raw score, Digit Span Subtest (WAIS-III).

⁷ **Commission Errors** = total number of commission errors (Conners CPT).

⁸ **Processing Speed Index** = Processing Speed Index score (M = 100; SD = 15; WAIS-III).

⁹ **PASAT Correct Responses** = total number of correct responses (PASAT).

¹⁰ **Overall *d*-prime** = Signal Detection Theory index of overall perceptual sensitivity (reflects degree to which patients successfully discriminated perceptual features of target and non-target stimuli; Conners CPT).

¹¹ **Omission Errors** = number of trials in which patient failed to respond to a target stimulus (Conners CPT).

* Statistically significant factor loadings ($\geq .63$; $p < .05$).

Table 7
Differences Across ADHD, LD, and Clinic-Referred Control Groups
on the Three Factor Model of Neurocognitive Executive Functioning¹

Neurocognitive EF Domain	ADHD ² n=35 (m=19; f=16)		LD ³ n=24 (m=12; f=12)		Control ⁴ n=21 (m=11; f=10)		<i>F</i> (df = 2,77)	<i>p</i>
	Mean	SD	Mean	SD	Mean	SD		
Verbal Working Memory ⁵	96.55 ^a	(10.31)	103.54	(11.71)	107.32 ^b	(13.61)	6.13	.0034
Sustained Intention ⁶	94.35 ^a	(11.83)	105.88 ^b	(9.03)	106.92 ^b	(10.77)	12.27	<.0000
Effortful Learning ⁷	96.20 ^a	(12.54)	102.09	(6.88)	106.67 ^b	(7.70)	7.61	.0010

¹ Mean scores for each group (arranged horizontally) with same superscripts, or no superscript, are not significantly different at $p < .01$ based on Fisher's LSD procedure for post hoc analyses.

² ADHD = Attention-Deficit/Hyperactivity Group.

³ LD = Learning Disorders Group.

⁴ Control = clinic-referred control group (adults receiving no diagnosis upon completion of their evaluation).

⁵ **Verbal Working Memory Factor.** Specific measures on this factor included: Working Memory Index (WMS-III); Digits Forward Total Score (DFTS; WAIS-III); Total Correct Responses (PASAT).

⁶ **Sustained Intention Factor.** Specific measures on this factor were all from the Conners CPT and included: Hits Percentile; Total Number of Commission Errors; Overall d' -Prime; Total Omission Errors.

⁷ **Effortful Learning Factor** (alternatively, Efficiency in Novel Learning Factor). Specific measures on this factor included: Auditory Immediate Index (WMS-III); Percent Perseverative Errors (WCST-CV2); Processing Speed Index (WAIS-III).

Table 8
Discriminant Validity of ADHD in Adults on Measures of Secondary Impairment:
Academic Achievement, Delayed Verbal Memory, and
Lower Executive Demand Cognitive Ability¹

Functional Domain	ADHD ² n=35 (m=19; f=16)		LD ³ n=24 (m=12; f=12)		Control ⁴ n=21 (m=11; f=10)		<i>F</i> (df = 2,77)	<i>p</i>
	Mean	SD	Mean	SD	Mean	SD		
Lower Executive Demand Cognitive Ability⁵								
Verbal Comprehension Index ⁶	109.46	(15.06)	113.46	(13.51)	112.52	(9.93)	.72	.4896
Perceptual Organization Index ⁷	105.83	(14.35)	114.46	(14.81)	113.00	(12.35)	3.23	.0449
Academic Achievement								
Broad Reading ⁸	103.17	(13.22)	101.50	(10.55)	108.10	(11.65)	1.81	.1711
Broad Math ⁹	101.51	(14.45)	97.63	(16.75)	105.29	(9.59)	1.65	.1989
Broad Written Language ¹⁰	89.69	(15.24)	86.21 ^a	(11.49)	96.76 ^b	(11.14)	3.70	.0292
Broad Knowledge ¹¹	88.23	(16.34)	86.50	(17.07)	94.33	(10.51)	1.63	.2032
Delayed Verbal Memory								
Auditory Delayed Index ¹²	98.77	(14.89)	107.08	(11.35)	106.45	(9.67)	3.95	.0233

¹ Mean scores for each group (arranged horizontally) with same superscripts, or no superscript, are not significantly different at $p < .009$ based on Fisher's Least Significant Difference (Fisher's LSD) procedure for post hoc analyses.

² ADHD = Attention-Deficit/Hyperactivity Disorder Group.

³ LD = Learning Disorders Group.

⁴ Control = clinic-referred control group (adults receiving no diagnosis upon completion of their evaluation).

⁵ That is, less executive control than is purportedly required for success on the Working Memory and Processing Speed Indices, also from the WAIS-III. Differences between primary groups on these measures were reported in Table 3.

⁶ **Verbal Comprehension Index** = Verbal Comprehension Index (VCI) Factor score (M=100; SD=15) from WAIS-III.

⁷ **Perceptual Organization Index** = Perceptual Organization Index (POI) Factor score (M=100; SD=15) from WAIS-III.

⁸ **Broad Reading** = Broad Reading standard score (Mean = 100; SD = 15) from WJ-R.

⁹ **Broad Math** = Broad Math standard score (Mean = 100; SD = 15) from WJ-R.

¹⁰ **Broad Writing** = Broad Writing standard score (Mean = 100; SD = 15) from WJ-R.

¹¹ **Broad Knowledge** = Broad Knowledge standard score (Mean = 100; SD = 15) from WJ-R.

¹² **Auditory Delayed Index** = Auditory Delayed Index (ADI; M=100; SD=15) from Wechsler Memory Scale, 3rd Edition (WMS-III).

Table 9
Number and Proportion of Participants Meeting Criteria
for a Comorbid Disorder in Each Category

	ADHD ¹ n=35 (m=19; f=16)		LD ² n=24 (m=12; f=12)		Chi-square ³	p
	Number	(%)	Number	(%)		
Affective Disorder ⁴	8	(23)	3	(13)	2.54	.11
Anxiety Disorder ⁵	4	(11)	5	(21)	.26	.61
Substance Abuse/Dependence ⁶	2	(6)	0	(0)	.21	.65
Total	14	(40)	6	(25)	.84	.36

	ADHD-C ⁷ n=20 (m=12; f=8)		ADHD-I ⁸ n=14 (m=7; f=7)		Chi-square	p
	Number	(%)	Number	(%)		
Affective Disorder	5	(25)	3	(21)	.03	.87
Anxiety Disorder	2	(10)	2	(14)	.03	.87
Substance Abuse/Dependence	2	(10)	0	(0)	.23	.63
Total	9	(45)	5	(36)	.04	.85

¹ ADHD = Attention-Deficit/Hyperactivity Disorder. Included participants meeting criteria for ADHD-Combined Type (n=20) and ADHD-Predominately Inattentive Type (n=14).

² LD = Participants meeting criteria for any learning disorder under *DSM-IV*, including Reading Disorder, Math Disorder, Disorder of Written Expression, and Learning Disorder-Not Otherwise Specified.

³ Given that the 2x2 tables used to approximate the Chi-square statistic for these group comparisons contained small observed frequencies (with some expected frequencies less than 10), Yates corrected Chi-square was used to make the estimation more conservative (Hays, 1988).

⁴ Affective Disorder = participants currently meeting criteria for any mood disorder included in *DSM-IV*.

⁵ Anxiety Disorder = participants currently meeting criteria for any anxiety disorder included in *DSM-IV*.

⁶ Substance Abuse/Dependence = participants currently meeting criteria for substance abuse or dependence *DSM-IV*.

⁷ ADHD-C = participants meeting criteria for ADHD-Combined Type.

⁸ ADHD-I = participants meeting criteria for ADHD-Predominately Inattentive Type.

Table 10
Differences Across ADHD-C, ADHD-I, and Clinic-Referred Control Groups
on the Three Factor Model of Neurocognitive Executive Functioning¹

Neurocognitive EF Domain	ADHD-C ² n=20 (m=12; f=8)		ADHD-I ³ n=14 (m=7; f=7)		Control ⁴ n=21 (m=11; f=10)		<i>F</i> (df = 2,52)	<i>p</i>
	Mean	SD	Mean	SD	Mean	SD		
Verbal Working Memory ⁵	97.23 ^a	(10.02)	95.37 ^a	(11.35)	107.32 ^b	(13.61)	5.57	.0064
Sustained Intention ⁶	93.38 ^a	(13.26)	95.02 ^a	(9.96)	106.92 ^b	(10.78)	8.12	.0008
Effortful Learning ⁷	95.67 ^a	(14.67)	97.21 ^a	(9.49)	106.67 ^b	(7.69)	5.66	.0060

¹ Mean scores for each group (arranged horizontally) with same superscripts, or no superscript, are not significantly different at $p < .0175$ based on Fisher's LSD procedure for post hoc analyses.

² ADHD-C = ADHD-Combined Type.

³ ADHD-I = ADHD-Predominately Inattentive Type.

⁴ Control = clinic-referred control group (adults receiving no diagnosis upon completion of their evaluation).

⁵ **Verbal Working Memory factor.** Specific measuring on this factor included: Working Memory Index (WMS-III); Digits Forward Total Score (DFTS; WAIS-III); Total Correct Responses (PASAT).

⁶ **Sustained Intention factor.** Specific measuring on this factor were all from the Conners CPT and included: Hits Percentile; Total Number of Commission Errors; Overall d' -Prime; Total Omission Errors.

⁷ **Effortful Learning factor** (alternatively, Efficiency in Novel Learning factor). Specific measures on this factor included: Auditory Immediate Index (WMS-III); Percent Perseverative Errors (WCST-CV2); Processing Speed Index (WAIS-III).

Table 11
Differences in Self-Ratings Across ADHD-C, ADHD-I, and Clinic-Referred Control
Groups in Empirically Derived Symptom Domains ¹

Symptom Domain	ADHD-C ² n=20 (m=12; f=8)		ADHD-I ³ n=14 (m=7; f=7)		Control ⁴ n=21 (m=11; f=10)		<i>F</i> (df = 2,52)	<i>p</i>
	Mean	SD	Mean	SD	Mean	SD		
Inattention/Memory Problems Factor ⁵	68.15	(11.00)	71.00 ^a	(10.31)	61.43 ^b	(9.21)	4.24	.0198
Hyperactivity/Restlessness Factor ⁶	64.55 ^a	(8.10)	54.86 ^b	(8.04)	58.43	(11.33)	4.65	.0139
Impulsivity/Emotional Lability Factor ⁷	62.50 ^a	(13.64)	51.07 ^b	(8.42)	51.48 ^b	(8.93)	6.85	.0023
Problems with Self-Concept Factor ⁸	60.45	(9.55)	61.00	(12.57)	52.24	(10.47)	4.03	.0236

¹ Mean scores for each group (arranged horizontally) with same superscripts, or no superscript, are not significantly different at $p < .01$ based on Fisher's LSD procedure for post hoc analyses.

² ADHD-C = ADHD-Combined Type subgroup

³ ADHD-I = ADHD-Predominately Inattentive Type subgroup

⁴ Control = clinic-referred control group (adults receiving no diagnosis upon completion of their evaluation).

⁵ **Inattention Memory Problems factor** = Mean T-scores (M=50; SD=10) on this factor from the Conners Adult ADHD Rating Scale - Self: Long Version (CAARS-S:L).

⁶ **Hyperactivity/Restlessness factor** = Mean T-scores (M=50; SD=10) on this factor from the CAARS-S:L.

⁷ **Impulsivity/Emotional Lability factor** = Mean T-scores on this factor from the CAARS-S:L.

⁸ **Problems with Self-Concept factor** = Mean T-scores on this factor from the CAARS-S:L.

Table 12
Classification Accuracy of Three Factor Model of Executive Functioning
for ADHD and all Non-ADHD Adults¹

EF Factors (cutoff scores)	Sensitivity ²	Specificity ³	Positive Predictive Power ⁴	Negative Predictive Power ⁵	Overall Correct ⁶	Kappa ⁷	Chi-square ⁸	<i>p</i>
Verbal Working Memory Factor (≤ 97)	54	73	61	67	65 ^{**}	28	6.33	.0120 (3)
Sustained Intention Factor (≤ 98)	60	80	70	72	71 ^{****}	41	13.44	.0002 (1)
Effortful Learning Factor (≤ 97)	54	84	73	70	71 ^{****}	40	13.46	.0002 (2)
All EF Factors Combined ⁹	69	82	75	77	76 ^{****}	51	21.16	<.0000
Jackknife Validation Procedure: All EF Factors Combined ¹⁰	60	80	70	72	71 ^{****}	41	13.44	.0002

Note. Press' *Q* statistic indicates whether a classification matrix may be considered statistically better than chance after comparing the overall number of correct classifications with the total sample size and number of groups (Hair et al., 1998).

¹ All probabilities were multiplied by 100.

² Sensitivity represents the degree to which a variable correctly identifies individuals diagnosed with the disorder.

³ Specificity represents the degree to which a variable correctly identifies individuals not diagnosed with the disorder.

⁴ Positive Predictive Power = proportion classified by the variable as having the disorder who actually received the diagnosis.

⁵ Negative Predictive Power = proportion classified by the variable as not having the disorder that truly did not meet criteria.

⁶ Overall Correct Classification = the variable's "hit rate," or the overall proportion correctly classified by the variable.

⁷ Kappa = level of agreement between a variable and a gold standard beyond chance (Kessel and Zimmerman, 1993).

⁸ Chi-square = values for chi-square analyses using the 2 x 2 contingency table (*p* values in the adjacent column).

⁹ Numbers in parentheses in the far right column designate the descending order of discriminatory power of EF variables.

¹⁰ A jackknife procedure was used to classify each participant after deriving classification functions to which his/her data did not contribute.

* Press' *Q* statistic indicates classification significantly better than chance based on $\alpha = .05$, $df = 1$, χ^2 critical value = 3.84.

** Press' *Q* statistic significant at $\alpha = .01$, $df = 1$, χ^2 critical value = 6.63.

*** Press' *Q* statistic significant at $\alpha = .005$, $df = 1$, χ^2 critical value = 7.88.

**** Press' *Q* statistic significant at $\alpha = .001$, $df = 1$, χ^2 critical value = 10.83.

Table 13
Classification Accuracy of Three Factor Model of Executive Functioning
for ADHD and LD Adults

EF Factors (cutoff scores) ¹	Sensitivity ²	Specificity ³	Positive Predictive Power ⁴	Negative Predictive Power ⁵	Overall Correct ⁶	Kappa ⁷	Chi-square ⁸	<i>p</i>	
Verbal Working Memory Factor (≤ 106)	80	46	68	61	66*	27	4.48	.034	(1)
Sustained Intention Factor (≤ 104)	77	46	68	58	64*	24	3.44	.064	(2)
Effortful Learning Factor (≤ 106)	83	21	60	45	58	4	.13	.720	(3)
All EF Factors Combined ⁹	80	58	74	67	71***	39	9.13	.003	
Jack-Knife Validation Procedure: All EF Factors Combined ¹⁰	83	54	73	68	71***	38	8.94	.003	

Note. Press' *Q* statistic indicates whether a classification matrix may be considered statistically better than chance after comparing the overall number of correct classifications with the total sample size and number of groups (Hair et al., 1998).

¹ All probabilities in table were multiplied by 100.

² Sensitivity represents the degree to which a variable correctly identifies individuals diagnosed with the disorder.

³ Specificity represents the degree to which a variable correctly identifies individuals not diagnosed with the disorder.

⁴ Positive Predictive Power = proportion classified by the variable as having the disorder who actually received the diagnosis.

⁵ Negative Predictive Power = proportion classified by the variable as not having the disorder that truly did not meet criteria.

⁶ Overall Correct Classification = the variable's "hit rate," or the overall proportion correctly classified by the variable.

⁷ Kappa = level of agreement between a variable and a gold standard beyond chance (Kessel and Zimmerman, 1993).

⁸ Chi-square = values for chi-square analyses using the 2 x 2 contingency table (*p* values in the adjacent column).

⁹ Numbers in parentheses in the far right column designate the descending order of discriminatory power of EF variables.

¹⁰ A jackknife procedure was used to classify each participant after deriving classification functions to which his/her data did not contribute.

* Press' *Q* statistic indicates classification significantly better than chance based on $\alpha = .05$, $df = 1$, χ^2 critical value = 3.84.

** Press' *Q* statistic significant at $\alpha = .01$, $df = 1$, χ^2 critical value = 6.63.

*** Press' *Q* statistic significant at $\alpha = .005$, $df = 1$, χ^2 critical value = 7.88.

**** Press' *Q* statistic significant at $\alpha = .001$, $df = 1$, χ^2 critical value = 10.83.

Table 14
Classification Accuracy of Three Factor Model of Executive Functioning
for ADHD and Control Adults

EF Factors (cutoff scores) ¹	Sensitivity ²	Specificity ³	Positive Predictive Power ⁴	Negative Predictive Power ⁵	Overall Correct ⁶	Kappa ⁷	Chi-square ⁸	<i>p</i>	
Verbal Working Memory Factor (≤ 108)	91	48	74	77	75****	42	11.23	.0008	(1)
Sustained Intention Factor (≤ 106)	80	52	74	61	70***	33	6.31	.012	(2)
Effortful Learning Factor (≤ 105)	80	38	68	53	64	13	2.19	.139	(3)
All EF Factors Combined ⁹	83	67	81	70	77****	50	14.02	.0002	
Jack-Knife Validation Procedure: All EF Factors Combined ¹⁰	80	57	76	63	71***	38	8.08	.005	

Note. Press' *Q* statistic indicates whether a classification matrix may be considered statistically better than chance after comparing the overall number of correct classifications with the total sample size and number of groups (Hair et al., 1998).

¹ All probabilities were multiplied by 100.

² Sensitivity represents the degree to which a variable correctly identifies individuals diagnosed with the disorder.

³ Specificity represents the degree to which a variable correctly identifies individuals not diagnosed with the disorder.

⁴ Positive Predictive Power = proportion classified by the variable as having the disorder who actually received the diagnosis.

⁵ Negative Predictive Power = proportion classified by the variable as not having the disorder that truly did not meet criteria.

⁶ Overall Correct Classification = the variable's "hit rate," or the overall proportion correctly classified by the variable.

⁷ Kappa = level of agreement between a variable and a gold standard beyond chance (Kessel and Zimmerman, 1993).

⁸ Chi-square = values for chi-square analyses using the 2 x 2 contingency table (*p* values in the adjacent column).

⁹ Numbers in parentheses in the far right column designate the descending order of discriminatory power of EF variables.

¹⁰ A jackknife procedure was used to classify each participant after deriving classification functions to which his/her data did not contribute.

* Press' *Q* statistic indicates classification significantly better than chance based on $\alpha = .05$, $df = 1$, χ^2 critical value = 3.84.

** Press' *Q* statistic significant at $\alpha = .01$, $df = 1$, χ^2 critical value = 6.63.

*** Press' *Q* statistic significant at $\alpha = .005$, $df = 1$, χ^2 critical value = 7.88

**** Press' *Q* statistic significant at $\alpha = .001$, $df = 1$, χ^2 critical value = 10.83.

Appendix A

HISTORICAL CONCEPTUALIZATIONS OF ADHD

The number and variety of symptoms which may be presented by patients suffering from this affliction, and the diverse combinations and sequences of the symptoms in single cases, are striking features of the disease. It occurs in an endless number of clinical forms... The variegated symptomatology, the great diversity of syndromes met with, the apparent absence of any constant chronology in the development of the syndromes, and the aping by this malady of almost every well-known and well-defined neurological symptom complex, have been responsible for many mistakes in diagnosis and have caused even some of the best-informed students of the disease almost to despair of creating any sort of order out of the clinical chaos presented (Barker, 1920, p.2).

Although Lewellys F. Barker, M.D., made these statements at the 1920 meeting of the Association for Research in Nervous and Mental Diseases regarding the epidemic disease, lethargic encephalitis (discussed below), the sentiments expressed are apt for the long history of efforts to adequately define the attention-deficit disorders in children, and more recently, adults. Moreover, although the general constellation of symptoms now termed Attention-Deficit/Hyperactivity Disorder (ADHD) was possibly identified in the late 19th century, questions concerning which symptoms, occurring in how many dimensions, starting at what age, and continuing until what point in development, should define the disorder continue to generate controversy (Shaywitz & Shaywitz, 1988). This controversy is reflected in the following:

No term in the history of childhood psychopathology has been subject to as many reconceptualizations, redefinitions, and renamings, as the disorder referred to nontechnically as hyperactivity. From its origins in the concept of minimal brain damage, through hyperkinesis, to attention deficit disorder with hyperactivity (ADD/H), little has remained constant in our understanding of this disorder, except for the belief that children

manifest such a disorder and that we have never defined it adequately.
(Lahey et al., 1988, p. 330)

Early Perspectives on ADHD¹

Identification and Early Association with Brain Damage

George Still, an English physician, first described the disorder in 1902 after treating 20 children who exhibited "defects in moral control" (Still, 1902, p. 1008). Still described these children as strong willed, inattentive, overactive, aggressive and impulsive. Interestingly, his century-old account of the behaviors and problems exhibited by these patients and their families are remarkably consistent with current knowledge about ADHD. Specifically, Still observed these difficulties in nearly three times as many boys as girls, and he hypothesized the syndrome was hereditary given that patients' biological relatives showed more depression, alcoholism, and criminal behavior than relatives of other patients. Moreover, he posited that in some cases, the set of problem behaviors appeared to arise from non-hereditary factors, such as head injury or illness.

Early Views of ADHD as Brain Damage

It was one such non-hereditary factor that likely first stimulated widespread interest in a similar syndrome in the United States early in the 20th century (Cantwell, 1975). During the tragic encephalitis epidemics (see Appendix I, p. 202) of 1916 through 1919, thousands of children and adults across Europe and North America died (Wynne, 1920). However, many children who survived the brain infection exhibited symptoms much like those described by Still (Hohman, 1922), and the term "postencephalic behavior disorder" was adopted to describe the phenomenon (Ebaugh, 1923, p.89).

¹ To maintain consistency, the term Attention-Deficit/Hyperactivity Disorder (ADHD), is used throughout this manuscript (apart from the historical review section).

Hohman (1922), for example, provided case-reports on 11 post-encephalic children who exhibited "decided, profound changes in character and behavior" (p. 372). He noted these children showed "reactions...usually classified as purely functional or psychobiological, which apparently are closely related with...organic alteration" (Hohman, 1922, p. 372). He further explained the reactions to which he referred included "tics and excessive talk," becoming "irritable, fussy, quick-tempered, or boisterous and restless," and being "quarrelsome" with "streaks of brutality" (Hohman, 1922, p. 372). He stated that teachers described these children as "impudent, disrespectful, disobedient, and no longer amenable to discipline," and that some parents indicated their post-encephalic children would "curse" or "strike" them, insisted they "would do as they pleased," and became "indolent" and "indifferent" (Hohman, p. 372). Other parents reported their "recovered" children "destroyed their own belongings or the house furnishings," and were frequently found to be "fabricating or lying," (p. 372). Furthermore, some parents reported their post-encephalitic child had "screaming attacks which were uncontrollable," were "emotionally quite unstable," and "were capriciously moody or very irritable, fussy, whiny, and excitable" (Hohman, 1922, p.373). Hohman (1922) further noted that discipline with these children was "quite ineffectual" and "punishment helps not at all," and he ultimately concluded, "we have discovered nothing that is of any value in the treatment of these patients," and "time seems to be the sole healing factor" (p. 373). In a separate case report, Hohman reported clinical findings for at least one adult who exhibited similar changes in character and behavior following infection with encephalitis lethargica (Hohman, 1921).

In retrospect, the possibility that some survivors of encephalitis lethargica (children and adults) exhibited a form of environmentally-induced ADHD seems plausible. This possibility is supported by descriptions of similar patterns of behavioral symptoms exhibited by children who survived infection during subsequent outbreaks of encephalitis (Bender, 1942; Gibbs, Spies, & Carpenter, 1964). Moreover, this notion is supported by morbid pathology reports shortly after the epidemics revealing lesions in the frontal regions of the brain and indicating "the brain stem bears the brunt of the attack [of the virus] in almost every case" (Ayer, 1920, p. 169). It is interesting to note that recent neuroimaging studies implicate frontosubcortical pathways in ADHD — pathways rich in catecholamine neurotransmitter substances (primarily norepinephrine and dopamine), and these neurotransmitter substances are produced primarily in the locus ceruleous region of the human brain stem (Faraone & Biederman, 1998; Halperin, Newcorn, Schwartz, McKay, & et al., 1993b; Pliszka, McCracken, & Maas, 1996; Seiden, Sabol, & Ricaurte, 1993). Moreover, the catecholamines have been implicated in ADHD by the mechanism of action of stimulants--the class of drugs found generally effective in treating many ADHD children (i.e., stimulant-induced increases in availability of dopamine, and to some extent, norepinephrine; Faraone & Biederman, 1998). Moreover, recently identified patterns of neuropsychological and attentional deficits, as well as under-controlled motor activities, in ADHD children are similar to those found among adults with known frontal lobe damage (Faraone & Biederman). This finding suggests the frontal cortex, or the dopamine rich projections to the frontal cortex from the locus ceruleous of the brain stem (projections involved in both cognitive and motor control),

are dysfunctional in at least some ADHD children and adults (Faraone & Biederman; Pliszka et al., 1996; Seiden et al., 1993).

Nonetheless, case reports from Hohman (1922; reviewed above), and others (e.g., Leahy & Sands, 1921), in the medical literature of the time stimulated interest among some physicians in children who exhibited similar behavior syndromes apparently caused by various other forms of brain insult (e.g., closed head injury, oxygen deprivation during birth, exposure to environmental toxins). For example, Kahn and Cohen (1934) described a syndrome in children they termed "organic drivenness" (p. 748). These investigators relayed case histories of three children whose behavior disturbance was marked by an inability to remain quiet, social abruptness, clumsiness, and explosiveness, all of which they viewed as secondary to a central behavioral disturbance of hyperactivity (Kahn & Cohen). They postulated the condition was generated by a problem in the organization of the brain stem, and was typically caused by "trauma, prenatal encephalopathy, or birth injury" (Kahn & Cohen, p.748). However, evidently, these authors were the first to acknowledge that cases of "organic drivenness" had been identified in which no history of brain trauma could be confirmed (p. 755).

As word of the relationship between brain insult and serious behavioral disturbance in children was disseminated through further case reports, interest in the phenomenon increased among medical researchers in the 1930s and 1940s. These medical investigators cataloged much information about this clinically-heterogeneous, yet partially consistent, set of behavioral problems (Strauss & Lehtinen, 1947, provide a comprehensive review sprinkled with detailed case reports). Eventually, these researchers adopted the term "brain injured child syndrome" (Strauss & Kephart, 1955).

This label initially referred only to behaviorally disturbed children who had experienced identifiable brain trauma, brain disease, or who had a serious developmental disorder linked to the brain (e.g., cerebral palsy; Strauss & Kephart). These investigators posited that brain injured children exhibited "forced responsiveness to stimuli, distractibility, ... perseverations, and the like," because brain injury interfered with "the patterning and activity of the brain" that allowed one to develop "patterns of excitation" from moment-to-moment on the basis of all features of his/her stimulus field rather than the single stimulus that became most salient at any given moment (Straus & Kephart, pp.142-143). They further hypothesized that this "chief deficiency" demonstrated by brain injured children emerged from their "incapacity to see simultaneously" and make behavioral decisions based on a combination of "simultaneous impressions" from the multiplicity of stimuli impinging on him/her from the environment at any given moment (p. 143). They further reasoned that the ability to perform appropriate behaviors in a given situation required one to weigh "foreground" (presumably, "what I'd like to do now") and "background" (presumably, "what I know I ought to do") considerations at the same moment in time (p. 143). Where this capacity was concerned, Strauss and Kephart concluded, "The appreciation of such relations involves the simultaneous impression of the entire [stimulus] field and here [the brain injured child] is unable to perform adequately" (p. 173).

Strauss and Kephart's (1955) notion of motor disinhibition occurring secondary to impaired ability to perform two or more intellectual considerations simultaneously presages later notions of working memory and its relation to the behavior and attention problems exhibited by both head injured and ADHD populations (Baddeley, 1993;

Kimberg, D'Esposito, & Farah, 1997). Moreover, the work of Strauss and Lehtinen (1947) and Strauss and Kephart and their phenomenological-derived designation of a brain injured child syndrome represented a noteworthy step forward in the long progression of events leading to a clinically-meaningful taxonomy of disruptive behavior disorders in children. However, in a more immediate sense, their careful descriptions of the clinical phenomena they observed in brain injured children set the stage for further research and new conceptualizations of the behavioral problems such children exhibited.

Conceptual Drift From Certain to Assumed Brain Insult

As noted above, Kahn and Cohen (1936) acknowledged that they had identified child cases of a syndrome characterized by hyperactivity (a syndrome termed "organic drivenness") apart from any clear history of brain trauma. However, it was not until the 1950's that researchers and clinicians began to widely adopt the perspective that children exhibited disordered behavior, similar to that described by Still (1902), even when the cause of the presumed brain insult was unknown (Barkley, 1997a). This subtle shift in conceptualization in which a debilitating, brain-based behavioral syndrome was assumed present, in many cases, despite lack of clear evidence, or reported history, of brain insult, led many researchers to adopt the terms "minimal brain dysfunction" or "minimal brain damage" (MBD) to describe the syndrome (Pasamanick, Knobloch, & Lilienfeld, 1956).

Further Conceptual Movement: From Etiological to Descriptive Definitions

By the 1950's and early 1960's, some researchers began to focus less on the syndrome's etiological basis in brain damage, or dysfunction, and adopted more descriptive terminology (e.g., "hyperkinetic impulse disorder") — terminology that emphasized presumed core behavioral deficits of hyperactivity and impulsivity (Knobel,

Wolman, & Mason, 1959; Laufer, Denhoff, & Solomons, 1957). Other well-known clinical researchers of the time also began to adopt purely descriptive labels for the syndrome, and these labels belied their assumptions concerning which of the constellation of problematic behaviors exhibited by such children should be considered definitive of the disorder (Burks, 1960; Chess, 1960). Chess (1960), for example, described a "hyperactive child syndrome" that she believed was fundamentally characterized by a core problem of excessive motor movement across the day that generated global impairment in child development.

Re-conceptualization of the Disorder as Psychodynamic Reaction

Nearly seven decades after Still's descriptions of the problematic set of behaviors appeared in the journal *Lancet* (1902), the syndrome was first recognized in the official psychiatric nomenclature with the publication of the *Diagnostic and statistical manual of mental disorders, second edition (DSM-II)*; American Psychiatric Association, 1968). Despite the fact that many researchers of the time believed the core behavioral deficits of impulsivity and hyperkinesis were inextricably linked to neurological dysfunction, psychoanalytic thought continued to dominate child psychiatry at the time (Barkley, 1997a). Subsequently, the psychoanalytic doctrine that all mental disorders of childhood emerged from internal psychological conflicts secondary to difficulties in important early relationships, the term "hyperkinetic reaction of childhood" was adopted in *DSM-II*. The full definition of the disorder in *DSM-II* reads: "The disorder is characterized by overactivity, restlessness, distractibility, and short attention span, especially in young children; the behavior usually diminishes in adolescence. If this behavior is caused by organic brain damage, it should be diagnosed under the appropriate non-psychotic

organic brain syndrome" (p. 50). Interestingly, the role of brain damage or neurological dysfunction was completely eliminated from this official definition of the disorder. For purposes of the present study, the most important aspects of this definition are: 1) the addition of short attention span and distractibility to the problem of overactivity as cardinal features of the disorder; 2) the omission of impulsivity as part of the disorder despite the work of Laufer et al. (1957; noted above) and others; and 3) the apparent assumption that the disorder rarely, if ever, continued into adulthood.

Virginia Douglas and Emergence of Empirically-Based Definitions of ADHD

In the early 1970s, shortly after the publication of *DSM-II*, research critical to recent conceptualizations of the disorder as fundamentally characterized by deficits in attention, impulse control, and hyperactivity was beginning to appear (e.g., Douglas, 1972). Virginia Douglas' research program was the first to attempt to empirically establish which symptoms, or impairments, were specific to children diagnosed with hyperkinetic reaction of childhood. Douglas' careful clinical observations and insistence on precise specification of symptoms permitted the acquisition of data suggesting that core symptoms of poor sustained attention, impulsivity, and excessive motor activity, were primarily responsible for most deficits exhibited by children with the disorder (Douglas, 1972).

Within a few years of the publication of her seminal paper in 1972, Douglas tested the viability of a training approach for hyperactive children based on work of A. R. Luria (1961) focused on teaching children diagnosed with the disorder problem solving strategies intended to promote acquisition of "inhibitory control of...behavior through...use of self-verbalization and modeling techniques" (Douglas, 1975, p. 199).

This approach foreshadowed many later interventions for such children in that it combined psychostimulant drug treatment with inhibitory control through self-verbalization, modeling techniques, and negative feedback, as well as in assisting such children in choosing tasks "...which could be solved only by careful looking, listening, or moving and for which a strategy is required before action is taken" (Douglas, 1975, p. 199). While results of Douglas' early "multimodal" treatment study in 1975 were encouraging, the greatest significance of her early research is seen in the observation that it laid a new conceptual foundation for defining ADHD on the basis of empirical data. Moreover, Douglas asserted that empirical data could reveal which dimensions of symptom impairment were most salient and should be the focus of treatment (Douglas, 1972, 1975). Furthermore, Douglas' early work prompted additional important research that occurred in the late 1970's investigating the impact of poor sustained attention, impulsivity, and hyperactivity on various aspects of child development, including studies of cognitive, social, and academic functioning (Douglas, 1983). Numerous studies examining the adverse impact of inattention and hyperactivity on cognitive development emerged in the mid and late 1970's.

Inattention, Secondary Deficits, and Developmental Aspects of ADHD

Douglas' work, and studies examining the impact of the disorder on child development, ultimately catalyzed another shift in the conceptualization of the disorder by challenging the view in child psychiatry that the disorder was fundamentally a maladaptive reaction of character-flawed children to dysfunctional parenting. Importantly, it also supported the notion that a core deficit of poor sustained attention may be the sine-qua-non of the disorder, and as such, was present in all children

exhibiting the syndrome. Moreover, researchers conducting the first longitudinal studies of the disorder in the late 1970's were becoming increasingly convinced that accruing secondary deficits in functioning (e.g., weaknesses in cognitive, academic, and interpersonal functioning) were perhaps even more debilitating than primary symptoms of the disorder (Weiss, Hechtman, Milroy, & Perlman, 1985). Hechtman and Weiss (1986, 1993) and Wender (1972, 1987) began to assert that such deficits were unlikely to wane with the onset of adolescence and were likely to generate impairment well into adult life.

The research emerging in the years leading up to 1980 served to further strengthen the perception that compromised attentional functioning played a fundamental role in the disorder. Moreover, the notion that some children may experience deficits in concentration and sustained attention apart from problems with hyperactivity and impulsivity was gaining acceptance. Indeed, as noted below, the notion that an "attention deficit" could stand alone proliferated so rapidly in the years just prior to the publication of the *Diagnostic and Statistical Manual of Mental Disorders, third edition (DSM-III;* American Psychiatric Association, 1980) that it was officially "canonized" in the next iteration of the psychiatric nomenclature, despite a near complete absence of empirical work to support it (Barkley, 1998).

Emergence of DSM-III and DSM-III-R Conceptualizations of ADHD

By 1980, the American Psychiatric Association had published the third edition of the official psychiatric classification scheme (*DSM-III*). Largely due to the work of Douglas and others outlined above, in *DSM-III*, the disorder previously called "a deficit in moral control," "brain injured child syndrome," "minimal brain dysfunction,"

"hyperkinetic impulse disorder," "hyperactive child syndrome," and "hyperkinetic reaction of childhood," had been renamed "attention-deficit disorder" (ADD). The significance of this change in diagnostic label is seen in the observation that the disorder was defined by its presumed core deficit (i.e., inattention) — a definition signifying an official recognition that childhood psychiatric conditions should be understood in terms of the specific behaviors that characterize them rather than their presumed etiological bases. However, where the present study is concerned, the larger significance of this change in designations is seen in the further observation that it allowed the authors of the category in *DSM-III* to make the bold move of formally separating deficits of inattention from problems of hyperactivity for at least one form of the disorder (see below).

Evidently, the authors of the Disruptive Behavior Disorders in *DSM-III* concluded if inattention, not hyperactivity, was the core deficit characterizing all cases of the disorder, then it was possible for one to experience attention problems apart from hyperactivity (Barkley, 1997).

Three Symptom Dimensions and Inclusion of Adults in DSM-III ADD-H

The increasingly accepted clinical lore in the early 1980s held that some children, and even adults, exhibited deficits in attention without problems of hyperactivity.

Moreover, research reports indicated that children who were exclusively inattentive were actually less active than desirable and tended to adopt fearful, anxious, and overcontrolled behavioral styles (see Goodyear & Hynd, 1992, for a review).

Subsequently, despite a lack of hard research to support the move, the authors of the category under *DSM-III* included two distinct subtypes of the disorder for children (Attention Deficit Disorder with Hyperactivity, ADD-H; and Attention Deficit Disorder

without Hyperactivity, ADD–W/O). Moreover, given the growing perception among clinicians and researchers that cognitive, academic, and interpersonal deficits accumulating across child development seemed unlikely to dissipate naturally with the onset of adolescence or adulthood, *DSM-III* included a distinct category for individuals with ADD-H who showed continuing impairment from the disorder in adult life (Attention Deficit Disorder-Residual Type, ADD-RT). Thus, *DSM-III* provided the first official recognition that affected individuals may experience impairing cognitive and other developmental sequelae of the disorder in adulthood. Moreover, publication of *DSM-III* provided the first detailed definition of the disorder with explicit symptom descriptions, specific symptom counts (cut-offs) indicating how many symptoms were required in each symptom domain for diagnosis, and other diagnostic criteria (i.e., onset before age seven; duration of at least six months; not due to Schizophrenia, Affective Disorder, or severe or profound Mental Retardation).

The category ADD–W/O was thought to include children who exhibited little hyperactivity but had considerable difficulty maintaining adequate concentration and attention. Similarly, the category ADD-RT for adults required a past history of the disorder (ADD-H) and persistence of clinical impairment from inattention and poor concentration, but not from hyperactivity. Thus, it was assumed under *DSM-III* that by the time individuals with the disorder became adults, they were unlikely to experience continuing impairment from hyperactive symptoms and would more closely resemble children diagnosed ADD–W/O. Moreover, it was also assumed in the *DSM-III* definition that children who exhibited the exclusively inattentive variant of the disorder should not be expected to maintain symptoms into adulthood. That is, although a history of ADD-H

in childhood was required for a later diagnosis of ADD-RT in adulthood, a history of ADD-W/O was considered insufficient for the adult diagnosis of ADD-RT. This distinction apparently emerged largely because the decision to include the exclusively inattentive variant of the disorder in childhood was necessarily based on clinically-based phenomenological descriptions of the disorder rather than empirical data (Lahey et al., 1988).

Importantly, the inclusion of three separate dimensions of symptom impairment in *DSM-III* ADD-H was based on the assumption that this most frequent expression of the disorder in children was fundamentally multifaceted (Lahey et al., 1988). Subsequently, the *DSM-III* required that a child not receive the diagnosis of ADD-H unless he/she exhibited problems in all three symptom areas: inattention, hyperactivity, and impulsivity. As noted above, the multidimensional definition of ADD-H was primarily the result of the early empirical and theoretical work of Virginia Douglas (1972; 1975; 1978; Douglas & Peters, 1979). However, despite her pioneering empirical work on symptom dimensions operative in attention disorders, little empirical data existed at that time that were relevant to the distinction of separate symptom dimensions of ADD-H (Lahey et al., 1988). Unfortunately, a similar situation prevails at the current time where adult developmental expressions of the disorder are concerned. Specifically, as will be discussed later, few empirical data exist to delineate which symptom dimensions are at work in adult variants of the disorder.

Controversy Over DSM-III Conceptualization: Does an Inattentive Subtype Exist?

Shortly after the creation of the category ADD-W/O, concern arose among some researchers that expressions of the disorder that occurred in the absence of hyperactivity potentially indicated the presence of another, undefined disorder that was fundamentally distinct from ADD-H (Barkley, DuPaul, & McMurray, 1990; Goodyear & Hynd, 1992). These investigators posited that the attention deficits that occur apart from hyperactivity were likely to be qualitatively different from the attention problems exhibited by children with ADD-H. Specifically, Barkley (1990) and others (Goodyear & Hynd, 1992), argued that the attention deficits exhibited by ADD-W/O children were deficits in information processing speed, and perhaps, weaknesses in selective attention (i.e., the ability to muster and selectively focus one's mental resources on stimuli relevant to the task at hand). Such deficits, they argued, were more like information processing problems exhibited by children with internalizing disorders (i.e., anxiety and depressive disorders) than the inattentiveness exhibited by hyperactive children. For example, in research that followed-up on these concerns several years after they were initially raised, Pliszka (1989) conducted a study using laboratory measures of behavior, cognition, and stimulant response in ADD children with and without comorbid anxiety. The findings suggested that attention-disordered children with comorbid Overanxious Disorder under *DSM-III* (Generalized Anxiety Disorder under *DSM-IV*) were less impulsive on a laboratory test of sustained attention, were more sluggish in their reaction times on a memory scanning task, and were significantly less likely to present with a comorbid conduct disorder than non-anxious, ADD-H children (Pliszka, 1989). Moreover, when a subset of Pliszka's (1989) original child sample completed a double-blind trial of psychostimulant

medication, comorbid attention- and anxiety-disordered children showed significantly weaker drug response than attention-disordered children without anxiety. Further, this differential group response to psychostimulant treatment obtained whether or not ADD-H children had comorbid Conduct Disorder (Pliszka, 1989). In support of the position that ADD-W/O may constitute a fundamentally different psychiatric phenomenon than ADD-H, Pliszka (1989) suggested that children with comorbid attention and anxiety disorders may actually represent children with a primary anxiety disorder who developed inattention secondarily.

In addition to the concern that ADD-H and ADD-W/O may comprise completely separate disorders, some investigators began to suggest that difficulties with hyperactivity and impulsivity were essential to any definition of the disorder (Barkley, 1990; Weiss & Hechtman, 1986). Specifically, these investigators asserted that hyperactivity and impulsivity were features so essential to an adequate understanding of the disorder, that clinicians and researchers would not be able to reliably differentiate primary disorders of attention from other disorders presenting with attention problems (e.g., internalizing disorders, learning disabilities), nor would they be able to adequately assess later developmental risks. Subsequently, these researchers asserted that the symptoms of hyperactivity and poor impulse control should be included in the official name of the disorder.

In response to objections like these, as well as the lack of empirical evidence that attention deficits occurred independent of problems with hyperactivity, the distinction between manifestations of the disorder that did and did not include hyperactivity was eliminated in 1987 with the publication of the *Diagnostic and statistical manual of*

mental disorders, third edition, revised (DSM-III-R; American Psychiatric Association, 1987). Subsequently, the distinction between the three symptom dimensions (inattentive, hyperactive, and impulsive) critical to the DSM-III definition of the disorder was discarded. Therefore, DSM-III-R, like DSM-II, described ADHD as a unidimensional phenomenon involving inattention, hyperactivity, and impulsivity. This trio of symptom domains in DSM-III-R was expressed in a single list of 14 symptoms, and the disorder was officially renamed "Attention deficit-Hyperactivity Disorder" (AD-HD). The polythetic¹ aspect of the new definition was important in that a child could be diagnosed with the disorder if he/she exhibited a minimum of eight symptoms from the list of 14. However, unlike the situation under DSM-III's "monothetic" definition of the disorder, under DSM-III-R, a child need not exhibit any specific symptom, nor did he/she need to show impairment from any particular combination of symptoms, to receive the diagnosis. In addition, DSM-III-R included a category termed "Undifferentiated Attention-deficit Disorder" (UADD) "for individuals not exhibiting signs and symptoms of impulsiveness and hyperactivity" (p. 52).

Reaction to DSM-III-R: Are ADHD Symptoms Single- or Multi-Dimensional Phenomena?

As was also noted by Lahey et al. (1988), the adoption of a unidimensional definition for the overall category of AD-HD seemed at odds with the decision of the DSM-III-R disruptive behavior disorders committee to include a category termed UADD. Specifically, Lahey et al. (1988) observed that the categories of AD-HD and UADD

¹ *DSM-III-R* explains that in contrast to earlier versions of DSM in which "each of several criteria must be present for the diagnosis" (monothetic format), in *DSM-III-R*, diagnostic criteria were revised "to form an index of symptoms of which a certain number, but no single one [nor group of symptoms in a given dimension], is required for diagnosis..." (polythetic format; p. xxiv).

appeared to rest on "contradictory assumptions" in that the polythetic, unidimensional definition of AD-HD assumed symptoms of inattention, hyperactivity, and impulsivity occurred along "a single unitary dimension of maladaptive behavior" (p. 331). In contrast, the category UADD was based on the assumption that "difficulties in inattention [were] sometimes independent of impulsivity and motor hyperactivity" (Lahey et al., 1988, p. 331). Moreover, and perhaps most important, no empirical data at the time suggested that disorders of inattention occurred completely independent of *both* hyperactivity and impulsivity. Even under *DSM-III*, a child was required to exhibit at least three of six symptoms of impulsivity in order to receive the diagnosis ADD-W/O. Where the clinical impact of the *DSM-III-R* definition was concerned, Lahey and colleagues (1994) later called UADD a "vague and tentative" category, and stated that the decision to adopt a polythetic definition of the disorder "effectively eliminated" diagnosis and treatment for those children who could have been identified ADD-W/O under *DSM-III* (Lahey et al., 1994, p. 628). The clinical importance of this observation is evident in the consideration that among the 14 symptoms of AD-HD under *DSM-III-R*, five describe poor attentional functioning, four represent hyperactivity, and five involve poor impulse control. Therefore, under *DSM-III-R*, a child could not meet diagnostic criteria for AD-HD unless he/she exhibited a minimum of three hyperactive or impulsive symptoms (i.e., assuming he/she exhibited five of five symptoms of inattention). Thus, the authors of the *DSM-III-R* AD-HD category assumed that individuals with disordered attention would also exhibited hyperactivity and/or impulsivity (and vice versa). However, this assumption was only partly supported by research that followed. Moreover, as is reviewed below, research stimulated by the controversy surrounding

DSM-III-R revealed that, in children, the unsubstantiated and assumption behind the category UADD (i.e., that disorders of inattention occur independent of both hyperactivity and impulsivity) would ultimately be vindicated by empirical data.

Appendix B

Official Consent Form

Title: Discriminant Validity and Dimensional Structure of *DSM-IV* Subtypes of ADHD in Clinic-Referred Adults: A Cluster Analysis

Experiment Number:

Principal Investigator: A. Timothy Butcher

Purpose of the Study

The purpose of this study is to investigate attention problems in young adults. 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 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 videotaped. 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.

Participant’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. Thomas Hurd, Chair, IRB | 231-5281 |
| RAFT Community Crisis Center | 382-1738 |

Signature

Date

Name (Please Print)

Appendix C

Release of Information Form

I, _____, give my consent to allow A. Timothy 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 adults. I understand that this contact will involve a brief letter of explanation and questionnaires about my behavior as a child and as an adult. I have reviewed this letter and the questionnaires. I understand that this permission to contact my parent(s)/guardian and/or other observer-raters listed below will terminate upon the completion of this study.

Parent/Guardian and/or Other Observer-Rater(s) Name and Address:

Signature: _____

Date: _____

Witness: _____

Date: _____

Appendix D

Research Diagnosis for ADHD and non-ADHD Groups

The following algorithm based on assessment data was utilized to assign participants to ADHD and non-ADHD groups. The diagnostic algorithm required that in order to receive a *full* diagnosis of ADHD as an adult, a participant must satisfy *DSM-IV* criteria for ADHD in the following ways: [**Criteria A**] **1.)** Endorse six of nine symptoms for one of the subtypes of ADHD during the ADHD structured clinical interview; **2.)** Obtain current self- and observer-ratings of "2" ("pretty much," "often") or "3" ("very much," "very frequently") on at least six of nine items from one of the *DSM-IV* Symptom Subscales (i.e., Inattentive Symptoms Subscale; Hyperactive/Impulsive Symptoms Subscale) from the CAARS-S/O:L — again, subscales comprised of items intended to represent each of the *DSM-IV* ADHD symptoms; [**Criteria B**] **3.)** Recall specific examples from early childhood during the retrospective portion of the ADHD interview indicating that prior to seven years of age, he/she experienced clinically significant impairment from some symptoms of ADHD as defined by *DSM-IV*; **4.)** When parent ratings are available, receive retrospective parent ratings ("...when your child was between ages 6 and 10 years old...") of "2" ("pretty much") or "3" ("very much") on at least two of the five items from the Wender Parent Rating Scale (WPRS) that are similar to specific *DSM-IV* ADHD symptoms (i.e., WPRS items four and six are similar to *DSM-IV* Inattentive Symptoms two, four, and eight, respectively; and WPRS items one, three, and five are similar to ADHD Hyperactive/Impulsive symptoms three, nine, and one respectively); [**Criteria C**] **5.)** Report during the ADHD interview that he/she currently experiences impairment in two or more settings from symptoms of ADHD; [**Criteria D**]

and **6.)** Describe several experiences from adulthood indicating he/she currently experiences clinically significant impairment in social, academic, or occupational functioning arising from symptoms of *DSM-IV* ADHD.

Moreover, the diagnostic algorithm required that in order to receive a current diagnosis of ADHD-NOS, adult participants must: [**Criteria A**] **1.)** Endorse a minimum of five symptoms for one of the subtypes of the disorder during the ADHD structured clinical interview; **2.)** Receive current ratings of "2" ("pretty much") or "3" ("very much") on at least five of nine items from one of the *DSM-IV* Symptom Subscales from the CAARS-O:L (i.e., Inattentive Symptoms Subscale; Hyperactive/Impulsive Symptoms Subscale); and **3.)** Fulfill items 3, 4, and 5 in the same manner identified above.

Appendix E

Table for Evaluating Diagnostic Performance of a Dependent Variable¹

		Diagnosis		Total:
		Present	Absent	
DV (Test/Measure): _____	Positive	a =	b =	(a+b) =
	Negative	c =	d =	(c+d) =
Total:		(a+c) =	(b+d) =	(a+b+c+d) =

Sensitivity: $a / (a+c) =$

Specificity: $d / (b+d) =$

Positive Predictive Power: $a / (a+b) =$

Negative Predictive Power: $d / (c+d) =$

False Positive Rate: $b / (b+d) =$

False Negative Rate: $c / (a+c) =$

Overall Correct Classification: $(a+d) / N =$

Kappa: $(P_o - P_c) / (1 - P_c) =$

P_o = observed agreement = $(a+d) / N$

P_c = chance agreement = $((a+b)(a+c) + (c+d)(b+d)) / N^2$

Press' Q^2 : $[N - (nK)]^2 / N (K - 1)$

N = total sample size

n = number of participants correctly classified

K = number of groups

¹ Based on Kessel and Zimmerman (1993)

² From Hair et al. (1998)

Appendix F

DSM-IV Adult ADHD Structured Clinical Interview

Instructions: *For the next set of questions, I want to ask you about behavioral and attentional difficulties you may have experienced as a child and that may continue to cause problems for you as an adult.*

Specifically, for the first part of each question, I'll ask you to think back to when you were in elementary school (1st - 5th grades; ages 6 - 10y/o). Please answer 'yes' to my questions about your childhood only if you think you had a lot more trouble with these problems than other children your age did.

For each problem we discuss, after I ask if you experienced it in childhood, I will ask whether the same problem, or a similar problem, occurs in your adult life. Again, I want you to say 'yes' to the questions about your adult life only if, in your opinion, you experience a lot more difficulty with the problem than most adults your age do.

Finally, for each of the problems that seemed to cause a lot of difficulty for you in both childhood and adulthood, I will ask if it has always, or almost always, been present in your life.

Do you have any questions?

ATTENTION-DEFICIT/HYPERACTIVITY DISORDER

***DSM-IV symptoms and criteria are in bold print.**

***Interview prompts are in italics.**

I. INATTENTION

<p>A.1. Six or more of the following symptoms of inattention have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level.</p>	
<p>(a)Often fails to give close attention to details or makes careless mistakes in schoolwork, work, or other activities.</p>	
<p><i>CHILD: 1. As a child, did you often make careless mistakes on school work, chores, or other things that you did?</i></p>	<p>? - +</p>
<p><i>ADULT: 1. Now, as an adult, do you often make careless mistakes in various activities such as at work or in other things that you do?</i></p>	<p>? - +</p>
<p><u>If appropriate:</u> <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <p>_____</p> <p>_____</p>	

<p>(b)often has difficulty sustaining attention in tasks or play activities.</p> <p><i>CHILD: 2. As a child, did you often have trouble keeping your attention focused on the task at hand or sustaining your attention?</i></p> <p><i>ADULT: 2. As an adult, is it often difficult for you to maintain focused attention when you need to?</i></p> <p>If appropriate: <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>
<p>(c)often doesn't seem to listen when spoken directly to.</p> <p><i>CHILD: 3. As a child, did you have a lot of trouble listening to other people when they spoke to you?</i></p> <p><i>ADULT: 3. As an adult, do you often find that you aren't really listening when people are speaking to you?</i></p> <p>If appropriate: <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>

<p>(d)often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace.</p> <p><i>CHILD: 4. In childhood, was it very difficult for you to finish things that others asked you to do, such as chores, homework, etc.?</i></p> <p><i>ADULT: 4. As an adult, is it difficult for you to finish things that others ask you to do at home, work, or in other situations?</i></p> <p>If appropriate: <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>
<p>(e)often has difficulty organizing tasks and activities.</p> <p><i>CHILD: 5. In childhood, did you have a lot of difficulty organizing your school work, or did you have a hard time getting things together for outings or activities?</i></p> <p><i>ADULT: 5. As an adult, do you have a lot of difficulty organizing your work, or do you have a hard time getting things together for activities (e.g., projects at work, packing for vacations, etc.)?</i></p> <p>If appropriate: <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>

<p>(f)often avoids, dislikes or is reluctant to engage in tasks that require sustained mental effort(such as schoolwork, or homework)</p> <p><i>CHILD: 6. As a child, did you dislike or refuse to do schoolwork or homework because it was hard for you to concentrate?</i></p> <p><i>ADULT: 6. As an adult, do you dislike or are you often reluctant to do mentally demanding work because it's hard for you to concentrate?</i></p> <p>If appropriate: <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>
<p>(g)often loses things necessary for tasks or activities (e.g., toys, school assignments, pencils, books or tools)</p> <p><i>CHILD: 7. As a child, did you often lose things that you needed for school such as books, pencils, papers, or did you frequently lose track of your toys?</i></p> <p><i>ADULT: 7. In adulthood, do you often misplace or lose things that you need (keys, wallet/purse, etc.)?</i></p> <p>If appropriate: <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>

<p>(h)is often easily distracted by extraneous stimuli.</p> <p><u>CHILD</u>: 8. In childhood, were you easily distracted by noise or other things going on around you?</p> <p><u>ADULT</u>: 8. How about as an adult. Are you easily distracted by noise or things going on around you when you are trying to concentrate?</p> <p>If appropriate: Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>
<p>(i)is often forgetful in daily activities.</p> <p><u>CHILD</u>: 9. In childhood, did you often forget things you needed to remember?</p> <p><u>ADULT</u>: 9. As an adult, do you often forget to do things that you need to do, or do you frequently start something and then forget what you were doing or why you were doing it? [Do you consider yourself, or do people often consider you, to be absent minded?; Does it seem like you are almost always "forgetting to remember" even important things?]</p> <p>If appropriate: Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>

Criteria B (age-of-onset for any inattentive symptoms coded as present):

Next, I need you to think back and try to recall how old you were when the difficulties we've just been talking about [review symptoms coded as present] first started to be a problem for you: [NOTE: Be sure to clarify any inconsistencies between the age-of-onset reported here and the patient's description of childhood difficulties above.]

[If unclear] Now, I want to make sure I have the right idea about whether the difficulties we've just been talking about [list again if necessary] continued to be a problem for you during other periods of your life:

Junior High: _____

High School: _____

Early Adulthood/(College): _____

[If appropriate] Middle and/or Later Adulthood: _____

II. Hyperactivity/Impulsivity

<p>A2. Six(or more) of the following symptoms of hyperactivity-impulsivity have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level.</p> <p>Hyperactivity:</p>	
<p>(a) often fidgets with hands or feet or squirms in seat.</p> <p><i>CHILD: 1. When you were in elementary school (1st grade, 2nd grade, etc.), did you fidget or squirm in your seat a great deal or have a lot of trouble sitting still?</i></p> <p><i>ADULT: 1. As an adult, do you often fidget or feel like you can't sit still? [Is some body part almost always moving?]</i></p> <p>If appropriate: <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>
<p>(b)often leaves seat in classroom or in other situations in which remaining seated is expected.</p> <p><i>CHILD: 2. As a child, did you frequently have difficulty staying seated when you were supposed to (e.g., in school)?</i></p> <p><i>ADULT: 2. As an adult, do you often find yourself feeling so restless that you have trouble staying seated in situations where its expected (e.g., during meetings at work, at an opera or a play, during a lecture/sermon, etc.)?</i></p> <p>If appropriate: <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>

<p>(c)often runs about or climbs excessively in situations in which it is inappropriate.</p> <p><i>CHILD: 3. In childhood, did you often get into trouble for running about excessively or climbing on furniture when you weren't supposed to?</i></p> <p><i>ADULT: 3. As an adult, are you so energetic that others have a hard time keeping up with you? [Do you find that its hard for you to ever fully relax?]</i></p> <p><u>If appropriate:</u> <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>
<p>(d)often has difficulty playing or engaging in leisure activities quietly.</p> <p><i>CHILD: 4. As a child, did you have a hard time playing quietly? [Did you often get into trouble at home or at school for being to loud when you were playing?]</i></p> <p><i>ADULT: 4. As an adult, do you often talk too loudly, or are you overly boisterous in social settings? [Have others complained that you are too loud or too wild at parties or during other group activities?]</i></p> <p><u>If appropriate:</u> <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>

<p>(e)is often "on the go" or often acts as if "driven by a motor"</p> <p><u>CHILD:</u> 5. As a child, were you "always on the go," or did you seem to be "driven by a motor?" [As a child, did you just wear people out because you had so much energy?]</p> <p><u>ADULT:</u> 5. In adulthood, do you tend to have so much energy that it seems like you can outlast others and not become tired until long after they are completely worn out?</p> <p><u>If appropriate:</u> Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>
<p>(f)often talks excessively</p> <p><u>CHILD:</u> 6. In childhood, did you frequently get into trouble for talking too much?</p> <p><u>ADULT:</u> 6. As an adult, do you believe, or do others comment, that you tend to talk too much?</p> <p><u>If appropriate:</u> Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>

<p>Impulsivity</p> <p>(g)often blurts out answers before questions have been completed.</p> <p><i>CHILD: 7. As a child, did you often answer a question even before the person had finished asking it?</i></p> <p><i>ADULT: 7. As an adult, when you are talking with others, do you often try to answer their questions before they have even finished asking them because you feel impatient or because you just can't wait to say what you want to? [When you are talking with someone when tends to talk a lot, do you have a tendency to cut them off frequently during the conversation?; Do you have a tendency to say things without thinking –things that you later regret?]</i></p> <p><u>If appropriate:</u> <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>
<p>(h)often has difficulty awaiting turn</p> <p><i>CHILD: 8. As a child, was it hard for you to wait your turn when playing games, when waiting for lunch in the cafeteria, etc.?</i></p> <p><i>ADULT: 8. As an adult, is it very hard for you to remain patient when waiting in lines (e.g., at the bank, when stuck in traffic, at the grocery store)?</i></p> <p><u>If appropriate:</u> <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <hr/> <hr/> <hr/>	<p>? - +</p> <p>? - +</p>

<p>(i)often interrupts or intrudes on others(e.g., butts into conversations or games)</p> <p><i>CHILD: 9. As a child, did you "butt-into" other children's games or conversations too much?</i></p> <p><i>ADULT: 9. As an adult, do you have a clear tendency to "butt-into" other peoples' conversations or activities when it might not be perceived as appropriate to do so?</i></p> <p><u>If appropriate:</u> <i>Did you experience difficulties with this(these) problem(s) continually from childhood to adulthood?</i></p> <hr/>	<p>? - +</p> <p>? - +</p>
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Criteria B (age-of-onset for any hyperactive/impulsive symptoms coded as present):
Next, I need you to think back and try to recall how old you were when the difficulties we've just been talking about [review symptoms coded as present] first started to be a problem for you: [NOTE: Be sure to clarify any inconsistencies between the age-of-onset reported here and the patient's description of childhood difficulties above.]

[If unclear] Now, I want to make sure I have the right idea about whether the difficulties we've just been talking about [list again if necessary] continued to be a problem for you during other periods of your life:

Junior High:

High School:

Early Adulthood/(College):

[If appropriate] Middle and/or Later Adulthood:

DSM-IV Requires the Following for an ADHD Diagnosis:	Childhood	Adulthood
A.1 6 of 9 symptoms of Inattention are met for childhood <u>AND</u> 6 of 9 symptoms of inattention are met in the past 6 months (adulthood).	? - + # of symptoms: _____	? - + # of symptoms: _____
A.2 6 of 9 symptoms of Hyperactivity/Impulsivity are met for childhood <u>AND</u> 6 of 9 symptoms of Hyperactivity/Impulsivity are met in the past 6 months (adulthood).	? - + # of symptoms: _____	? - + # of symptoms: _____
B. <u>Some</u> hyperactive-impulsive or inattentive symptoms that caused impairment were present before age 7.	? - +	
C. Some impairment from the symptoms is present in two or more settings(e.g., at school or work, and at home)	? - +	? - +
D. Clear evidence of clinically significant impairment in social, academic, or occupational functioning.	? - +	? - +
314.01 Attention-Deficit/Hyperactivity Disorder, combined type: Criteria A1 and A2 are met for the past 6 months, and criteria B, C, and D are met.	? - +	? - +
314.00 Attention-Deficit/Hyperactivity Disorder, Predominantly Inattentive Type: Criterion A1 only is met for the past 6 months and criteria B, C, and D are met.	? - +	? - +
314.01 Attention-Deficit/Hyperactivity Disorder, Predominantly Hyperactive-Impulsive type: Criterion A2 is met but Criterion A1 is not met for the past 6 months.	? - +	? - +
314.9 Attention-Deficit/Hyperactivity Disorder Not Otherwise Specified. (This category is for disorders with prominent symptoms of inattention or hyperactivity-impulsivity that do not meet full criteria for Attention-Deficit/Hyperactivity Disorder.)	? - +	? - +

Appendix G

List of Measures

- I. *Structured Clinical Interview for DSM-IV—Axis I (SCID-I)*
Structured Clinical Interview for DSM-IV—Axis II (SCID-II)
SCID-II Personality Questionnaire (SPQ)
Copyrighted material, available from:
American Psychiatric Press
1400 K Street, N.W.
Washington, D.C. 20005
- II. *DSM-IV Adult ADHD Structured Clinical Interview*
Available from:
A. Timothy Butcher, M.Div., M.S.
Baylor College of Medicine
Department of Psychiatry and Behavioral Sciences
Houston Medical Center Professional Building
6655 Travis Street, Suite 500
Houston, Texas 77030
Phone: 713-798-4840
E-mail: abutcher@bcm.tmc.edu
- III. *Conners Adult ADHD Rating Scale — Self-Report: Long Version (CAARS-S:L)*
Conners Adult ADHD Rating Scale — Observer-Report: Long Version (CAARS-O:L)
Conners Continuous Performance Test Software Program (Conners CPT)
Copyrighted material, available from:
Multi-Health Systems, Incorporated
908 Niagara Falls Boulevard
North Tonawanda, New York 14120
Phone: 800-456-3003
- IV. *Paced Auditory Serial Attention Test (PASAT)*
Copyrighted material, available from:
The Psychological Corporation
19500 Bulverde
San Antonio, TX 78259
Attn: Customer Care
Phone: 1-800-872-1726 (Voice)
Phone: 1-800-232-1223 (Fax)
- V. *Wender Utah Rating Scale (WURS)*
Wender Parent's Rating Scale (WPRS)
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.

- VI. *Wisconsin Card Sorting Test — Computer Version 2 (WCST-CV2)*
Copyrighted material, available from:
Psychological Assessment Resources
Post Office Box 998
Odessa, FL 33556
Phone: 800-331-8378
- VII. *Wechsler Adult Intelligence Scale — Third Edition (WAIS-III)*
Wechsler Memory Scale — Third Edition (WMS-III)
Copyrighted material, available from:
The Psychological Corporation
Harcourt Brace and Company
555 Academic Court
San Antonio, Texas 78204
Phone: 800-211-8378
- VIII. *Woodcock-Johnson Psychoeducational Battery — Revised (WJ-R)*
Copyrighted material, available from:
Riverside Publishing

Appendix H

Considerations Regarding Estimated Reliability of Factors

The following issues informed considerations regarding the estimated reliability of factors, the number of factors to extract, and the practical and statistical significance of factor loadings, for the exploratory factor analysis of CAARS-S/O ratings and the principle components analysis of the 10 executive functioning variables.

First, popular rules suggest the number of variables factor analyzed determines sample size necessary (range = 2 - 20 participants per variable) for reliable factors (Stevens, 1996). However, recent evidence indicates the most important issues for reliable factors are component saturation (or the magnitude of loadings when taken together) and absolute sample size (Guadagnoli & Velicer, 1988). Of greatest importance here, Guadagnoli and Velicer (1988) provide at least tentative, empirically-based guidelines for deciding whether factors extracted in a given study should be considered reliable. Specifically, based on findings from their Monte Carlo study, Guadagnoli and Velicer (1988) concluded, in part, that: 1.) factors with four or more loadings $\geq .60$ in absolute value should be considered reliable, irrespective of sample size; and 2.) factors with 10 or more lower loadings ($\geq .40$) should also be considered reliable if sample size is approximately 150. As can be seen in Table 2, both factors extracted from observer- and self-rating data exhibited sufficient "component saturation" to meet the first reliability criterion listed above.

Second, the latent root criterion was used to determine how many factors should be initially extracted (Kaiser, 1960). The Kaiser criterion requires that if a factor does not account for variance equivalent to that of one original variable, it should not be

retained for interpretation (Kaiser, 1960). Thus, only latent roots (eigenvalues) ≥ 1.0 were considered noteworthy. Subsequently, two factors were extracted from each of the separate factor analyses with observer- and self-rating data sets. However, as noted by Hair et al (1998), when the number of variables factor analyzed is less than 20, the latent root criterion may be overly conservative, causing too few factors to be extracted. Therefore, a "percentage of variance criterion" (Hair et al., 1998, p. 104) was also evaluated. The percentage of variance criterion requires that additional factors continue to be extracted until a prespecified proportion of the total variance is accounted for by the factor model, or until additional factors account for so little variance that they carry little practical significance (e.g., ≤ 5 percent of total variance; Hair et al., 1998). The two-factor solution adopted for the observer and self-ratings accounted for 49 percent and 41 percent respectively of the total variance in item scores. However, further principal factors analyses conducted separately using observer data and extracting a third, and then a fourth factor, only accounted for an additional four percent, and three percent, respectively of the total variance. Moreover, additional principal factors analyses with self-rating data extracting three, and four, factors, respectively accounted for 4 percent and 3 percent of the total variance respectively.

Second, where the statistical significance of factor loadings was concerned, the author of the current study adopted a relatively conservative criterion. Any factor loading used in the interpretation of a factor should, at a minimum, be statistically significant (Stevens, 1996). Given Cliff and Hamburger's (1967) findings that standard errors of factor loadings for orthogonally rotated solutions were considerably larger (frequently 200 percent larger) than standard errors for an ordinary correlations, critical values for

typical correlations could seriously increase risk of Type-I Error when interpreting factor loadings. Moreover, issues of sample size and power are also critical for estimating which factor loadings are statistically significant (Hair, Anderson, Tatham, & Black, 1998). Therefore, based on a sample size of 93 for observer-ratings, an alpha (α) level of .05, a minimum power level of 80 percent, and standard errors assumed to be twice those of conventional correlation coefficients, factor loadings of $\geq .58$ were considered statistically significant (StatSoft, 1998). Similarly, based on a sample size of 95 for self-ratings, an α level of .05, a minimum power level of 80 percent, and standard errors doubled, factor loadings of $\geq .56$ were considered statistically significant (StatSoft, 1998).

However, practical significance should also play a role in determining which variables are worth considering in the interpretation of a factor. In general, since a factor loading is the correlation of the variable with the factor, the squared loading is the amount of a variable's total variance accounted for by the factor. Therefore, the amount of variance in a variable accounted for by the factor on which it loads is approximately 10 percent with a loading of .30, 25 percent with a loading of .50, and nearly 50 percent with a loading of .70 (Hair et al., 1998). In social science research, variable loadings as low as .30 may be conceptually relevant, although at $\alpha = .05$, 80 percent power, and standard errors assumed doubled, a sample size of 350 would be required to reach statistical significance (StatSoft, 1998). Variable loadings that approach, but do not reach, statistical significance may be clinically meaningful, and an overly strict adherence to the statistical significance criterion may lead theoretically useful interpretations to be

overlooked (Hair et al., 1998). Therefore, factor loadings $\geq .40$ are listed in Table 1 unless the variable cross-loaded.

Where the issue of factor cross-loading was concerned, Lahey et al (1988), among others (Quay & Peterson, 1983), noted variables with loadings $\geq .35$ on more than one factor "may not be descriptive of only one maladaptive dimension" (Lahey et al., 1988, p. 332). Therefore, one item from the observer-ratings was not included in Table 1, because it loaded high on both factors (i.e., restlessness/overactivity symptom four). Moreover, three self-rated items were not included in Table 1 due to strong loadings on both factors (i.e., inattentive symptoms one and eight; and restlessness/overactivity item four).

Appendix I

Encephalitis Lethargica

Encephalitis is literally "inflammation of the brain" (Stedman, 1995, p. 564).

Encephalitis lethargica was presumably viral in origin and was unique from other forms of viral encephalitis — a disease *sui generis*. During acute stages of the infection, victims were afflicted with febrile, nasal catarrh (increased flow of mucus), severe lethargy, stupor, somnolence, cranial nerve palsies, and "great feebleness" (Abrahamson, 1920, p. 969). Of this constellation of symptoms, typically of greatest concern to family, friends, and physicians, was profound somnolence, and thus, the disease became popularly known as "sleeping sickness" (Abrahamson, p. 969). The illness first reached epidemic proportions in Vienna, Austria in the winter of 1916-1917 (Abrahamson). There, it was identified by a physician named von Economo, and he termed the illness, "lethargic encephalitis" (Abrahamson, p. 970). After Vienna, the epidemic appeared in New South Wales, Australia in February, 1917, and from there spread to Queensland and Victoria, where it remained epidemic until the following May. The disease appeared in France in late 1917, and the first case was reported in England in February, 1918. From September to October, 1918, the disease raged through Uruguay, Algeria, Germany, and Greece. The outbreak in Britain remitted in January, 1919. Abrahamson identified the first known case in the United States at New York City's Mount Sinai Hospital in September, 1918. By early 1919, the disease had appeared in all regions of the U.S., and as it had in other countries, it afflicted individuals from all demographic and ethnic groups. However, subsequent analysis of epidemiological data from the U.S. revealed the disease struck males more frequently by a ratio of approximately 3:1. It remains unknown why males of all ages were more susceptible to the disease.

CURRICULUM VITAE

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atbutcher@hotmail.com

PERSONAL

Birthdate: January 27, 1962
Corpus Christi, Texas
Married: To Lydia Chu Butcher, BSN, RN
Children: Rachel Erin Butcher (October 19, 1990)
Lauren Ashley Butcher (October 15, 1992)
Andrew Davison Butcher (May 21, 1999)

EDUCATION

Candidate, Doctor of Philosophy, December 1996

Clinical Psychology
Clinical Adult and Child Specializations
Virginia Polytechnic Institute and State University

Master of Science, December 1996

Clinical Psychology
Clinical Adult and Child Specializations
Virginia Polytechnic Institute and State University

Master of Divinity, May 1989

Theological Studies Major
Pastoral Counseling Specialization
Southern Theological Seminary
Louisville, Kentucky

Bachelor of Arts, May 1985

Psychology Major
Baylor University
Waco, Texas

CLINICAL EXPERIENCE

Graduate Clinician - August 1993 - Present

Psychological Services Center (PSC) and Child Study Center (CSC)
Virginia Polytechnic Institute and State University
3110 Prices Fork Road
Blacksburg, Virginia 24061
(540) 231-6914

Training Directors: Thomas H. Ollendick, Ph.D.
Richard A. Winett, Ph.D.

Clinical Experience (Continued)

Graduate Clinician, August 1993 – Present (Continued)

August 1996 – Present

•1,837 hours of supervised clinical activities including, psychotherapy, assessment, consultation, report writing, training and supervising testing technicians, and supervising 1st, 2nd, and 3rd year graduate students in assessment and psychotherapy.

Supervisor: Thomas H. Ollendick, Ph.D.

August 1996 – May 1997

•480 hours of supervised practicum *

Supervisor: George A. Clum, Ph.D.

January 1994 - May 1996

•1,620 hours of supervised practicum, clinical research activities, and assessment and consultation duties associated with graduate assistantship at PSC/CSC.

Supervisor: Thomas H. Ollendick, Ph.D.

August 1994 - May 1995

•480 hours of supervised practicum *

Supervisors: Ellie T. Sturgis, Ph.D. and Richard Eisler, Ph.D.

May 1994 - August 1994

•180 hours of supervised practicum *

Supervisor: Richard Eisler, Ph.D.

August 1993 - May 1994

•240 hours of supervised practicum *

Supervisors: Jack W. Finney, Ph.D. and Robert S. Stephens, Ph.D.

*Practicum experiences included: **1)** outpatient individual and group psychotherapy with children, adolescents, adults, couples, parents, and families; **2)** diagnostic interviewing, psychoeducational assessment, and some projective testing; **3)** at least once weekly participation on practicum teams; **4)** presentation at case conferences; and **5)** weekly individual supervision.

Co-coordinator ADHD/Anxiety Assessment Clinic, January 1994 – May 1998

Psychological Services Center and Child Assessment Clinic

Virginia Polytechnic Institute and State University

Blacksburg, Virginia 24061

Supervisor: Thomas H. Ollendick, Ph.D.

•Duties included: **1)** co-leading Child Assessment Clinic with faculty supervisor; **2)** supervising graduate clinicians in assessment and therapy; **3)** supervising undergraduate assistants on research projects; **4)** conducting psychological testing with children and adolescents; **5)** providing psychotherapy to children, adolescents, and families, and conducting parent training; **6)** consulting with schools, physicians, and other community agencies; **7)** writing reports; and **8)** establishing and managing clinic database.

Graduate Psychotherapy Extern, September 1994 - September 1996

Center for Psychological and Family Services

101 Cloister Court, Suite E

Chapel Hill, North Carolina 27514

(919) 408-3212, Ext. 22

Director and Supervisor: Stephen D. Bennett, Ph.D.

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

•Conducted 563 hours of supervised clinical activity

Clinical Experience (Continued)

Graduate Psychology Extern, May - August 1996

Duke University Medical Center
Attention Deficit Disorders Program
Department of Psychiatry
Division of Medical Psychology
Durham, North Carolina 27710
(919) 416-2080

Director and Supervisor: C. Keith Conners, Ph.D.

- Duties included psychological testing with children, adolescents, and adults, outpatient psychotherapy with individual adults and couples, parent training, report writing, weekly supervision, and data management.
- Conducted 320 hours of supervised clinical activity

Graduate Psychology Extern, May - August 1995

Duke University Medical Center
Durham, North Carolina 27710

Supervisor: C. Keith Conners, Ph.D.

- Duties included psychological testing with children, adolescents, and adults, parent training, report writing, weekly supervision, and data management.
- Conducted 400 hours of supervised clinical activity

Research Assistant, May 1990 - October 1993

Duke University Medical Center

Supervisor: C. Keith Conners, 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 parents' perceptions of stress and overall parental functioning.

Chaplain Intern, May 1989 - May 1990

Duke University Medical Center

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

- Duties included performing all aspects of pastoral care including: **1)** crisis intervention (e.g., in emergency room); **2)** supportive grief counseling (e.g., for terminally ill patients and their families); **3)** conducting baptism, memorial, and Sunday services in hospital chapel; **4)** participation in weekly interdisciplinary team meetings on assigned hospital units; and **5)** weekly individual and group supervision.

Therapeutic Activities 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.

Clinical Experience (Continued)

Student Counselor, May 1984 - May 1985

McClennen County Juvenile Detention Center

Waco, Texas

Supervisor: John Moser, Ph.D.

- Duties included coordinating recreational activities and participating in processing groups for juveniles.

SUPERVISORY EXPERIENCE

Graduate Clinician Supervisor of Advanced Undergraduate Psychology Students on Field Study, August 1998 – Present

Psychological Services Center (PSC)

Virginia Polytechnic Institute and State University

Blacksburg, Virginia 24061

Supervisor: Thomas H. Ollendick, Ph.D.

- Supervisory duties (under Dr. Ollendick's supervision) include: **1)** conducting initial twice weekly training meetings for 2 months with a group of 5 advanced undergraduate psychology students (on field study placement at the PSC) preparing them to conduct structured interviews, administer objective testing instruments, and function as testing technicians at the PSC for assisting in evaluating clinic-referred adults with learning and attentional difficulties; **2)** supervising all clinic activities of these advanced psychology student testing technicians; **3)** conducting on-going weekly training sessions with all 5 undergraduate technicians until the conclusion of their field study in May, 2000; and **4)** supervising and facilitating the conceptualization and write-up of theoretical papers related to field study activities and written by interested technicians among our advanced psychology students for presentation at the Virginia Tech Psychology Conference in April, 2000.

Co-coordinator ADHD/Anxiety Assessment Clinic, January 1994 – May 1998

Psychological Services Center and Child Assessment Clinic

Virginia Polytechnic Institute and State University

Blacksburg, Virginia 24061

Supervisor: Thomas H. Ollendick, Ph.D.

- Supervisory duties (under Dr. Ollendick's supervision) included: **1)** co-leading the Child Assessment Clinic with faculty supervisor; **2)** supervising graduate clinicians conducting psychological testing with children, adults, and families; **3)** supervising psychotherapy with children, adolescents and adults; **4)** supervising school consultation conducted by graduate clinicians; and **5)** supervising case conceptualization, treatment planning, and report writing.

Graduate Clinician Supervisor of Advanced Undergraduate Psychology Students on Field Study, August 1997 – May 1998

Psychological Services Center (PSC)

Virginia Polytechnic Institute and State University

Blacksburg, Virginia 24061

Supervisor: Thomas H. Ollendick, Ph.D.

- Supervisory duties (under Dr. Ollendick's supervision) included: **1)** conducting twice weekly training meetings for 2 months of a group of 7 advanced undergraduate psychology students (on field study placement at the PSC) preparing them to conduct structured interviews, administer objective testing instruments, and function as testing technicians at the PSC for assisting in the evaluation of clinic-referred adults with learning and attentional difficulties; **2)** supervising all clinic activities of these advanced psychology student testing technicians; **3)** conducting on-going weekly training sessions with all 7 undergraduate technicians until the conclusion of their field study in May of 1998; and **4)** supervising and facilitating the conceptualization and write-up of theoretical papers written by 5 these students for presentation at the Virginia Tech Psychology Conference near the conclusion of their field study.

**Graduate Clinician Supervisor (Co-Team Leader with Dr. Ollendick) of Summer 1997
Team of PSC Graduate Clinicians, May – August 1997**

Psychological Services Center (PSC)

Virginia Polytechnic Institute and State University

Supervisor:

Thomas H. Ollendick, Ph.D.

•Supervisory duties (under Dr. Ollendick's supervision) included: **1)** attending and co-leading twice weekly practicum team meetings; **2)** supervising (in weekly individual supervision meetings) graduate clinicians in case conceptualization and treatment planning in providing psychotherapy to adults, adolescents, children, families, and couples; **3)** supervising graduate clinicians conducting psychological testing with children, adults, and families; **4)** supervising school consultation conducted by graduate clinicians on their child assessment cases (May); and **5)** supervising and training graduate clinicians in the development and write-up of case conceptualizations for formal case presentations, treatment planning based on theoretically-driven case formulations, and documentation of assessment results in integrated psychological reports.

TEACHING EXPERIENCE

Graduate Teaching Assistant, July - August 1998 (2nd Summer Term)

Department of Psychology

Virginia Polytechnic Institute and State University

Supervisors:

Jack W. Finney, Ph.D. & Robert S.

Stephens, Ph.D.

•Teaching duties included: **1)** functioning as the sole instructor during a summer-term course titled **Psychological Disorders of Children** for undergraduate students at Virginia Tech; **2)** preparing a syllabus and reading list for the course; **3)** preparing and giving lectures covering foundational issues in the nosology, potential etiology, and developmental course of psychological disorders of children, as well as the assessment, diagnosis, and treatment of psychopathology developing in childhood and often continuing into adolescence and adulthood; **4)** developing a 2-week teaching module focusing in-depth on empirically-supported treatments for specific child disorders; **5)** preparing and grading examinations and other assignments; and **6)** meeting with students to answer questions or discuss concerns about the course during regular office hours or scheduled appointments.

Graduate Teaching Assistant, January 1998 - May 1998

Department of Psychology

Virginia Polytechnic Institute and State University

Supervisor:

Jack W. Finney, Ph.D.

•Teaching duties included: **1)** co-teaching a graduate level course titled **Child Psychopathology**; **2)** working with Dr. Finney to develop a reading list covering fundamental conceptual issues, theoretical approaches, and specific disorders in child psychopathology; **3)** preparing short didactics on selected topics in child psychopathology; **4)** preparing outlines and questions to facilitate class discussion; and **5)** assisting Dr. Finney in evaluating student case presentations, grading student theoretical review papers, and assessing each student's overall contribution to the course.

Graduate Teaching Assistant, January - May 1997

Department of Psychology

Virginia Polytechnic Institute and State University

Supervisors:

Jack W. Finney, Ph.D. & Robert S. Stephens, Ph.D.

•Teaching duties included: **1)** functioning as the sole instructor for a course titled **Research Methods for the Psychological Sciences** for undergraduate students at Virginia Tech; **2)** preparing a syllabus and reading list for the course; **3)** preparing and giving lectures covering foundational issues in measurement, data management, research design, statistical analysis, and formal write-up of research findings; **4)** preparing and grading examinations and other assignments; and **5)** maintaining regular office hours to answer student questions or concerns regarding the course, as well as provide additional assistance to those students struggling in the course.

Graduate Teaching Assistant, August 1993 - December 1993

Department of Psychology
Virginia Polytechnic Institute and State University

- 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 EXPERIENCE

Dissertation Preparation and Research, December 1996 - Present

Title: Effects of Methylphenidate and Placebo on Symptom Severity and Cognitive Performance in Adults with ADHD: Multiple Controlled Single-Case Comparisons

Department of Psychology
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061
(540) 231-6914

Chairperson: Thomas H. Ollendick, Ph.D.

- Designed and set the stage for a study attempting to corroborate the findings of the only recent, well-controlled study of methylphenidate in adults with ADHD of clear childhood onset. The study will use a double-blind, placebo-controlled, single-case methodology in which: **1)** repeated self- and observer-report measures of behavioral symptom severity; **2)** laboratory measures of high-level cognitive performance under Systematically increasing information processing and working memory demand; and **3)** side-effects ratings will serve as outcome measures of overall and dose-dependent medication effects. The study is under review by the Virginia Tech Psychology Department Human Subjects Committee and the University Institutional Review Board.

Consultant, May - June 1996

Center for Research in Health Behavior
620 North Main Street
Blacksburg, Virginia 24061
(540) 231-8747

Director: Richard A. Winett, Ph.D.

- Hired by Center for Research in Health Behavior to set up a database for a grant funded research project evaluating the effectiveness of a nutritional awareness program for high school students.

Graduate Research Assistant, September 1996 – August 1998

Department of Psychology
Virginia Polytechnic Institute and State University
Supervisor: Thomas H. Ollendick, Ph.D.

- Assisted in data management, data analysis, conceptualization and interpretation of findings, 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.

Consultant, February - March 1996

Health Sciences Consortium
Education and Training Systems International
201 Silver Cedar Court
Chapel Hill, North Carolina 27514
(919) 942-8731

Director: Vera M. Pfifferling

- Hired by Health Sciences Consortium to research and author a training module for a major pharmaceutical company to use in educating sales staff about seizure disorders, commonly used anticonvulsive medications, and pivotal studies of Depakote (see Non-Refereed Publications section of Curriculum Vitae).

Graduate Psychology Research 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, wrote integrated psychological reports (approved by supervisor), provided 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 24061
(541) 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 into ADHD and non-ADHD categories.

Consultant, April - May 1995

Health Sciences Consortium
Education and Training Systems International
Chapel Hill, North Carolina 27514

Director: Vera M. Pfifferling

•Hired by Health Sciences Consortium to write a training module for a large pharmaceutical company to use in training staff to work with neurologists (see Non-Refereed Publications section of Curriculum Vitae).

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
Member, American Psychological Association of Graduate Students
Student Member, Association for the Advancement of Behavior Therapy
Student Member, Society for Psychological Science, APA
Student Affiliate, APA, Division 12 – Clinical Psychology
Student Affiliate, APA, Division 12, Section 1 – Clinical Child Psychology

POSTER PRESENTATIONS

- Butcher, A.T., Briones, R., Raintree, J., O'Malley, A., Tyler, J., and Whitfield, T.
(April, 1998). Application of the Functional Analytic Clinical Case Model to adults with Attention-Deficit/Hyperactivity Disorder: A proposed methodology. Poster session presented at the annual meeting of the Virginia Collegiate Psychology Conference, Virginia Tech, Blacksburg, Virginia.
- Butcher, A.T., Raintree, J., Tyler, J., O'Malley, A., Briones, R., and Whitfield, T.
(April, 1998). Executive functioning and working memory in clinic-referred adults with and without ADHD: A test of Barkley's Theory of Disinhibition. Poster session presented at the annual meeting of the Virginia Collegiate Psychology Conference, Virginia Tech, Blacksburg, Virginia.
- Butcher, A.T., O'Malley, A., Raintree, J., Tyler, J., Briones, R., and Whitfield, T.
(April, 1998). Clinical and diagnostic utility of the WAIS-III factor indices in clinic-referred adults with ADHD. Poster session presented at the annual meeting of the Virginia Collegiate Psychology Conference, Virginia Tech, Blacksburg, Virginia.
- Butcher, A.T., Raintree, J., Tyler, J., O'Malley, A., Briones, R., and Whitfield, T.
(April, 1998). DSM-IV personality disorder symptomatology in ADHD adults with and without comorbid symptomatology. Poster session presented at the annual meeting of the Virginia Collegiate Psychology Conference, Virginia Tech, Blacksburg, Virginia.
- Seligman, L.D., Butcher, A.T., Goza, A.S., Byrd., D., Rock., C., and Ollendick, T.H. (November, 1997). The impact of negative family environment on the behavioral expression of conduct disorder. Poster session presented at the 31st Annual Meeting of the Association for the Advancement of Behavior Therapy, Miami, Florida.
- Seligman, L.D., Butcher, A.T., and Ollendick, T.H. (November, 1995). Relationship among anxiety, depression, and conduct disturbance in incarcerated delinquents: A test of Gray's Theory. Poster session presented at the 29th Annual Meeting of the Association for the Advancement of Behavior Therapy, Washington D.C.
- Jones, R. T., Butcher, A. T., Ribbe, D.P., Cunningham, P.B., & Weddle, J.D. (October, 1995). Fire disaster: Psychological impact on children and their parents. Poster presented at the annual meeting of the Virginia Beach Symposium for Children and Adolescents with Emotional and Behavioral Disorders sponsored by the Commonwealth Institute for Child and Family Studies, Virginia Beach, Virginia.

Butcher, A.T., Yang, B., & Ollendick, T.H. (November, 1994). 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, California.

Conners, C.K., March, J.M., Fiore, C., & Butcher, A.T. (October, 1993). Information processing deficits in ADHD: Effect of stimulus rates and methylphenidate. Poster session presented at the annual meeting of the ACNP in Honolulu, Hawaii.

SYMPOSIUM PRESENTATIONS

Mattis, S.G., Ollendick, T.H., Rock, C.M., Butcher, A.T., Seligman, L.D., Ingman, K.A., Curtin, L. Febraro, G.A., and Gulotta, C.S. (April, 1998). Group treatment of nonclinical panic attacks in late adolescence. Symposium presentation at the 18th Annual Meeting of the Anxiety Disorders Association of America, Boston, Massachusetts.

Jones, R.T., Ollendick, T.H., Byrd, D., Davis-Parker, M., Seligman, L.D., Butcher, A.T., Weeks, C. (September, 1997). NIMH Residential Fire Study: Case study examinations of the psychological effects of fire on children and their parents. Symposium presentation at the annual meeting of the Virginia Beach Symposium for Children and Adolescents with Emotional and Behavioral Disorders sponsored by the Commonwealth Institute for Child and Family Studies, Virginia Beach, Virginia.

Butcher, A.T., Seligman, L.D., Goza, A.E., Ollendick, T.H. (September, 1997). Relationship between negative family environment and DSM-IV ADHD subtype. Symposium presentation at the annual meeting of the Virginia Beach Symposium for Children and Adolescents with Emotional and Behavioral Disorders sponsored by the Commonwealth Institute for Child and Family Studies, Virginia Beach, Virginia.

Seligman, L.D., Butcher, A.T. & Ollendick, T.H. (September, 1996). The effects of comorbid anxiety on delinquency in children with severe conduct disorder. Symposium presentation at the annual meeting of the Virginia Beach Symposium for Children and Adolescents with Emotional and Behavioral Disorders sponsored by the Commonwealth Institute for Child and Family Studies, Virginia Beach, Virginia.

Butcher, A.T. & Ollendick, T.H. (October, 1995). 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 Children and Adolescents with Emotional and Behavioral Disorders sponsored by the Commonwealth Institute for Child and Family Studies, Virginia Beach, Virginia.

Butcher, A.T., Seligman, L.D., & Ollendick, T.H. (October, 1995). The mitigating effects of anxiety on severe conduct disorder: Preliminary findings. Symposium presentation at the annual meeting of the Virginia Beach Symposium for Children and Adolescents with Emotional and Behavioral Disorders sponsored by the Commonwealth Institute for Child and Family Studies, Virginia Beach, Virginia.

NON-REFEREED PUBLICATIONS

- 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, North Carolina 27514)
- Butcher, A.T. (1995). Profiling the neurologist. (Training module written for Health Sciences Consortium, 201 Silver Cedar Court, Chapel Hill, North Carolina 27514)

MANUSCRIPTS

- Butcher, A.T., Ollendick, T.H., Conners, C.K., Seligman, L.S., & Burke, R. (To be submitted). Laboratory-based tasks in the diagnosis of ADHD in adults: A theoretical and empirical analysis.
- Butcher, A.T. & Ollendick, T.H. (To be submitted). Identifying empirically-supported, prescriptive interventions for psychopathology across the life-span: A proposed model.
- 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, North Carolina.

REFERENCES

Thomas H. Ollendick, Ph.D.
President-elect, Division 12
American Psychological Association
Professor, Department of Psychology
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

C. Keith Conners, Ph.D.
Professor, Division of Medical Psychology
Department of Psychiatry, Box 3362
Duke University Medical Center
Durham, North Carolina 27710

Jack W. Finney, Ph.D.
Chair, Department of Psychology
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