Examination of Psychosocial and Neuropsychological Characteristics of Young Adults
with and without Attention-Deficit/Hyperactivity Disorder

A dissertation presented to
the faculty of
the College of Arts and Sciences of Ohio University

In partial fulfillment
of the requirements for the degree
Doctor of Philosophy

Laura C. Fox
August 2008
This dissertation entitled
Examination of Psychosocial and Neuropsychological Characteristics of Young Adults
with and without Attention-Deficit/Hyperactivity Disorder

by
LAURA C. FOX

has been approved for
the Department of Psychology
and the College of Arts and Sciences by

Julie A. Suhr
Associate Professor of Psychology

Benjamin M. Ogles
Dean, College of Arts and Sciences
Abstract

FOX, LAURA C., Ph.D., August 2008, Psychology

Examination of Psychosocial and Neuropsychological Characteristics of Young Adults with and without Attention-Deficit/Hyperactivity Disorder (146 pp.)

Director of Dissertation: Julie A. Suhr

The present study pursued two broad goals related to the examination of psychological, demographic, and neuropsychological correlates of ADHD in young adulthood. First, the study investigated the phenomenology of ADHD and ADHD symptomatology in young adult college students. Using data collected from a large cohort of non-treatment-seeking college students, the current study examined the degree to which differences in symptom expression, impairment, and psychiatric status differentiate young adults who do and do not meet diagnostic criteria for ADHD. The second broad goal of this project was to further explore the evidence for neuropsychological deficits in adult ADHD while addressing some important methodological and conceptual limitations of prior studies. Specifically, the neuropsychological performance of individuals with a previously established diagnosis of ADHD was compared to two control groups of healthy, young adults: one group who endorsed significant levels of current ADHD characteristics and one who did not. Results suggest that young adults with ADHD-like symptomatology resemble those with previously established diagnoses of ADHD in multiple psychosocial and demographic characteristics, with the exception of retrospective report of childhood ADHD symptoms and self-report of current psychological difficulties. With regard to neuropsychological
functioning, participants with ADHD diagnoses performed significantly worse than both control groups on tests of processing speed and executive functioning. Findings suggest that neuropsychological evaluation may have utility in the assessment process for adult ADHD. In particular, measures that emphasize processing speed and executive functioning may hold value in distinguishing between those with ADHD and those who report ADHD-like characteristics. Implications for assessment of adult ADHD in both research and clinical settings are discussed.

Approved: ____________________________

Julie A. Suhr

Associate Professor of Psychology
Acknowledgments

This project reflects the contributions and efforts of a number of people. Dr. Julie Suhr directed the dissertation and provided much-needed guidance throughout the research and writing process. She has served as a professional and personal role model in many ways, and I have benefited greatly from her mentorship. My other committee members, Drs. Heather Alvarez, Christine Gidycz, Tracy Leinbaugh, and Julie Owens, made valuable contributions in terms of time, encouragement, and thoughtful critiques. I would also like to thank Eric Zimak, who took on the unenviable task of overseeing data collection for the project during my clinical internship, and did so with zeal, determination, and great care. Thanks also go to Tara Riddle, who generously volunteered her time to assist with data collection. Several undergraduate students at Ohio University served as research assistants for the project: Kris Buelow, Cody Carson, Katy Dobbins-Buckland, Carrie Hughes, and Lauren Lausberg. Their dedication and hard work facilitated the completion of the project. I am also grateful for the monetary assistance provided by the Ohio University Department of Psychology Competitive Research Grant and the Thomas Creer Memorial Research Grant in Health Psychology. Finally, I would like to acknowledge and thank my family, Tom, Quinn, and Luke Scanlan. They gave me everything I could ask for when embarking on such a monumental task: support, love, patience, and time. Their unwavering faith in me allowed me to undertake and complete my graduate training, and I will be forever grateful.
Table of Contents

Abstract ........................................................................................................................................ 3

Acknowledgements ..................................................................................................................... 5

List of Tables ............................................................................................................................ 10

Introduction ............................................................................................................................. 11

Method ....................................................................................................................................... 27

  Participants ........................................................................................................................... 27

  Procedure ............................................................................................................................. 30

    Initial Screening .................................................................................................................. 30

    Parent Mailings .................................................................................................................. 31

    Laboratory Session ........................................................................................................... 31

Measures – Study 1 .................................................................................................................... 32

  Demographic Questionnaire ............................................................................................... 32

  Personal Health History Questionnaire ............................................................................... 33

  Beck Depression Inventory – Second Edition ..................................................................... 33

  Alcohol Use Disorders Identification Test ............................................................................ 34

  Conners’ Adult ADHD Rating Scales .................................................................................. 34

  Wender Utah Rating Scale ................................................................................................. 35

  Consent for Future Contact ............................................................................................... 36
<table>
<thead>
<tr>
<th>Measures – Study 2</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory Questionnaire</td>
<td>36</td>
</tr>
<tr>
<td>Word Memory Test</td>
<td>36</td>
</tr>
<tr>
<td>Matrix Reasoning</td>
<td>37</td>
</tr>
<tr>
<td>Digit Symbol-Coding</td>
<td>37</td>
</tr>
<tr>
<td>Stroop Color and Word Test</td>
<td>37</td>
</tr>
<tr>
<td>Trail-making Test</td>
<td>38</td>
</tr>
<tr>
<td>Spatial Span</td>
<td>38</td>
</tr>
<tr>
<td>Conners’ Continuous Performance Test</td>
<td>39</td>
</tr>
<tr>
<td>Rey Auditory Verbal Learning Test</td>
<td>40</td>
</tr>
<tr>
<td>Arithmetic</td>
<td>40</td>
</tr>
<tr>
<td>Letter-Number Sequencing</td>
<td>40</td>
</tr>
<tr>
<td>Controlled Oral Word Association</td>
<td>41</td>
</tr>
<tr>
<td>Stop-Signal Task</td>
<td>41</td>
</tr>
<tr>
<td>Iowa Gambling Task</td>
<td>42</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Results – Study 1 (ADHD Characteristics Study)</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic and Descriptive Characteristics</td>
<td>43</td>
</tr>
<tr>
<td>Characteristics Related to ADHD Diagnosis</td>
<td>44</td>
</tr>
<tr>
<td>Characteristics Related to ADHD Symptom Report</td>
<td>46</td>
</tr>
</tbody>
</table>
Comparison of Diagnosis, Symptom, and Control Groups .........................47

Results – Study 2 (Neuropsychological Study) .............................................50

Statistical Analysis .....................................................................................50

Participant Characteristics .........................................................................52

Analyses of Neuropsychological Measures ...............................................56

Attention ....................................................................................................56

Response Inhibition ...................................................................................57

Working Memory .......................................................................................57

Verbal Learning and Memory .....................................................................57

Processing Speed .......................................................................................58

Executive Functioning ...............................................................................59

Experimental Measure of Decision Making ..............................................60

Analysis of Clinical Significance ................................................................60

Discussion ..................................................................................................62

Exploratory Analysis of ADHD Characteristics ........................................63

Implications of Exploratory Analysis .........................................................65

Developmental Course of ADHD .................................................................65

Implications for College Functioning .......................................................69

Characteristics of ADHD-Symptom-Endorsing Individuals ......................71
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specificity of Self-Report of ADHD Symptoms</td>
<td>73</td>
</tr>
<tr>
<td>Examination of Neuropsychological Performance in ADHD</td>
<td>76</td>
</tr>
<tr>
<td>Implications of Neuropsychological Results</td>
<td>76</td>
</tr>
<tr>
<td>Limitations</td>
<td>72</td>
</tr>
<tr>
<td>Conclusion</td>
<td>85</td>
</tr>
<tr>
<td>References</td>
<td>89</td>
</tr>
<tr>
<td>Appendix A: Copies of Original or Amended Measures</td>
<td>108</td>
</tr>
<tr>
<td>Appendix B: Psychometric Properties of Instruments</td>
<td>117</td>
</tr>
</tbody>
</table>
List of Tables

Table 1. Sequence of Tasks in the Laboratory Session .................................................................134
Table 2. Demographic and Descriptive Data by Group – Study 1 ............................................135
Table 3. CAARS-S:L Scores by Group – Study 1 .......................................................................137
Table 4. Demographic and Descriptive Data by Group – Study 2 ............................................138
Table 5. CAARS-S:L Scores by Group – Study 2 .......................................................................140
Table 6. CAARS-O:SV by Group – Study 2 ..............................................................................141
Table 7: Neuropsychological Test Scores by Group .................................................................142
Table 8. Performance on Iowa Gambling Task ...........................................................................144
Table 9. Clinical Significance: Percentage above Clinical Cutoff .............................................145
Table 10. Clinical Significance: Impairment Index ...................................................................146
Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is a common neurodevelopmental disorder that has far-reaching implications for the psychological, social, and academic functioning of affected individuals. Although ADHD is often considered a disorder confined to childhood, longitudinal research over the past two decades has confirmed that symptoms of ADHD extend into adolescence and adulthood for the majority of people diagnosed with the disorder (Faraone et al., 2000; Hechtman, 1992; Klein & Mannuzza, 1991). The combination of both scientific and popular recognition of the persistence of ADHD into adulthood has created a strong demand for assessment services for adults seeking to determine if they may be experiencing symptoms of “adult ADHD” (Reilley, 2005; Roy-Byrne et al., 1997). Indeed, with increasing frequency, adults are referring themselves to specialty clinics for evaluations of adult ADHD on the basis of subjective complaints of distractibility, disorganization, inability to establish and maintain routines, and a general sense of underachievement in their academic and/or professional endeavors. Many adults will bring information that they have downloaded from the internet that supports their impressions of having ADHD, and some will bolster their self-diagnosis with their observation that they have experienced subjective improvement in their “ADHD symptoms” after taking stimulant medication borrowed from a friend, coworker, or even their own child.

The demand for evaluation of ADHD is particularly pronounced on college campuses, where students request confirmation of prior ADHD diagnoses or seek new diagnoses for ADHD-like difficulties that may be causing interference with academic
performance (Harrison, 2004; Jachimowicz & Geiselman, 2004; Reilley, 2005; Suhr, Zimak, Buelow, & Fox, under review). It has been estimated that at least 4% of college students meet symptom criteria for ADHD (Heiligenstein, Conyers, Berns, & Smith, 1998). If this estimate is accurate, ADHD represents a substantial presence on college campuses that has the capacity to adversely impact the academic and social functioning of students affected by the disorder. The few studies that have examined academic performance of college students with ADHD have demonstrated that those with ADHD tend to have lower mean GPAs, greater rates of academic probation, and higher dropout rates relative to college students without the disorder (Frazier, Youngstrom, Glutting, & Watkins, 2007; Heiligenstein, Guenther, Levy, Savino, & Fulwiler, 1999; Heiligenstein & Keeling, 1995; Wilkins, 2007). In pursuing evaluations for ADHD, students typically hope to gain access to academic support services as well as prescriptions for stimulant medication, both of which have the potential to be misused (Harrison, Edwards, & Parker, 2007; Sullivan, May, & Galbally, 2007). Thus, given the unprecedented demand for ADHD assessment services and the potential benefits that can accompany a diagnosis of ADHD, it is important for both clinical and research endeavors to identify reliable and valid methods for evaluating individuals with ADHD-like symptoms.

Despite professional consensus that ADHD is a valid disorder that can be diagnosed in adulthood, there are many difficulties associated with establishing a diagnosis in adults. Clinicians who assess ADHD in adults face a number of impediments to making an accurate diagnosis, including the questionable validity of current diagnostic criteria for adults, unavailability of verifiable behavioral information
from childhood, questionable sensitivity and specificity of standardized adult ADHD rating scales, and the overlap of ADHD symptoms with medical or psychiatric conditions as well as potentially normal human behavior (Biederman et al., 1993; McGough & Barkley, 2004; Millstein, Wilens, Biederman, & Spencer, 1997; Murphy, Gordon, & Barkley, 2000; Roy-Byrne et al., 1997). Of these impediments, two stand out as particularly relevant to the current study: the difficulty of making a differential diagnosis based on the presenting ADHD symptoms, and the questionable sensitivity and specificity of current self-report measures of ADHD.

First, accurate diagnosis of ADHD in adulthood is complicated by the fact that the cardinal symptoms of the disorder overlap substantially with medical conditions and other psychiatric disorders. For instance, inattention and distractibility can characterize patients with hypothyroidism, chronic pain conditions, learning disorders, mood disturbances, and anxiety disorders, while impulsivity and restlessness often accompany head injury, substance use, mood, and/or antisocial and borderline personality disorders (Conners, Erhardt, & Sparrow, 1999; McCann & Roy-Byrne, 2004; McGough & Barkley, 2004; Searight, Burke, & Rottneck, 2000). Thus, clinicians must determine if the presenting problems are caused by ADHD, an alternative psychiatric or medical diagnosis, or a combination of both. Adding to the diagnostic difficulty is the fact that many ADHD symptoms represent more extreme dimensions of normal functioning, and therefore they can be thought of as characteristics that nearly everyone experiences from time to time. As an illustration of the “universality” of ADHD symptomatology, Murphy, Gordon, and Barkley (2000) investigated the occurrence of ADHD symptoms
among the normative standardization group from a DSM-IV checklist. Exploration of the data revealed that 12% of the normative group endorsed significant current ADHD symptoms, and 25% of the same group endorsed six or more ADHD symptoms in childhood. These rates, based on self-report checklists of symptoms, far exceed the estimated prevalence of ADHD in childhood, which is between 3 and 7%. Findings from this study, which demonstrate the poor specificity of self-report measures of both current and childhood ADHD symptomatology, have been replicated in clinical, community, and college student populations (DuPaul et al., 2001; Heiligenstein et al., 1998; Mannuzza, Klein, Klein, Bessler, & Shrout,, 2002; Roy-Byrne et al., 1997). Results from this and other studies support the conclusion that the characteristics of ADHD are common features of medical or psychiatric conditions as well as part of the normal spectrum of human behavior. Additional studies are clearly needed to determine if there are certain demographic, psychological, academic, or social features that may help to accurately identify individuals with ADHD.

A related diagnostic impediment involves reliance on self-report of ADHD symptomatology, either through interview or through the use of rating scales. In both clinical and research settings, diagnosticians run the risk of misdiagnosing the disorder when they rely solely on self-report of clinical symptomatology (Johnson & Conners, 2002). Indeed, substantial evidence suggests that reliance on self-report can result in both overdiagnosis and underdiagnosis of ADHD in adults. For instance, individuals who endorse high rates of ADHD symptomatology may perceive themselves as having tendencies associated with ADHD, but lack other evidence (e.g., childhood history of
symptoms or lack of confirmation from collateral sources) supporting a true diagnosis of the disorder. Thus, lack of appreciation for the developmental nature of the disorder as well as for the high base rate of symptoms in typical populations can lead to overdiagnosis of ADHD in adult patients (Murphy et al., 2000). To illustrate, Mannuzza and colleagues (2002), presented data obtained from their 16-year follow-up of children with ADHD compared to community control individuals on retrospective report of childhood ADHD symptomatology. They found that as young adults, 11% of the normal control participants were identified as having ADHD based on their self-reported recall of childhood symptomatology. Such results call into question the accuracy of retrospective accounts of childhood behavior and symptomatology, and caution against overreliance on self-reported symptomatology in diagnostic assessments of ADHD.

Conversely, reliance on self-reports for ADHD diagnosis can result in underdiagnosis of the disorder, as it has been demonstrated that individuals with ADHD often underestimate both past and current ADHD symptomatology and associated impairment (Barkley, Fischer, Edelbrock, & Smallish, 1991; Barkley, Fischer, Smallish, & Fletcher, 2002; Kooij et al., 2008). Given the challenges related to making an accurate diagnosis of ADHD in adulthood, researchers stress the critical importance of obtaining a detailed developmental history and assessing for present symptoms and impairment using a multi-method, multi-source approach (e.g., Johnson & Conners, 2002). Use of clinical interviews or observer rating scales that obtain the perspective of a third-party informant, such as a parent, spouse, or employer would provide essential information to supplement patient self-report. However, it has still not become universal
practice in either research or clinical settings to obtain collateral information from individuals who know the patient well. Given the challenges associated with accurate diagnosis of ADHD based on presenting subjective complaints, clinicians may seek supplementary evidence of ADHD through the use of neuropsychological assessment.

Neuropsychological evaluation of adults with complaints of ADHD-like symptoms has gained prominence in both clinical and research settings. Clinically, neuropsychological measures can be used in the assessment process as an adjunct to interviews and self-report rating scales. The clinical use of neuropsychological or psychoeducational measures in the ADHD assessment process can be helpful for differential diagnosis, particularly in cases when a learning disability may be present. Furthermore, neuropsychological testing holds the promise of providing objective evidence of impairment, and thus may help to decrease the reliance on self-report of symptomatology, which, as noted above, may result in misdiagnosis (Mannuzza et al., 2002; Murphy et al., 2000; Suhr et al., under review). In research settings, many professionals have turned to neuropsychological testing in an attempt to clarify the mechanisms that result in the characteristic behavioral symptoms of ADHD. Indeed, investigation of the neuropsychological correlates of ADHD in adulthood has proven to be one mechanism for validating the presence of the disorder in adults (Biederman et al., 1993; Johnson et al., 2001). Furthermore, neuropsychological research has added to the body of literature illustrating that the manifestation of the disorder in adulthood is often similar to that in childhood.
An extensive empirical literature has developed examining patterns of neuropsychological functioning in children with ADHD, particularly in comparison to typically developing children without the disorder. This literature has generally found evidence of weaknesses in the domains of sustained and selective attention, response inhibition, executive functioning, and processing speed (Barkley, 1997; Seidman, Biederman, Faraone, Weber, & Oullette, 1997; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). However, not all children and adolescents with ADHD demonstrate diminished performance in these areas, and no neuropsychological profile specific to ADHD has emerged (Sergeant, Geurts, & Oosterlaan, 2002; Willcutt et al., 2005). While lacking the breadth and depth of the child research, the neuropsychological research conducted with adults with ADHD has produced similar findings. When compared to adults without the disorder, adults with ADHD show poorer performance in the domains of attention, response inhibition, and executive functioning—domains that are theoretically coherent with our understanding of ADHD. Indeed, the patterns of cognitive weakness seen on neuropsychological instruments appear to align with theoretical arguments and neuroimaging findings that implicate the frontal lobes and their connections with subcortical structures in the etiology of ADHD (Barkley, 1997; Bush, Valera, & Seidman, 2005; Casey et al., 1997; Castellanos, 1997; Castellanos et al., 2002; Semrud-Clikeman et al., 2000). However, neuropsychological differences are also commonly detected on tasks of verbal learning and memory as well as on tasks of processing speed, which may indicate that ADHD is associated with more diffuse
neurological impairment, or alternatively, that performance on these tasks is adversely affected by weaknesses in executive functions (Roth & Saykin, 2004).

In the domain of attention, multiple studies have demonstrated weaker performance on sustained attention and vigilance, as measured by omission errors on versions of the Continuous Performance Task (CPT; a lengthy computerized task that requires participants to respond to continuous visual stimuli; Barkley, Murphy, & Kwasnik, 1996; Epstein, Conners, Sitarenios, & Erhardt, 1998; Fischer, Barkley, Smallish, & Fletcher, 2005; Gansler et al., 1998; Murphy, Barkley, & Bush, 2001; Weyandt, Mitzlaff, & Thomas, 2002). In the domain of response inhibition, studies have shown that adults with ADHD tend to perform more poorly on tests of “behavioral impulsivity,” such as CPT tasks (errors of commission) and the Stop Signal Reaction Test, as well as on tests of “cognitive impulsivity,” such as the Iowa Gambling Test (IGT; Epstein et al., 1998; Epstein, Johnson, Varia, & Conners, 2001; Malloy-Diniz, Fuentes, Borges Leite, Correa, & Bechara, 2007; Murphy et al., 2001; Walker, Shores, Trollor, Lee, & Sachdev, 2000). Adults with ADHD also demonstrate weaknesses in the domain of executive functioning, which refers to a diverse set of higher-order cognitive abilities that are thought to underlie goal-directed behavior (Spreen & Strauss, 1998). Abilities that fall within this rubric include planning, initiation of activity, self-regulation, set shifting, and cognitive flexibility. Tasks that appear to show the most consistent weaknesses in adults with ADHD include measures of cognitive flexibility, such as the Trail-making Test Part B and the Color/Word condition from the Stroop Test; verbal fluency, such as the Controlled Oral Word Association test; and complex planning and
problem solving, such as the Tower of Hanoi (Jenkins et al., 1998; Johnson et al., 2001; Lovejoy et al., 1999; Nigg et al., 2005; Riordan et al., 1999).

In addition to these domains that fit well within the conceptual framework of ADHD, weaknesses in neuropsychological functioning have also been observed in the domains of verbal learning and memory and processing speed. Overall, tasks that measure verbal learning and memory, such as auditory list-learning tasks or measures of story recall, have been robust in discriminating adults with ADHD from adults without the disorder (Dige & Wik, 2005; Downey, Stelson, Pomerleau, & Giordani, 1997; Holdnack, Moberg, Arnold, Gur, & Gur, 1995; Jenkins et al., 1998; Seidman, Biederman, Weber, Hatch, & Faraone, 1998). Finally, tasks of processing speed, which typically involve timed tests of cognitive processing while relying on a speeded motor component, have shown promising, though less consistent, group differences (Biederman et al., 1993; Murphy et al., 2001; Nigg et al., 2005; Riordan et al., 1999; Seidman et al., 1998; Walker et al., 2000). Representative tasks from this domain include the Trail-making Test Part A, the WAIS-III Digit Symbol-Coding subtest, and the Color and Word conditions from the Stroop Test.

As an aggregate, studies of neuropsychological performance of adults with ADHD indicate that adults with ADHD demonstrate diminished performance in multiple domains of functioning when compared to their nonaffected counterparts. Evidence has accrued suggesting that cognitive symptoms of ADHD persist into adulthood, are independent of psychiatric comorbidities, and are manifested similarly in males and females (Nigg et al., 2005; Seidman et al., 1997). Several domains of functioning have
consistently shown to be spared in both children and adults with ADHD, including simple motor speed, visuospatial/visuoconstructional skills, and basic language functions. Thus, a picture is emerging using literature derived from a lifespan perspective of ADHD suggesting that, from a neuropsychological standpoint, ADHD is characterized by subtle and inconsistent difficulties in multiple domains of function that are related to fronto-subcortical dysfunction rather than a consistent weakness in any one cognitive domain (Lovejoy et al., 1999).

Despite the vigorous research activity in this area, existing studies have not shown uniformity in identifying specific measures that successfully discriminate between adults with and without ADHD. It remains to be seen if the inconsistency in results is a function of the heterogeneity of the disorder itself, or a result of conceptual and methodological limitations of existing studies. In support of the latter interpretation, the lack of convergence on core cognitive impairments in adults may be explained by the absence of adult-specific diagnostic criteria to enable reliable and accurate identification of ADHD in adulthood. Furthermore, inadequate or inconsistent diagnostic methods used in many research studies have yielded diagnostic groups that are poorly defined or insufficiently screened. In this regard, many studies rely on self-report rating scales of symptom criteria, unstandardized clinical interviews, or non-standardized measures of ADHD to assign participants to diagnostic groups (e.g., Dinn, Robbins, & Harris, 2001; Horton, 1996; Murphy, 2002a; Ossmann & Mulligan, 2003). Studies are also not uniform in their use of clinical criteria, with some using DSM-based criteria and others using Wender-Utah criteria to define groups (e.g., Walker et al., 2000). It is likely that
use of divergent criteria will result in heterogeneous and non-equivalent groups, all subsumed under the label of “ADHD.” Moreover, studies often fail to obtain collateral information from parents or significant others to confirm the self-report of the patients (e.g., Jenkins et al., 1998; Murphy et al., 2001; Murphy, 2002b; Ossmann & Mulligan, 2003; Seidman et al., 1998). Indeed, roughly 75% of the studies reviewed by this author failed to corroborate patients’ self-report of childhood history and current symptomatology with an informed third-party.

Another limitation of the existing literature is that many studies of neuropsychological performance in adult ADHD used patients referred to specialty clinics who were specifically seeking a diagnosis of ADHD (e.g., Jenkins et al., 1998; Roy-Byrne et al, 1997; Walker et al., 2000). While this type of sampling increases the likelihood that the participants are experiencing significant and impairing ADHD symptoms, the possibility exists that participants are treatment-seeking and are motivated for various reasons to present an exaggerated picture of their perceived deficits. Such individuals may be inclined to put forth poor effort on neuropsychological tests, thus calling into question the validity of the results obtained. The assessment of effort in both clinical and research populations has come to be viewed as a vital piece in standard neuropsychological batteries, particularly with forensic and “potentially compensable” populations (Hartman, 2002, p. 713). Indeed, data generated from research studies with pain populations and mild traumatic brain injured patients suggest that effort alone accounts for a substantial portion of the variance in performance on neuropsychological testing, and poor effort among patients can render results spurious or uninterpretable.
As noted above, individuals with ADHD-like complaints may fall into the category of those who potentially stand to benefit from their diagnosis, through access to controlled substances, academic and occupational accommodations, and/or placement on Social Security disability (Quinn, 2003).

Another limitation that characterizes the literature on neuropsychological functioning in adult ADHD relates to the issue of clinical significance. For the most part, studies have interpreted the presence of significantly lowered performance in relation to non-ADHD controls as evidence of cognitive “deficits” or “impairments” (e.g., Johnson et al., 2001; Murphy, 2002b; Nigg, Butler, Huang-Pollack, & Henderson, 2002; Nigg et al., 2005; Ossmann & Mulligan, 2003; Riordan et al., 1999). Rarely do researchers examine these performance discrepancies in terms of their clinical significance, as measured by comparisons against the normative data of the tests or through an ipsative interpretive approach. Such comparisons may demonstrate that these relative weaknesses do not meet typical standards for impairment, or alternatively, may demonstrate that ADHD is associated with clinically significant deficits in specific cognitive domains. A review of the effect sizes generated from a recent meta-analysis of this literature (Hervey, Epstein, & Curry, 2004) reveals that most reported performance differences have typically been subtle, within the medium range of effect sizes. However, in certain domains of functioning, including attention, verbal learning and memory, and response inhibition, adults with ADHD tend to show performance differences that approach clinical significance (e.g., Downey et al., 1997; Jenkins et al., 1998; Quinlan & Brown,
In order to demonstrate the functional impact of the disorder on cognitive processes, studies must examine the clinical significance of their findings, above and beyond the statistically significant results that may be evident between groups.

Finally, considerably less empirical attention has been devoted to the examination of patterns of neuropsychological functioning in ADHD adults in relation to medical, psychiatric, or other high-symptomatic control groups. Existing studies that compare adults with ADHD to adults with other psychiatric or neurological conditions (e.g., Tourette’s syndrome, Reading Disorder, Depression/Dysthymia) have yielded mixed results regarding the presence and specificity of neuropsychological deficits (e.g., Riordan et al., 1999; Roy-Byrne et al., 1997; Silverman, Como, Palumbo, West, & Osborn, 1995; Weyandt, Rice, Linterman, Mitzlaff, & Emert, 1998). Two studies using clinically referred adult patients have examined the specificity of the neuropsychological performance of adults diagnosed with ADHD in reference to an ADHD symptom group (Jenkins et al., 1998; Walker et al., 2000). In both studies, the clinical groups were composed of adults with attentional complaints who were self-referred to an outpatient neuropsychology clinic. These studies produced divergent results, with the Jenkins et al. (1998) study demonstrating significant differences between ADHD and attentional complainers on multiple neuropsychological tasks, including measures of working memory, attention, verbal fluency, and verbal learning and memory. However, the Walker et al. (2000) produced null findings (but a trend towards worse performance in the ADHD subjects, with effect sizes in the medium range). In clinical settings, clinicians who assess ADHD are routinely confronted with questions of differential
diagnosis. Therefore, research investigating the specificity of neuropsychological findings in ADHD relative to psychiatric or high-symptom-endorsing control groups is essential to identify cognitive impairments that may be unique to the disorder, as well as to determine the utility of neuropsychological measures in the assessment of adult ADHD.

The difficulties involved with clinic-based assessment of ADHD and empirical research on this topic are intrinsically intertwined: without a solid research base explicating the phenomenology and specific correlates of adult ADHD, clinicians will encounter barriers to effective assessment; and without good clinical diagnostic strategies, research studies will continue to include poorly defined groups of individuals who may or may not have “true” ADHD. Recognizing these issues, the present study pursued two broad goals: first, the study sought to examine the psychosocial, behavioral, and demographic correlates of ADHD in young adulthood using a large sample of non-treatment-seeking college students. Second, the study investigated the neuropsychological performance of young adults with ADHD by comparing them to two control groups: one group who endorsed significant levels of current ADHD characteristics and one who did not. In this way, the current project attempted to identify patterns of neuropsychological performance in individuals with ADHD that may be distinct from healthy, non-ADHD individuals as well as individuals who have current complaints of ADHD characteristics but who lack a history of clinically significant ADHD symptomatology.
As an exploratory analysis of ADHD symptomatology in young adults, the study examined issues related to appropriate diagnosis of ADHD in young adulthood, including characteristics (both current and retrospective) that best distinguish those with and without diagnoses of ADHD. Specifically, the study examined the patterns of current ADHD symptoms as derived from standardized adult ADHD rating scales and investigated the relationship between ADHD symptoms and current and past diagnostic status. Examining patterns of ADHD-symptom endorsement and concurrent psychosocial characteristics (e.g., levels of depression, risky alcohol use) may help to inform current understanding of the developmental trajectory of ADHD, given the questions regarding the nature and severity of ADHD symptom expression in adulthood. Furthermore, the information gathered by this study enabled examination of the degree to which differences in symptom expression, symptom impairment, and psychiatric histories differentiate young adults who do and do not meet diagnostic criteria for ADHD. Thus, the current study contributes to both applied clinical and research endeavors, where the accuracy and utility of self-report methodologies are often called into question.

As an investigation of neuropsychological performance in adult ADHD, the current study adds to the growing body of literature that examines ADHD across the lifespan from a neuropsychological perspective. Specifically, this project serves as an extension of previous studies of neuropsychological functioning of adults with ADHD by addressing limitations of prior research and incorporating heretofore underused measures in an adult population. The study used a combination of well-validated clinical measures and several experimental measures to identify the core cognitive deficits that may exist in
adults with ADHD relative to two control groups: one age-matched group of healthy young adults without past or present ADHD symptomatology, and one age-matched group of healthy young adults who endorse significant levels of current ADHD symptoms but who lack other corroborating evidence of an ADHD diagnosis (e.g., childhood history of ADHD symptoms, parent confirmation of symptoms). The design of the current study allowed for an examination of the ability of neuropsychological measures to discriminate not only between ADHD and non-disordered adults but also between ADHD adults and those with subjective ADHD-like complaints, thereby adding to the literature on specificity of neuropsychological deficits in this population.

The present study introduced several methodological and conceptual improvements in an attempt to address the shortcomings of prior research. First, in order to identify participants who have reliable diagnoses and symptom patterns of ADHD, the present study employed a rigorous screening process to select participants. The study used a standardized rating scale (the Conners’ Adult ADHD Rating Scale; CAARS) that employs DSM-IV criteria to assess current ADHD symptoms. This rating scale also provides a quantifiable measure of severity of ADHD symptoms as well as an index that is sensitive to inconsistent responding. Also improving upon existing studies, the current study obtained collateral information from parents to establish a childhood diagnosis of ADHD and confirm the presence of current symptomatology. As a final improvement in the participant selection process, the current study attempted to limit the effects of comorbid disorders on neuropsychological functioning by excluding potential participants who reported having a learning disability, psychotic disorder, or who had
significant current alcohol or substance abuse, since these disorders have been shown to influence cognitive performance (Hoegerman, Resnick, & Schnoll, 1993; Weiler, Holmes Bernstein, Bellinger, & Waber, 2002; Weyandt et al., 1998). To enhance the clinical utility of the findings obtained, the present investigation included a well-standardized measure of effort as a means of identifying participants who put forth sub-optimal effort and examined the clinical significance of the results from the neuropsychological measures.

Based on results from the literature examining the neuropsychological performance of adults relative to normal controls as well as adults with attentional complaints, it was predicted that young adults with an established diagnosis of ADHD will exhibit greater difficulties on neuropsychological tests of attention, working memory, response inhibition, executive function, processing speed, and memory than either control group. It was also predicted that young adults with ADHD would perform more poorly on one experimental measure of risky decision making.

**Method**

**Participants**

Participants were recruited through the web-based experiment management system available each quarter through the Ohio University Department of Psychology. Students enrolled in Psychology 101 and other psychology classes offering experimental research credit signed up for available times to participate in a group screening session. All individuals who participated in the group screening sessions provided informed consent and completed a battery of questionnaires and rating scales to assess aspects of
personal health history and psychological characteristics (described below). A total of 1659 participants completed the initial screening phase of the project between November 2005 and June 2007, composing the “Study 1” sample (see Table 2). Participants who met broad eligibility criteria and specific diagnostic group criteria for “Study 2” were invited to participate in the laboratory session for neuropsychological testing. A final sample of 87 participants was obtained using individuals who met eligibility criteria for Study 2 (see Table 4).

Broad inclusion criteria for sample selection for the neuropsychological study (Study 2) included: (a) 18 to 25 years of age, (b) English-language proficiency, (c) provision of contact information of parent or guardian, (d) no history of head injury, defined as a blow to the head resulting in loss of consciousness of greater than 30 minutes, (e) no self-reported diagnosis of a learning disability, psychotic disorder, or substance use disorder, and (f) score of \( \leq 8 \) on an inconsistency measure on an adult ADHD symptomatology questionnaire, indicating consistent responding to questions. Additionally, potential participants met all eligibility requirements for the specific groups of interest in Study 2, described below.

Three experimental groups were culled from the pool of participants who completed the initial screening session and who met both broad and specific inclusion criteria. The first group, labeled the ADHD Diagnosis group (ADHD-DX), included individuals who self-reported having a previously established diagnosis of ADHD and currently met symptomatic criteria for ADHD. For inclusion in the ADHD-DX group, participants demonstrated: (a) at least one Conners Adult ADHD Rating Scale (CAARS)
form (Self or Observer) with a T-score of at least 65 on the DSM-IV Inattentive Symptoms, Hyperactive-Impulsive Symptoms, and/or ADHD Symptoms Total subscales with the other CAARS form (Self or Observer) having a t-score of at least 60 on the DSM-IV Inattentive Symptoms, Hyperactive-Impulsive Symptoms, and/or ADHD Symptoms Total subscales; (b) evidence of ADHD diagnosis in childhood via participant report of diagnosis and/or parent report of childhood history; and (c) evidence of current impairment related to ADHD symptoms. In the initial phase of the study, participants who reported having an ADHD diagnosis were excluded if they indicated that they were currently taking stimulant medication to treat ADHD symptoms. A subsequent change to the protocol, which received approval from Ohio University’s Institutional Review Board, permitted the principle investigator to request participants on stimulant medications to refrain from taking their stimulant medications for at least 12 hours preceding participation in the neuropsychological study. The ADHD-DX group included 28 participants (18 males, 10 females).

The second group, labeled the ADHD Symptom Group (ADHD-SX), included individuals who reported no prior history of ADHD diagnosis, but who currently endorsed significant ADHD symptomatology on a standardized rating scale. For inclusion in the ADHD-SX group, participants demonstrated: (a) a t-score of 65 or greater on the CAARS Self-report DSM-IV Inattentive Symptoms, Hyperactive-Impulsive Symptoms, and/or ADHD Symptoms Total subscales; (b) a t-score less than 55 on the CAARS Observer form DSM-IV Inattentive Symptoms, Hyperactive-Impulsive Symptoms, and ADHD Symptoms Total subscales; (c) no self or parent report of ADHD
diagnosis; (d) no evidence of significant ADHD symptomatology in childhood via self report (i.e., WURS < 46) and parent report; and (e) no current or past use of stimulant medications for ADHD symptoms. The ADHD-SX group included 28 participants (13 males, 15 females).

The third participant group, labeled the Normal Control group (NC), included individuals who denied a history of an ADHD diagnosis and who endorsed non-clinical levels of childhood and current ADHD symptomatology. For inclusion in the NC group, participants demonstrated: (a) $t$-scores of 55 or less on all CAARS DSM-IV subscales (for both Self and Observer forms); (b) no self or parent report of ADHD diagnosis; (c) no evidence of significant ADHD symptomatology in childhood via self report (i.e., WURS < 46) and parent report; and (d) no current or past use of stimulant medications for ADHD symptoms. The NC group included 31 participants (19 males, 12 females).

Procedure

Initial screening. All participants attended a group screening session, where they provided informed consent and completed multiple rating scales and questionnaires. The instruments assessed relevant demographic characteristics, psychological symptoms of ADHD and depression, and aspects of participants’ personal health history, such as history of learning difficulties, head injuries, and psychological diagnoses (see Appendix A for copies of original measures used in the study; see Appendix B for detailed description of psychometric properties of published measures). Participation in the group screening session took approximately thirty minutes, and participants received psychology course credit for their time and effort.
The information provided on these instruments was used in the exploratory analysis of ADHD symptomatology in young adults with and without a prior history of ADHD diagnosis. Furthermore, responses on these measures were used to determine eligibility for the neuropsychological study and assignment to one of three experimental groups: 1) ADHD-DX group; 2) ADHD-SX group; and 3) NC group. Group assignment took place as outlined in the Participants section above.

Parent mailings. Mailings were sent to parents/guardians of individuals who met initial inclusion criteria in order to gain collateral information to supplement the self-report information provided during the screening session. The parent mailings included several items: a cover letter explaining the purpose of the study and providing instructions for completion of the questionnaires (see Appendix A); the Conners’ Adult ADHD Rating Scale Observer: Screening Version (CAARS – O:SV), which asked the parents to rate the ADHD-relevant behaviors of their son or daughter; and an additional form inquiring about the onset of ADHD symptoms and the presence of childhood diagnoses of ADHD, Oppositional Defiant Disorder, and Conduct Disorder (see Appendix A). Parent ratings on the CAARS – O:SV were used to confirm the self-reported diagnostic information provided by the participants.

Laboratory session. Individuals who met eligibility requirements based on the screening measures and the parent report measures, and who provided permission for future research contact, were invited to participate in the laboratory session for neuropsychological testing. Participants were contacted by either phone or e-mail (depending on the mode of preferred contact indicated on their consent form) using a
standard script. The laboratory session, which lasted approximately two hours, was conducted by a trained examiner who was unaware of the participants’ group status. It should be noted that there were several cases in which the principal investigator, who had knowledge of the participant’s group status prior to the testing session, conducted the neuropsychological testing. Participants were assessed individually in a quiet room located in the Clinical Neuropsychology Research Laboratory. During the laboratory session, the examiner obtained written informed consent from participants and administered a brief questionnaire to assess for recent caffeine, alcohol, recreational drug, and medication use (see Appendix A for copy of laboratory questionnaire). All participants completed a second BDI-II to assess for the presence of recent depressive symptoms, in order to control for the potential influence of depressive symptomatology on performance results. Neuropsychological testing commenced following completion of these questionnaires (see Appendix B for detailed description of psychometric properties of measures). The tests were administered in a standard sequence, owing to interference or delay requirements for several of the measures (see Table 1 for a list of measures in the order in which they were administered). At the end of the laboratory session participants were provided with a verbal and written explanation of the study and given experimental credit for their undergraduate psychology class (one point for each hour of participation), or a cash payment of $20.00 if no experimental credit was needed.

Measures – Study 1

Demographic questionnaire. Participants completed a brief demographic questionnaire that requested information about personal demographic characteristics such
as age, ethnicity, gender, and grade point average. Participants also provided contact information for parents/guardians on this questionnaire in order to obtain collateral information regarding the participants’ history of ADHD symptoms.

*Personal health history questionnaire.* Participants completed a health history questionnaire to obtain information related to the participants’ physical and psychological history. The questionnaire inquired about ADHD diagnostic history (including subtype status and medication status), impairment related to ADHD diagnosis, history of head injury, alcohol and substance use, and psychiatric history and treatment. Participants’ responses on this questionnaire, along with information provided on rating scales, were used to determine study eligibility and group assignment.

*Beck Depression Inventory-Second Edition* (BDI-II; Beck, Steer, & Brown, 1996). Participants completed the BDI-II during the group screening session and at the start of the laboratory session to assess for the presence of current depressive symptomatology. The BDI-II is a 21-item instrument that measures the presence and severity of depressive symptoms in adolescents and adults ages 13 and older. Items on the BDI-II have been designed to correspond to criteria for diagnosing unipolar depressive disorders found in the DSM-IV (1994). For each item, participants are asked to select one of four statements that best characterizes their mood and functioning during the past two weeks. Items are summed to yield a total depression score, with higher scores representing greater symptom severity. The BDI-II has demonstrated sound psychometric properties in multiple research studies and with multiple adult populations (Beck et al., 1996; Groth-Marnat, 2003).
Alcohol Use Disorders Identification Test. (AUDIT; Saunders, Aasland, Babor, de la Fuente, & Grant, 1993). The AUDIT is a 10-item screening measure designed to assess alcohol intake, alcohol dependence, and adverse consequences from alcohol consumption. Scores range from 0 to 40, and a cutoff of 8 has been shown to discriminate reliably between individuals with and without alcohol use problems (Aertgeerts et al., 2000; Kills Small, Simons, & Stricherz, 2007; Saunders et al., 1993). The AUDIT has demonstrated very strong psychometric properties in multiple populations, including primary care patients, veterans, and college students (e.g., Aertgeerts et al., 2000; Fleming, Barry & McDonald, 1991; Kokotailo et al., 2004; Reinert & Allen, 2002).

Conners’ Adult ADHD Rating Scales (CAARS; Conners, et al., 1999). The Conners’ Adult ADHD Rating Scale Self-Report: Long Version (CAARS – S:L; Conners et al., 1999) consists of 66 items that assess the core symptoms of ADHD as well as problematic behaviors related to ADHD. The long version yields four factor-derived subscales (Inattention/Memory Problems, Hyperactivity/Restlessness, Impulsivity/Emotional Lability, and Problems with Self-Concept) and three DSM-IV ADHD Symptom Subscales (Inattentive, Hyperactive-Impulsive, and Total ADHD symptoms). The CAARS – S:L also contains an Inconsistency Index, which was used in the present study to gauge the consistency of endorsement patterns. Participants were instructed to rate their own behavior without the effects of medication, if they happened to be taking medication to address symptoms of ADHD.
The Conners’ Adult ADHD Rating Scale Observer: Screening Version (CAARS – O:SV) is a 30-item questionnaire that was mailed to the parents of participants. This measure, which asks an observer to rate the behaviors of the individual in question, contains items that are similar to the self-report rating scale but is shorter in length. The CAARS – O:SV yields three DSM-IV ADHD Symptom Subscales (Inattentive, Hyperactive-Impulsive, and Total ADHD symptoms) as well as the ADHD Index. In a cover letter, parent observers were instructed to rate behavioral characteristics as observed when their child is not on medication. Both forms of the CAARS have demonstrated good reliability and validity (Conners et al., 1999; Erhardt, Conners, Epstein, Parker, & Sitarenios, 1999). Both the self- and observer-versions of the CAARS were used to determine eligibility for Study 2 and to assign participants to experimental groups.

Wender Utah Rating Scale (WURS; Ward, Wender, & Reimherr, 1993). The 25-item version of the WURS was administered as a retrospective measure of childhood ADHD characteristics. Participants are instructed to rate each item on a 0 to 4 scale (not at all or very slightly to very much), and items are summed to compute a total score ranging from 0 to 100. A score of 46 or greater is typically used as a cutoff score for identifying adults with ADHD (Ward et al., 1993). Studies have supported the reliability and validity of the WURS as a retrospective measure of childhood ADHD symptoms (Rossini & O’Connor, 1995; Stein et al., 1995; Ward et al., 1993; Weyandt, Linterman, & Rice, 1995). For the purposes of this study, information from the WURS was examined as part of the descriptive analyses performed to answer questions raised in Study 1. The
WURS was also used conjointly with the CAARS and self-reported diagnostic history to assign participants to experimental groups for the neuropsychological study.

*Consent for future contact.* On a Consent for Future Contact Form, participants were asked to provide consent to contact them with an invitation to participate in another study in the Psychology Department. Participants indicated their permission by checking a box, providing contact information, and signing and dating the form. Participants who met all eligibility criteria and gave consent for future contact were invited to participate in Study 2.

*Measures – Study 2*

*Laboratory questionnaire.* At the start of the laboratory session, participants completed a brief questionnaire that assessed for the use of caffeine, alcohol, recreational drug and prescription/non-prescription medication use in the 24 hours prior to the study.

*Word Memory Test.* The Word Memory Test (WMT; Green, 2003) is a computerized measure of verbal memory that allows for the empirical measurement of effort. Participants are presented with a sequence of 20 word pairs and are tested on immediate recognition of correct words, recognition of correct words after a 30-minute delay, and recognition of word pairs after a 30-minute delay. The WMT has been subjected to extensive clinical validation studies, all of which support the psychometric properties of the instrument (Green, 2003). It was proposed that participants whose performance on the WMT suggested poor effort (as determined by specific cutoff scores for each of the four effort measures) would not be considered for inclusion in the final
data analysis. However, all participants who completed the neuropsychological study scored above cutoff requirements.

Matrix Reasoning. The Matrix Reasoning (MR) subtest from the Wechsler Abbreviated Scale of Intelligence (WASI) is a test of perceptual reasoning ability that was used as a rough estimate of general intelligence. MR is an untimed task that consists of a series of increasingly complex colored patterns that have a component part missing. Participants must select the one component from an array of 5 choices that best completes the matrix. The MR subtest was normed on an adult sample, and has demonstrated acceptable reliability and validity (The Psychological Corporation, 1999). The MR t-score was used as the dependent measure.

Digit Symbol-Coding. The Digit Symbol-Coding subtest from the Wechsler Adult Intelligence Scale-III (WAIS-III) was used as a measure of processing speed. In this timed task, participants are required to copy an array of symbols that have been arbitrarily paired with numbers 1 through 9 into a series of blank boxes. Participants are given two minutes to complete the task as quickly and accurately as they can. Test-retest reliability is considered good, and a review of the literature suggests that Digit Symbol-Coding is the most sensitive of all WAIS-III subtests to cognitive dysfunction (Lezak, Howieson, & Loring, 2004). The dependent measure on this task was the age-corrected scaled score.

Stroop Color and Word Test. The Stroop Color and Word Test (SCWT; Golden, 1978) is a timed measure of selective attention and cognitive flexibility that contains three parts. In Part 1, participants are instructed to read aloud as quickly as they can the
color names (blue, red, green) printed in black ink. In Part 2, participants identify the color of the X’s printed in colored ink (blue, red, green). In Part 3, participants are asked to name the color of the ink that the color names are printed in, while ignoring the verbal content of the words. In this final task, participants must suppress a learned response (reading a word) and produce a less habitual response (naming the color of ink the word is printed in). Psychometric data on this task are sound, and it has been shown to be effective in identifying and distinguishing among diffuse neurological conditions (Lezak et al., 2004). T-scores for each part (Word, Color, and Color-word) were used as dependent measures.

**Trail-making Test.** The Trail-making Test (TMT; Parts A and B) is a timed test that measures attention, sequencing ability, mental flexibility, visual scanning, and motor function. In Part A of the TMT, which was used as a measure of processing speed, participants draw lines connecting 25 encircled numbers in order that are randomly distributed on a piece of paper as quickly and accurately as they can. In Part B of the TMT, which was used as a measure of executive functioning, participants draw lines connecting 25 encircled numbers and letters in alternating order on a piece of paper as quickly as they can. Both TMT-A and TMT-B show good reliability and validity, and are useful in evaluating medical and psychiatric patients (Spreen & Strauss, 1998). Time (in seconds) to complete each part was the dependent measure.

**Spatial Span.** Nonverbal working memory was assessed using the Spatial Span subtest from the Wechsler Memory Scale-III (WMS-III). In this task, participants touch a series of blocks that are fixed on a horizontal board in the pattern presented to them by
the examiner. Sequences become longer as the task proceeds. Participants are first instructed to tap the blocks in the pattern presented to them, and then they are instructed to tap the blocks in the reverse order presented to them by the examiner. Spatial Span was normed on a broad adult population and demonstrates good reliability and validity (The Psychological Corporation, 1997). The dependent measure on this task was the age-corrected scaled score.

**Conners’ Continuous Performance Test.** Conners’ Continuous Performance Test Computer Program (CPT; Conners, 1995) was used to measure attention, vigilance, and response inhibition. This computerized task requires participants to press the space bar or click the mouse button when any letter except for the target letter X appears on the screen. Participants are told to respond as quickly and accurately as possible, and the entire task takes 14 minutes to complete. Performance on the CPT is measured by rates of errors of omission (number of letters to which the participant did not respond); errors of commission (number of times the participant incorrectly responded to the target letter X); hit reaction time (mean response time for all target responses over all six blocks); hit reaction time standard error (consistency of response times), and perceptual discrimination ($d'$ prime, which is a measure of how well the participant discriminates between targets and non-targets). The CPT was normed using data from both clinical and nonclinical populations across the developmental spectrum, and psychometric data are considered adequate to good (Conners, 1995, 2002). All aforementioned performance measures from the CPT were used as dependent variables.
**Rey Auditory Verbal Learning Test.** The Rey Auditory Verbal Learning Test (AVLT) is a list-learning task that assesses learning, immediate memory, delayed recall, and susceptibility to interference. Participants are read a list of 15 nouns over 5 trials, and after each trial they are asked to recall as many words as they can remember. A second 15-word list is then presented as an interference trial, with recall of this list assessed. Following the interference list, participants are asked to recall the words from the original list. Free recall and recognition of the original word list are examined after a delay of 30 minutes. For this study, the dependent measures included the sum of words correctly recalled on learning trials 1 through 5, immediate free recall, 30 minute delayed free recall, and 30 minute delayed recognition.

**Arithmetic.** The Arithmetic subtest from the WAIS-III requires participants to answer orally administered math and numerical reasoning questions without using pencil and paper. This subtest is a timed task that measures working memory as well as mental computation abilities and concentration (Spreen & Strauss, 1998). This task was normed on a broad adult population and possesses good psychometric properties (The Psychological Corporation, 1997). The age-corrected scaled score was used as the dependent measure.

**Letter-Number Sequencing.** The Letter-Number Sequencing (LNS) subtest from the WAIS-III was used as a measure of working memory. It requires participants to mentally rearrange and repeat a sequence of orally administered letters and numbers. Participants must first arrange the numbers in ascending order and then the letters in alphabetical order. The sequences become longer as participants progress through the
task. This task was normed on a broad adult population and possesses good psychometric properties (The Psychological Corporation, 1997). The age-corrected scaled score was used as the dependent measure on this task.

*Controlled Oral Word Association.* Verbal association fluency, a component of executive functioning, was measured using the Controlled Oral Word Association test (COWA). This test requires participants to generate orally as many words as possible that begin with a given letter in one minute. Participants are presented the letters F, A, and S in separate trials, and they are asked to say as many words as they can that begin with the designated letter, excluding proper nouns, numbers, and the same word with a different suffix. Psychometric data for this task are excellent (Spreen & Strauss, 1998). The total number of admissible words generated on all three trials was used as the measure of performance.

*Stop-Signal Task.* The Stop-Signal Task is an experimental computerized task that was used as a measure of response inhibition. In this task, participants are asked to respond to two letters that appear on the computer screen (X and O) by pressing two designated keys on the computer keyboard as quickly as possible. However, on approximately 25% of the trials, participants hear a tone immediately following the presentation of the target letter that serves as a signal to inhibit their on that trial. The stop signal tone will occur unpredictably throughout the task, and the timing of the tone will vary according to the participants’ performance. The Stop-Signal Task consists of four blocks of 24 trials (18 “go” trials and 6 “stop” trials). Stop Signal Reaction Time (SSRT), which measures the speed of the inhibition process, is estimated by subtracting
the mean delay between the onset of the target stimulus and the onset of the tone, from the mean reaction time for the go trials. Individuals who exhibit inhibitory deficits will demonstrate a longer SSRT compared to individuals with good inhibitory control (Schachar, Mota, Logan, Tannock, & Klim, 2000). This task has been used in multiple studies investigating children with ADHD and several adult studies, many of which have demonstrated the task’s ability to discriminate between ADHD patients and normal controls (Aman, Roberts, & Pennington, 1998; Murphy, 2002b; Nigg et al., 2005; Oosterlaan, Logan, & Sergeant, 1998; Ossmann & Mulligan, 2003; Schachar et al., 2000). The SSRT was used as the outcome measure on this task.

Iowa Gambling Task. The Iowa Gambling Task (IGT; Bechara, Tranel, & Damasio, 2000) is a computerized measure of risky decision making or “cognitive impulsivity” (Malloy-Diniz et al., 2007). Participants must select one card at a time from four available decks of cards shown on the screen (A, B, C, and D). The four decks are designed so that consistent selection from decks A and B will result in a net loss of money, and consistent selection from decks C and D will result in a net gain of money. However, decks A and B have larger immediate wins of money, making them appear to be superior when participants first select from them. The schedule of immediate rewards and future punishments is not obvious, but participants are informed at the start of the game that some decks are worse than others, and they are generally expected to detect the pattern over the course of the task. Participants are provided with $2000 in play money and informed that the goal of the task is to win as much money as possible, or to lose the least amount of money possible. Participants are instructed to select one card at a time
from any deck, and each time the participants select a card, the computer will inform them that they have won or lost a certain sum of money. The computer ends the task automatically when participants have completed 100 selection trials. The IGT has been used in multiple studies with neurological and psychiatric populations in which it has demonstrated strong construct validity (e.g., Bechara, 2003; Bechara, Damasio, Damasio, & Anderson, 1994; Bechara et al., 2000; Busemeyer & Stout, 2002). The dependent measure used in this task was the proportion of selections from the advantageous decks as a function of training trials (computed by dividing selection trials into quintiles and examining change in performance across time).

Results – Study 1 (ADHD Characteristics Study)

Demographic and Descriptive Characteristics

Data for the present analyses were obtained from 1659 participants who completed the initial screening phase of the project between November 2005 and June 2007. Participants ranged in age from 18 to 25 years old, with a mean age of 19.05 years ($SD = 1.13$). Gender composition of the sample was 575 males (34.6%) and 1076 females (64.8%), with 8 participants not providing information on gender status. Of the 1650 participants who provided their self-report of race/ethnicity, 1496 were Caucasian (90.1%), 77 were black/African American (4.6%), 31 were Hispanic (1.9%), 17 were Asian/Pacific Islander (1%), 6 were Native American (.4%), and 22 were “other” racial/ethnic identity (1.3%). Of the 1582 individuals who provided information on college GPA, 51.8% reported having a GPA higher than 3.0, 33.8% reported having a GPA between 2.5 and 3.0, and 14.3% reported having a GPA less than 2.5. Mean levels
of self-reported depressive symptoms, as measured by the BDI-II, were 8.37 ($SD = 7.28$), which fall below the cutoff for mild-to-moderate depression. The mean score on the AUDIT, a self-report measure of alcohol intake, drinking behavior, and problematic alcohol use, was 9.43 ($SD = 5.94$), which falls above the commonly-accepted cutoff point of 8 for hazardous or harmful alcohol consumption (Aertgeerts et al., 2000; Kokotailo et al., 2004; Kills Small et al., 2007). 11.2% of the sample reported a lifetime history of diagnosis of depression, anxiety, or other psychological condition, and 7% of the sample indicated that they are currently receiving treatment (e.g., prescription medication, counseling) for depression, anxiety, or other psychological condition.

**Characteristics Related to ADHD Diagnosis**

Of the 1654 individuals who responded to the question of whether they have ever been diagnosed with ADD or ADHD, 115 (7%) indicated that they had received a diagnosis of ADD or ADHD. In this self-reported ADHD-diagnosis group, 60 (52.6%) were male and 54 (47.4%) were female. With regard to childhood history of ADHD symptomatology, participants in the self-reported ADHD-diagnosis group had a mean WURS score of 36.44 ($SD = 18.41$), with 36 participants (33.3%) falling above the commonly-used clinical cutoff score of 46. With regard to current ADHD symptom report, of the 112 ADHD-diagnosis participants who had complete CAARS-S:L scores, 49 (43.8%) endorsed elevated levels ($t$-scores above 65) of DSM-IV inattentive symptoms, 18 (16.1%) endorsed elevated levels of DSM-IV hyperactive-impulsive symptoms, and 45 (40.2%) endorsed elevated levels of total DSM-IV ADHD symptoms. Of those who scored high on CAARS-S:L inattentive symptoms, 34.7% also scored high
on hyperactive-impulsive symptoms. An additional 20.4% of ADHD-diagnosed individuals with elevated levels of inattentive symptoms endorsed high (but subclinical) levels of hyperactive/impulsive symptoms (i.e., had $t$-scores on CAARS F subscale between 60-64). Of those who scored high on CAARS-S:L hyperactive-impulsive symptoms, 94.4% also scored high on inattentive symptoms. Taken together, these results indicate: 1) that less than half of the individuals in this sample with a lifetime history of an ADHD diagnosis continue to report clinically relevant symptomatology related to their ADHD status; and 2) that most individuals in this sample with clinically elevated levels of ADHD symptomatology endorsed predominantly inattentive symptoms versus hyperactive-impulsive symptoms. Indeed, only one participant in the self-reported ADHD-diagnosis group endorsed elevated levels of hyperactive-impulsive symptoms without correspondingly high levels of inattentive symptoms. It is also worth noting that only 17.1% of participants in the ADHD diagnosis group had elevated scores on both the WURS and the CAARS-S:L subscale G (Total DSM-IV ADHD Symptom subscale).

Finally, with regard to current medication use, 65 participants (58.6%) in the self-reported ADHD-diagnosis group indicated that they currently take prescription medication to address symptoms of ADD or ADHD (25 Adderall, 16 Concerta, 7 Ritalin, 4 Strattera, 2 Focalin, 2 taking multiple medications, and 2 taking medications other than those listed on the questionnaire). Of those individuals in the ADHD diagnosis group who endorsed current high levels of ADHD symptoms (as measured by CAARS G
60.1% report taking medication for ADD or ADHD. Of note, no participants in the non-ADHD diagnosis group reported taking medications for ADD or ADHD symptomatology.

**Characteristics Related to ADHD Symptom Report**

Of the 1539 remaining participants who did not report having a diagnosis of ADD or ADHD, 265 individuals (17.2%) endorsed clinically significant levels of ADHD symptomatology, as defined by CAARS-S:L t-scores of 65 or greater on DSM-IV ADHD symptom subscales (CAARS-S:L scales E, F, and G). In this group of high ADHD symptom-endorsing individuals, 139 (52.5%) were male and 126 (47.5%) were female. The remaining 1274 participants from the original sample did not report having a diagnosis of ADHD, nor did they endorse current high levels of ADHD symptomatology. It is worth noting that the rate of ADHD-symptom endorsement in this non-treatment-seeking sample is consistent with existing studies that report rates of self-reported ADHD symptomatology in community populations (e.g., Manuzza et al., 2002; Murphy & Barkley, 1996; Murphy et al., 2000). Such results highlight the prevalence of ADHD symptomatology in the general population, as well as the difficulty in relying on ADHD self-report scales for diagnosis in both research and clinical practice.

With regard to childhood history of ADHD symptomatology, participants in the ADHD-symptom-reporting group had a mean WURS score of 28.92 (SD = 16.80), with 38 participants (16.5%) falling above the commonly-used clinical cutoff score of 46. With regard to self-report of current ADHD symptoms in the ADHD-symptom-reporting group (as measured by the CAARS-S:L), 236 (89.1%) endorsed elevated levels (t-scores
above 65) of DSM-IV inattentive symptoms, 102 (38.5%) endorsed elevated levels of DSM-IV hyperactive-impulsive symptoms, and 182 (68.7%) endorsed elevated levels of total DSM-IV ADHD symptoms. Of those who scored high on CAARS-S:L inattentive symptoms, 31.4% also scored high on hyperactive-impulsive symptoms. Of those who scored high on CAARS-S:L hyperactive-impulsive symptoms, 72.5% also scored high on inattentive symptoms.

**Comparison of Diagnosis, Symptom, and Control Groups**

These three groups of participants (“ADHD-Diagnosis,” “ADHD-Symptom-Reporting,” and “Normal Controls”) were compared on multiple demographic, psychological, and descriptive variables in order to examine general differences among these groups and to explore how the presence of self-reported ADHD symptomatology may relate to selected aspects of psychosocial functioning. Demographic and descriptive characteristics of participants in each group are provided in Table 2. Groups did not differ in age, $F(2, 1648) = 2.52, p > .05$, or ethnic composition, $\chi^2(12, N = 1650) = 14.77, p > .05$, but did differ with regard to gender, $\chi^2(2, N = 1651) = 67.74, p < .001$. Follow-up tests indicated that both the ADHD-diagnosis and ADHD-symptom-reporting groups had a higher proportion of males than the normal control group (both $p < .001$), but did not differ from each other ($p > .05$). Groups also differed with regard to college achievement, as measured by self-reported college GPA, $\chi^2(4, N = 1582) = 25.40, p < .001$. Follow-up tests indicated that both the ADHD-diagnosis and ADHD-symptom-reporting groups had disproportionately more participants in the lowest GPA category
(GPA below 2.5) and fewer participants in the highest GPA category (GPA above 3.0) than the normal control group (both $p < .05$), but they did not differ from each other ($p > .05$).

Groups were also compared on self-reported depressive symptoms (BDI-II), problematic alcohol use (AUDIT), lifetime history of psychological difficulties, and current treatment for psychological difficulties. Groups differed significantly on mean levels of self-reported depressive symptoms, $F(2, 1633) = 93.54, p < .001$. Follow-up tests (Dunnett’s T3 because of non-homogeneity of variance) revealed that mean levels of depression for participants in both the ADHD-diagnosis and ADHD-symptom-reporting groups were significantly higher than for those in the normal control group ($p < .001$). However, the ADHD-diagnosis and ADHD-symptom-reporting groups did not significantly differ ($p > .05$). Groups also differed significantly on self-reported problematic alcohol use, as measured by total AUDIT scores, $F(2, 1256) = 28.36, p < .001$. Follow-up tests (Tukey’s HSD) indicated that both the ADHD-diagnosis and ADHD-symptom-reporting groups endorsed significantly higher levels of problematic alcohol use than the normal control group ($p < .001$), but did not differ from each other ($p > .05$). With regard to self-reported history of psychological problems (e.g., anxiety or depression), groups differed at the omnibus level, $\chi^2(2, N = 1622) = 93.80, p < .001$. Follow-up tests revealed that more participants in the ADHD-diagnosis and ADHD-symptom-reporting groups had histories of psychological difficulties than participants in the normal control group (both $p < .001$). Additionally, significantly more participants in the ADHD-diagnosis group reported a history of psychological difficulties than
participants in the ADHD-symptom reporting group ($p < .001$). Groups also differed with regard to endorsing current treatment for a psychological disorder (other than ADHD), $\chi^2(2, N = 1622) = 35.64, p < .001$. Follow-up tests indicated that more participants in both the ADHD-diagnosis and ADHD-symptom-endorsing groups reported that they are currently receiving treatment for a psychological disorder (other than ADHD) than participants in the normal control group ($p < .001$). No differences were found between the ADHD-diagnosis and ADHD-symptom-endorsing groups.

Finally, groups were compared on self-reported childhood and current levels of ADHD symptomatology. Significant group differences emerged for retrospective report of childhood ADHD symptomatology, as measured by mean WURS scores, $F(2, 1480) = 239.31, p < .001$. Post-hoc tests (Dunnett’s T3 because of non-homogeneity of variance) indicated that the ADHD-diagnosis group reported a significantly greater number of ADHD-related difficulties in childhood than both the normal controls and the ADHD-symptom-endorsing group (both $p \leq .001$). However, the ADHD-symptom-reporting group also had significantly higher WURS scores than the normal control group ($p < .001$). Groups were also compared on all subscales of the CAARS-S:L, which includes three subscales based on DSM-IV criteria for ADHD (inattention, hyperactivity/impulsivity, and total ADHD symptoms), as well as four empirically derived scales (see Table 3 for CAARS-S:L data for each group). Omnibus tests on group differences on all subscales of the CAARS were significant (all $p < .001$). Post-hoc tests (Dunnett’s T3 tests because of non-homogeneity of variance) indicated that the ADHD-diagnosis group endorsed significantly higher levels of current DSM-IV ADHD
symptoms than the normal control group (CAARS-S:L subscales E, F, and G; all \( p < .001 \)). They also reported more problems than the normal control group on the empirically derived scales measuring inattention/memory problems, hyperactivity/restlessness, impulsivity/emotional lability, and poor self-concept (CAARS-S:L subscales A through D; all \( p \leq .001 \)). Interestingly, the ADHD-symptom-endorsing group reported significantly higher levels of current DSM-IV ADHD symptoms on the CAARS-S:L than both the normal control group and the ADHD-diagnosis group (CAARS-S:L subscales E, F, and G; all \( p < .001 \)). Furthermore, the ADHD-symptom-endorsing group reported having significantly greater problems than the ADHD-diagnosis group with inattention/memory, hyperactivity/restlessness, impulsivity/emotional lability, and poor self-concept (CAARS-S:L subscales A through D; all \( p \leq .01 \)). Overall, these results reinforce both existing research and growing clinical observation that self-report rating scales of ADHD symptomatology in both childhood and adulthood lack specificity to the disorder.

Results – Study 2 (Neuropsychological Study)

Statistical Analysis

Prior to the conduct of statistical analyses, exploratory data analyses were performed to examine variable skew, homogeneity of variance, and the presence of outliers. Outlier values (scores between 1.5 and 3 standard deviations from the mean) were identified for the following variables: AUDIT, BDI-II at Time 2, Matrix Reasoning, Digit Symbol Coding, SCWT-Word, SCWT-Interference, Trail-making Test-B, CPT-Omissions, CPT-Hit Reaction Time, CPT-Hit Reaction Time SE, CPT-d prime,
Spatial Span, AVLT Total Trials 1-5, AVLT Immediate Recall, AVLT Delayed Recognition, Arithmetic, Letter-Number Sequencing, and SSRT. No participants had values exceeding 3 standard deviations from the mean. However, because of outlier status on several neuropsychological variables, one case was removed from the data set. Statistical analyses were conducted with and without the outlier values for the above variables, and results did not significantly vary. Therefore, what is reported below includes all scores for the remaining participants.

Variables were also examined to determine if they met normality assumptions. The following variables failed to meet normality assumptions (i.e., demonstrated significant skew and/or kurtosis using Shapiro-Wilk test at \( p < .01 \)): Trail-making Test-B (positive skew), CPT-Omissions (positive skew, positive kurtosis), CPT-Hit Reaction Time (positive skew, positive kurtosis), CPT-Hit Reaction Time Standard Error (positive skew, positive kurtosis), CPT-d prime (positive kurtosis), Spatial Span (negative skew, positive kurtosis), AVLT Immediate Recall (negative skew), AVLT Delayed Recall (negative skew), AVLT Delayed Recognition (negative skew, positive kurtosis), Arithmetic (negative skew, positive kurtosis), Letter Number Sequencing (positive kurtosis), SSRT (positive skew, positive kurtosis). However, given the sample size and the robustness of MANOVA to violations of normality, these variables were not transformed (Stevens, 2002; Tabachnick & Fidell, 2001).

The current study employed several data analytic strategies. First, preliminary analyses were conducted on demographic and psychological variables. One-way analysis of variance (ANOVA) was used to examine differences among groups on continuous
demographic and psychological variables (i.e., age and scores on BDI-II, CAARS, WURS, and AUDIT); chi-square tests were conducted to determine group differences in gender, ethnicity, presence of current psychological disorder, and handedness. Second, one-way multivariate analysis of variance (MANOVA) was conducted to examine differences among groups on neuropsychological variables thought to reflect specific constructs of cognitive functioning, as derived from the theoretical literature and meta-analytic studies (Frazier, Demaree, & Youngstrom, 2004; Hervey et al., 2004; Lezak et al., 2004; Spreen & Strauss, 1998). Separate one-way MANOVAs were conducted using variables representing the domains of attention, response inhibition, working memory, verbal learning and memory, processing speed, and executive functioning. Finally, performance on the one experimental measure of decision making (the Iowa Gambling Task) was examined using repeated-measures ANOVA (for proportion of selections from advantageous decks as a function of blocks of trials).

**Participant Characteristics**

A total of 87 individuals participated in Study 2, with 28 individuals in the ADHD-DX group, 28 individuals in the ADHD-SX group, and 31 individuals in the NC group. Self-reported racial composition of the sample was 92% Caucasian, 2.3% African American, 2.3% Hispanic, 1.1% Asian/Pacific Islander, and 2.3% endorsing “other” racial status. Participants ranged in age from 18 to 22 years, with an average age of approximately 19 years ($M = 19.21, SD = 1.10$).

Demographic and descriptive characteristics of participants in each group are provided in Table 4. The groups did not demonstrate significant differences with regard
to age, $F(2, 84) = .05, p > .05$, gender, $\chi^2(2, N = 87) = 2.11, p > .05$, or self-reported ethnicity, even after recoding ethnic status to compare Caucasians to all other ethnic groups, $\chi^2(2, N = 87) = 4.25, p > .05$. Additionally, groups did not differ on self-reported college GPA, $\chi^2(4, N = 82) = 4.63, p > .05$ or estimated intellect, as measured by the Matrix Reasoning subtest of the WASI, $F(2, 84) = .53, p > .05$. Because group differences in gender, age, college GPA, and estimated intellect were not statistically significant, they were not used as covariates in subsequent multivariate analyses.

Group differences in self-reported retrospective and current ADHD symptomatology were also examined. As expected given the selection criteria for the study, significant differences emerged among groups on retrospective ADHD symptoms, as measured by the WURS, $F(2, 83) = 27.46, p = .000$. Post-hoc tests (Tukey’s HSD) indicated that the ADHD-DX group reported significantly greater childhood symptomatology than both the ADHD-SX ($p = .000$) and the NC ($p = .000$) groups, and that the ADHD-SX group reported greater childhood symptomatology than the NC group ($p = .01$). It should be noted that WURS scores for prospective ADHD-SX and NC participants needed to be below the generally accepted clinical cutoff of 46 to qualify for participation in Study 2.

Also as expected based on group assignment, there were significant group differences on current self-report of ADHD symptoms, as measured by the CAARS-S:L, on each of the DSM-IV ADHD symptom subscales: the Inattention subscale, $F(2, 84) = 110.07, p = .000$; the Hyperactivity/Impulsivity subscale, $F(2, 84) = 31.96, p = .000$; and the Total Symptom subscale, $F(2, 84) = 103.35, p = .000$. Post-hoc tests (Tukey’s HSD)
indicated that the ADHD-DX and ADHD-SX groups endorsed significantly higher levels of ADHD symptomatology than the NC group (all $p < .001$). Significant group differences also emerged between the ADHD-DX and ADHD-SX group on the CAARS-S:L Inattention subscale, in which ADHD-DX participants reported significantly higher levels of inattentive symptoms than ADHD-SX participants ($p = .01$). See Table 5 for means and standard deviations for CAARS-S:L scores for each group.

Group differences were also examined with regard to parent report of current ADHD symptomatology, as measured by the CAARS-O (see Table 6 for means and standard deviations for groups). As anticipated given the criteria for group assignment, there were significant differences among groups on each of the DSM-IV ADHD symptom subscales: the Inattention subscale, $F(2, 79) = 121.79, p = .000$; the Hyperactivity/Impulsivity subscale, $F(2, 79) = 25.67, p = .000$; and the Total Symptom subscale, $F(2, 79) = 92.11, p = .000$. Post-hoc tests (Tukey’s HSD) revealed that the parents of participants in the ADHD-DX group rated their children as having significantly higher levels of current ADHD symptomatology than both the ADHD-SX group and the NC group (all $p < .001$). No significant differences on the CAARS-O rating scale emerged between the ADHD-SX and NC groups (all $p > .05$).

Groups were also compared on several psychological variables, including current levels of self-reported depressive symptoms, current psychological diagnoses, and self-report of alcohol use (see Table 4 for group means and standard deviations). Current levels of depressive symptoms, as measured by the BDI-II at the start of the laboratory session, did not differ significantly among groups, $F(2, 83) = 2.62, p > .05$. Self-report of
current psychological diagnosis also did not differ significantly among groups, $\chi^2(2, N = 87) = 3.86, p > .05$. However, groups were significantly different on self-report of alcohol use, as measured by the AUDIT, $F(2, 82) = 4.96, p < .01$. Tukey HSD post-hoc tests indicated that participants in the ADHD-DX scored significantly higher on the AUDIT than participants in the NC group ($p < .01$), but did not score significantly higher than participants in the ADHD-SX group ($p > .05$). Because significant group differences emerged on this variable, correlational analyses were conducted to determine if AUDIT scores were significantly related to performance on the neuropsychological variables of interest. Results of these analyses, along with statistical methods used to account for significant correlations, are reported in subsequent sections.

Descriptive analyses were also run on ADHD-DX group characteristics to examine the composition of this group of participants. In this ADHD-DX group, the mean age at which participants were diagnosed with ADHD was 13.52 years, with a minimum of 5 years and a maximum of 20 years old. Of the 14 participants (50% of ADHD-DX group) who indicated that they knew their specific ADHD subtype, 11 (78.6%) reported having ADHD-Inattentive type, 2 (14.3%) reported having ADHD-Combined type, and 1 (7.1%) reported having ADHD-Hyperactive/Impulsive type. Twenty-four participants (85.7% of the ADHD-DX group) endorsed having a current diagnosis of ADHD, and 16 participants (57.1%) indicated that they are currently taking medication to address symptoms of ADHD (e.g., Adderall, Concerta, Ritalin, Straterra). 10 ADHD-DX participants (35.7%) reported that they had at least one immediate family member who was diagnosed with ADHD (compared to 10.0% of NC and 14.3% of
ADHD-SX participants; \( \chi^2(2, N = 86) = 6.83, p = .03 \). Finally, with regard to subjective impression of impairment related to ADHD, 96% of ADHD-DX participants reported experiencing academic impairment, 56% reported impairment in interpersonal relationships, and 40% reported experiencing impairment in the workplace. Overall, 70.4% of the ADHD-DX group indicated that their ADHD symptoms have had a significant negative effect on their school work, ability to function at a job, or their social relationships.

*Analyses of Neuropsychological Measures*

Six separate MANOVAs were conducted on neuropsychological variables hypothesized to be sensitive to group differences based on ADHD diagnostic and symptom status. Performance on the one experimental measure of decision making (the Iowa Gambling Task) was examined using repeated-measures ANOVA (for proportion of selections from advantageous decks as a function of blocks of trials). Descriptive data for all variables included in the MANOVAs are provided in Table 7. Descriptive data for the Iowa Gambling Task are provided in Table 8.

*Attention.* It was hypothesized that ADHD-DX participants would perform significantly worse on tests of attention than both ADHD-SX and NC participants, as measured by CPT errors of omission, CPT reaction time standard error, and CPT d prime. A one-way MANOVA that was conducted to test this hypothesis found no significant effects for the omnibus test, Wilks’ \( \Lambda = .931, F(6, 154) = .928, p > .05 \), multivariate partial \( \eta^2 = .035 \).
**Response inhibition.** It was hypothesized that ADHD-DX participants would perform more poorly on tests of response inhibition than both ADHD-SX and NC participants, as measured by CPT errors of commission and the Stop Signal Reaction Time on stop signal trials. A one-way MANOVA that was conducted to test this hypothesis found no significant effects for the omnibus test, Wilks’ $A = .974$, $F(4, 146) = .483$, $p > .05$, multivariate partial $\eta^2 = .013$. Because mean AUDIT scores were significantly related to CPT errors of commission ($r = .228$, $p < .05$), a MANCOVA was conducted using AUDIT scores as a covariate. As a covariate, the AUDIT was not significant, Wilks’ $A = .936$, $F(2, 71) = 2.41$, $p > .05$, and the multivariate $F$ remained non-significant for the group, $F(4, 142) = .216$, $p > .05$.

**Working memory.** It was hypothesized that ADHD-DX participants would perform more poorly on tests of working memory than both ADHD-SX and NC participants, as measured by Arithmetic, Letter-Number Sequencing, and Spatial Span. A one-way MANOVA that was conducted to test this hypothesis found no significant effects for the omnibus test, Wilks’ $A = .948$, $F(6, 164) = .744$, $p > .05$, multivariate partial $\eta^2 = .026$.

**Verbal learning and memory.** It was hypothesized that ADHD-DX participants would perform significantly worse on tests of verbal learning and memory than both ADHD-SX and NC participants, as measured by AVLT sum of learning trials 1-5, AVLT free recall short delay, AVLT free recall long delay, and AVLT delayed recognition. A one-way MANOVA that was conducted to test this hypothesis found no significant
effects for the omnibus test, Wilks’ $\Lambda = .909$, $F(8, 158) = .961, p > .05$, multivariate partial $\eta^2 = .046$.

*Processing speed.* It was hypothesized that ADHD-DX participants would perform more poorly on tests of processing speed than both ADHD-SX and NC participants, as measured by TMT Part A, Digit Symbol Coding, SCWT Word trial, and SCWT Color trial. MANOVA results revealed significant differences among groups on the dependent variables for the omnibus test, Wilks’ $\Lambda = .681$, $F(8, 162) = 4.29, p = .000$, multivariate partial $\eta^2 = .175$. As the AUDIT was significantly correlated with TMT-A performance ($r = .236, p < .05$), this analysis was re-run using MANCOVA. As a covariate, the AUDIT was not significant, Wilks’ $\Lambda = .959$, $F(4, 79) = .845, p > .05$, but the multivariate $F$ remained significant for the group, $F(8, 158) = 3.53, p = .001$.

Analysis of Variance (ANOVA) was conducted on each dependent variable as a follow-up test to MANOVA, with Bonferroni adjustments applied to each variable to create a more conservative alpha level of .01. Group differences were significant for all variables: TMT-A, $F(2, 84) = 5.30, p = .007$, partial $\eta^2 = .112$; Digit Symbol Coding, $F(2, 84) = 4.94, p = .009$, partial $\eta^2 = .105$; SCWT Word trial, $F(2, 84) = 8.27, p = .001$, partial $\eta^2 = .164$; and SCWT Color trial, $F(2, 84) = 9.65, p = .000$, partial $\eta^2 = .187$.

Tukey HSD post-hoc analysis revealed that, as hypothesized, ADHD-DX participants performed significantly worse than both NC and ADHD-SX participants on all tests included in this domain (all $p < .05$, 1-tailed). No differences in performance between ADHD-SX and NC participants emerged.
Executive functioning. It was hypothesized that ADHD-DX participants would perform more poorly on tests of executive functioning than both ADHD-SX and NC participants, as measured by TMT Part B, COWA total number of words, and SCWT, Color/Word trial. MANOVA results revealed significant differences among groups on the dependent variables for the omnibus test, Wilks’ $\Lambda = .788$, $F(6, 164) = 3.45$, $p = .003$, multivariate partial $\eta^2 = .112$. Because mean AUDIT scores were significantly related to performance on TMT-B ($r = .310$, $p < .01$), a MANCOVA was conducted using AUDIT scores as a covariate. As a covariate, the AUDIT was not significant, Wilks’ $\Lambda = .928$, $F(3, 79) = 2.04$, $p > .05$, but the multivariate $F$ remained significant for the group, $F(6, 158) = 2.85$, $p = .01$.

ANOVA was conducted on each dependent variable as a follow-up test to MANOVA, with Bonferroni adjustments applied to each variable to create a more conservative alpha level of .017. Group differences were significant for SCWT Color/Word trial, $F(2, 84) = 7.22$, $p = .001$, partial $\eta^2 = .147$. Tukey HSD post-hoc analysis revealed that, as hypothesized, ADHD-DX participants performed significantly worse than both NC and ADHD-SX participants on the SCWT Color/Word trial (all $p < .05$, 1-tailed). No differences in performance between ADHD-SX and NC participants emerged.

In order to examine potential contributions of processing speed to performance on the SCWT Color/Word trial, a one-way ANCOVA was conducted using performance on SCWT Word trial as a covariate. Even with SCWT Word performance covaried, group differences still emerged on the SCWT Color/Word ($p = .03$), suggesting that the
performance on this task was related to aspects of cognitive functioning above and beyond simple processing speed.

*Experimental measure of decision making.* It was hypothesized that ADHD-DX participants would perform more poorly on the Iowa Gambling Task (IGT) than both ADHD-SX and NC participants. A repeated-measures ANOVA that was conducted to test group differences on proportion of selections from advantageous decks as a function of trials over time indicated that all groups performed better over time, Wilks’ Λ = .485, \( F(4, 81) = 21.47, p < .001 \), and that there were no group differences across the total number of trials, \( F(2, 84) = .337, p > .05 \). However, a significant Group x Time interaction emerged, Wilks’ Λ = .753, \( F(8, 162) = 3.08, p < .01 \). Follow up ANOVAs on each quintile indicated that while the groups demonstrated similar performance on this task on quintiles one through four (all \( p > .05 \)), the ADHD-SX group made more risky decisions in quintile five than both the NC (\( p < .01 \)) and ADHD-DX groups (\( p < .01 \); multivariate \( F(2, 84) = 4.60, p < .01 \)).

*Analysis of Clinical Significance*

Because MANOVAs revealed significant differences between groups in the domains of processing speed and executive functioning, additional analyses were conducted to examine the clinical significance of the current findings. Three separate methods were used to determine if the neuropsychological measures that reached statistical significance had the ability to successfully discriminate among groups. First, receiver operating characteristic (ROC) analyses were conducted on each variable that reached statistical significance (Digit Symbol Coding, SCWT-Word, SCWT-Color,
SCWT-Color/Word, and TMT-A). All ROC analyses were conducted comparing the ADHD-DX and ADHD-SX groups to determine if these measures had utility in discriminating between groups scoring high on self-report measures of ADHD symptomatology. Holding specificity at .80 or better for all analyses, the sensitivity of each measure was as follows: Digit Symbol Coding = .43, SCWT-Word = .50, SCWT-Color = .46, SCWT-Color/Word = .36, and TMT-A = .43. In all cases, sensitivity was not high enough to be clinically useful. Furthermore, the values corresponding to specificity cut-off levels of .90 for each variable were well within the normal range of performance on these measures, and thus did not provide a useful indicator of impairment. For example, the standard score from Digit Symbol-Coding that corresponded with a specificity falling between .80 and .90 was 8, which represents a score in the average range of functioning.

A second approach to examining clinical significance was undertaken by creating a cutoff score for each of the four variables found statistically significant in the original analysis and comparing the percentage of individuals from each group who scored above the clinical cutoff. The cutoff scores were set at 1.5 standard deviations from the normative mean as published in standard clinical manuals or normative compendiums for each variable, which is a somewhat liberal definition of impairment. Chi-square analyses revealed that significantly more ADHD-DX participants scored above the clinical cutoff on TMT-A, Digit Symbol-Coding, and SCWT-C than NC participants (all $p < .03$). In addition, significantly more ADHD-DX participants scored above the clinical cutoff on SCWT-C test than ADHD-SX participants ($p = .03$). See Table 9 for data.
As a final examination of clinical significance, an impairment index was created, representing the incremental sum of impaired neuropsychological measures (see Table 10 for data). Groups were compared on the number of test scores that fell in the range of clinical impairment (i.e., 1.5 standard deviations from the normative mean). In the ADHD-DX group, 25% of the participants \((n = 7)\) had 2 or 3 neuropsychological test scores that crossed the threshold for clinical impairment, compared to 0 in both the ADHD-SX and NC groups. Chi-square tests conducted to examine the significance of this finding demonstrated that ADHD-DX participants were significantly more likely to have more scores in the impaired range than both the NC participants, \(\chi^2(3, N = 59) = 9.70, p = .02\), and the ADHD-SX participants, \(\chi^2(3, N = 56) = 8.20, p = .04\). This finding suggests that use of an impairment index with at least two neuropsychological measures exceeding clinical impairment may assist in the assessment of ADHD. The finding also suggests that consistent impairments in the domains tested by these measures (i.e., processing speed and executive functioning) may be specific to ADHD.

Discussion

The present study addressed two issues within the broad domain of ADHD symptomatology and diagnosis in adulthood. First, the study examined the degree to which ADHD symptom endorsement patterns and psychosocial histories differentiate young adults who do and do not report a history of an ADHD diagnosis. Second, the study extended prior research findings related to neuropsychological functioning in young adults with and without a diagnosis of ADHD. Specifically, the study addressed the question of whether the pattern of neuropsychological performance seen in
individuals with ADHD is specific to this patient group, or if it is instead more widely
representative of individuals who report current difficulties with ADHD-like symptoms.
The two-pronged approach of the current study allowed for an examination of the
epidemiology and phenomenology of ADHD symptomatology in young adult college
students, as well as a more robust investigation of the utility of neuropsychological
measures in discriminating among individuals with and without a diagnosis of ADHD.

*Exploratory Analysis of ADHD Characteristics*

Results from the exploratory analysis of ADHD diagnosis and symptomatology in
young adult college students indicated that 7% of participants reported having been
diagnosed with ADD or ADHD, with less than half of these individuals reporting current
high levels of ADHD symptomatology. This estimate of ADHD prevalence in a large
cohort of undergraduate students is generally consistent with previously published
estimates of ADHD in college settings. Although empirically-based research on this
topic is sparse, investigators have hypothesized that the prevalence of ADHD on college
campuses likely falls between 3 to 5% (e.g., DuPaul et al., 2001; Heiligenstein et al.,
1998; Murphy & Barkley, 1996; Weyandt et al., 1995). However, it should be noted that
the prevalence estimates derived from these studies were generally based on self-reported
symptom endorsement on ADHD rating scales rather than on standardized clinical
assessments that include indices of impairment and evidence of developmental
progression of the disorder.

Within the current sample, a sizable portion (17.2%) of young adults who did not
report having a prior diagnosis of ADD or ADHD endorsed clinically significant levels of
current ADHD symptomatology on a standardized rating scale of adult ADHD. When psychosocial characteristics that held the potential to discriminate between ADHD-diagnosed and ADHD-symptom endorsing individuals were explored, very few differences emerged between young adults with a self-reported diagnosis of ADHD and those who lacked a diagnosis but endorsed high rates of current ADHD symptoms. Overall, these two groups of young adults shared many similarities, particularly when compared to participants who did not endorse significant levels of ADHD symptomatology. Specifically, ADHD-diagnosed and symptom-endorsing young adults were significantly more likely than their peers to be receiving treatment for a current psychological disorder, to endorse higher rates of current depressive symptoms, and to engage in high-risk drinking behaviors. Both groups were also more likely to have lower GPAs (i.e., a self-reported GPA of 2.5 or below) than their peers without ADHD or ADHD symptomatology.

Only lifetime psychiatric history and self-report of childhood ADHD symptomatology differentiated these two groups, with the ADHD-diagnosis group reporting significantly higher lifetime rates of psychological problems (e.g., depression and anxiety) and greater levels of ADHD symptomatology in childhood. Differences were also found between ADHD-diagnosis and ADHD-symptom-endorsing individuals on the self-reported presence and severity of current ADHD symptoms, as measured by the CAARS-S:L, such that ADHD-symptom-endorsing participants reported significantly higher levels of current ADHD symptoms in all DSM-IV ADHD symptom domains. Furthermore, the ADHD-symptom-endorsing group reported having significantly greater
problems than the ADHD-diagnosis group with inattention/memory, hyperactivity/restlessness, impulsivity/emotional lability, and poor self-concept, as measured by CAARS-S:L subscales A through D.

**Implications of Exploratory Analysis**

Results from this exploratory study highlight several salient issues related to ADHD diagnosis and symptom report in college students. First, results of this study provide information regarding the developmental course of ADHD in a group of presumably high-functioning ADHD-diagnosed young adults, an historically underexamined subset of individuals with ADHD. Second, results of this study draw attention to the implications of self-report of ADHD diagnosis and/or ADHD symptomatology for psychosocial and academic functioning in a university setting. Third, results of the study shed light on the psychosocial, behavioral, and demographic characteristics of individuals who self-report high levels of ADHD symptomatology but who lack an ADHD diagnosis. Finally, the current results reinforce findings from other studies on adult ADHD that have illustrated problems related to self-report of retrospective and current ADHD symptoms in research and clinical endeavors.

**Developmental course of ADHD.** With regard to the developmental course of ADHD, in the present study less than half (40%) of the participants who reported having received a diagnosis of ADD or ADHD by a health/mental health professional endorsed current significant ADHD symptomatology. This symptom-endorsement pattern in those with prior ADHD diagnoses may reflect what is thought to be part of the natural course of the disorder, in which some individuals display remission from their symptoms and
impairment, while others continue to meet either partial or full diagnostic criteria for the disorder. In the current study, the percentage of individuals who appear to have continuing difficulties with ADHD (as measured by current symptom endorsement) corresponds with general estimates that roughly 40 to 70% of individuals with ADHD will continue to experience both significant ADHD symptoms and related impairment through adolescence and adulthood (e.g., Barkley, Fischer, Smallish, & Fletcher, 2002; Biederman, Mick, & Faraone, 2000; Mannuzza, Klein, Bessler, Malloy, & LaPadula, 1993). In this sample, the ADHD-diagnosed individuals who denied experiencing current ADHD symptoms may represent the subset of individuals diagnosed with ADHD in childhood who “grow out” of their ADHD symptoms and impairment as they progress into adulthood (Barkley et al., 1991; Barkley et al., 2002; Mick, Faraone, & Lynam, 2004). Given the fact that ADHD in childhood is related to significant impairment in academic performance, those individuals with ADHD who progress to college may represent those with a less severe manifestation of ADHD. Thus, the current sample composed of university students may contain a disproportionately higher number of “remissions” than is likely to be found in a community setting. It may be speculated that these individuals received appropriate, effective treatment that provided long-lasting benefits.

Alternatively, the present findings could reflect the well-established observation that adults with ADHD tend to underreport both symptom levels and impairment related to their ADHD (e.g., Barkley et al., 2002; Biederman et al., 2000; Connors et al., 1999; Kooij et al., 2008). In this regard, parent ratings of current ADHD symptoms for
participants in Study 1 would have been helpful confirmation of presence or absence of ADHD symptoms; however, parental corroboration of symptom reporting was not within the scope of the study. A third explanation for the current findings concerns the potential inaccuracy of the self-report ADHD diagnostic status. Some individuals may have inaccurately recalled their being “diagnosed” with ADHD (e.g., if a grade school teacher referred to his/her disruptive classroom behavior as being “ADHD”). It is also possible that participants in this group may have received an inaccurate diagnosis of ADHD by a medical or mental health professional. In these cases of inaccurate self-report of ADHD diagnosis, it would not be expected that these individuals would endorse high levels of current ADHD symptomatology.

Of the ADHD-diagnosed individuals who endorsed current high levels of ADHD symptoms, most (91%) reported having current difficulties in the domain of inattention, with only 16% indicating current difficulties in the domain of hyperactivity/impulsivity. The fact that most of these individuals differentially endorsed inattentive symptoms over hyperactive-impulsive symptoms is consistent with longitudinal research that documents higher rates of remission of hyperactive-impulsive symptoms compared to inattentive symptoms over time (Biederman et al., 2000; Mick et al., 2004; Millstein et al., 1997). When compared to studies that examined the nature and prevalence of ADHD symptomatology in college students, the current findings corroborate those reported by Heiligenstein and colleagues (1998) in their sample of university students. Specifically, in their survey of 468 university students, Heiligenstein et al. found that rates of hyperactive-impulsive symptoms declined significantly as a function of age, relative to
inattentive symptoms. However, the current findings differ from results reported in a study conducted by DuPaul and colleagues (2001), which found that hyperactive-impulsive symptoms were the most commonly endorsed symptoms in both males and females in their cross-national sample of university students. DuPaul et al. noted, however, that their results stand in contrast to the majority of studies that have examined ADHD symptom persistence and expression in adulthood.

The current study found no significant differences regarding the distribution of ADHD diagnosis and symptomatology across gender. That is to say, both the ADHD-diagnosis and ADHD-symptom-endorsing groups had relatively equal numbers of males and females. Furthermore, no differences in symptom-endorsement patterns based on gender emerged in the current study. These results are similar to those reported by DuPaul et al. (2001), who found no significant gender differences for self-reported DSM-IV inattention or hyperactivity-impulsivity symptoms in their cross-national sample ($n = 1209$) of university students. In the present study, when examining just ADHD-diagnosed individuals, there was a slight trend ($p = .06$) in the direction of having more males than females report current significant total ADHD symptoms (i.e., having a CAARS-G t score $> 65$). These results, which suggest no gender differences in ADHD symptom report or ADHD diagnostic status, differ from those obtained in community studies, where the gender ratio of ADHD symptomatology in adults is reported as 1.8:1 to 2.6:1 (e.g., Murphy & Barkley, 1996). As DuPaul et al. (2001) note, these gender differences in ADHD symptom reporting may not exist in samples composed of higher-achieving individuals with ADHD.
Implications for college functioning. Another noteworthy finding from this exploratory investigation of ADHD symptomatology involved the high rates of self-reported depressive symptoms, problematic alcohol use, and past and current psychiatric difficulties reported by both the ADHD-diagnosis and ADHD-symptom-endorsing groups. Individuals in these groups also had lower GPAs than individuals who did not report having an ADHD diagnosis or current ADHD symptomatology. These results echo findings from previous investigations of functional impairments and academic consequences related to ADHD symptomatology in young adults generally, and university students in particular. A significant body of evidence has accumulated that points to impairments in multiple domains of functioning in young adults with ADHD, ranging from increased rates of substance use/abuse, risky sexual activity, and driving accidents to increased risk for comorbid psychiatric conditions (e.g., Barkley et al., 1996; Barkley & Gordon, 2002; Biederman et al., 1993; Millstein et al., 1997; Molina & Pelham, 2003; Murphy et al., 2001). However, even more compelling is the evidence indicating that psychosocial impairments are also present in relatively high-functioning individuals with ADHD, as implied by their educational status.

Although the ADHD-diagnosed and symptom-endorsing individuals in this study are arguably a higher functioning cohort compared to those in clinical or community settings, they nevertheless provided information on multiple self-report instruments suggesting difficulties in several psychosocial and academic domains. The present findings coincide with prior research on the academic performance of students with ADHD. For instance, previous research has indicated that once enrolled in college,
young adults with ADHD are significantly less likely than their non-ADHD peers to earn their college degree (5% in ADHD-diagnosed versus 41% of control participants in a study conducted by Weiss and Hechtman, 1993). A more recent study examining the relation between ADHD symptomatology and college student attrition found that self-reported ADHD symptomatology in the freshman year was a significant predictor of subsequent dropout, above and beyond alcohol use, GPA, and school involvement (Wilkins, 2007). Additionally, in their study of ADHD symptomatology and achievement in college students, Frazier and colleagues found a significant correlation between self- and parent-reported ratings of inattentive symptoms and probation status in their sample of 380 first-year college students (Frazier et al., 2007).

In the present study, the impact of ADHD diagnosis and symptomatology in college students extended beyond academic difficulties. Unlike prior studies of college students with ADHD or ADHD symptomatology, which found no significant relationship between ADHD status and patterns of maladaptive psychosocial and physical functioning (e.g., Heiligenstein et al., 1995; Heiligenstein et al., 1999), the current study did find higher rates of risky alcohol use, depressive symptoms, and past and current psychological difficulties in college students with ADHD diagnoses and/or high levels of ADHD symptomatology. Although the current study did not examine the full spectrum of potential impairment, findings on the measures included in Study 1 illustrate a pattern of difficulties that appear to be related to ADHD symptomatology. When viewed as a whole, investigations of the impact of ADHD diagnostic status and symptomatology on college student functioning demonstrate that this “high functioning” group experiences
greater impairment in an objective sense (i.e., scoring above normative cutoffs on well-standardized instruments) as well as in relation to their non-ADHD peers. Thus it would appear that ADHD diagnostic history and current ADHD symptomatology confer a risk for adverse psychosocial, behavioral, and academic outcomes in university students.

*Characteristics of ADHD symptom-endorsing individuals.* Findings from the present study suggest that a substantial percentage of college students endorse significant symptoms of ADHD and possess psychosocial and behavioral profiles that resemble their peers with prior diagnoses of ADHD. Such findings raise the obvious question of who composes this high symptom-endorsing group. In all likelihood, this group comprises a heterogeneous mix of individuals who report high ADHD symptomatology for several different reasons. First, the group may contain individuals who are endorsing transient characteristics of ADHD, or who are generally “symptom magnifiers” (Wasserstein, 2005, p. 4)—that is, individuals who rate themselves on the higher end of the spectrum of these fairly common characteristics. It is possible that a college student sample may have higher base rates of ADHD-like characteristics, particularly those in the inattentive domain. As full-time students (many of whom are in their first year of college), these individuals may be experiencing the strain of college demands, and thus may be likely to see themselves as having difficulty with completing tasks, sustaining attention, resisting distraction, sitting still during classes, and keeping track of responsibilities and commitments—all of which may be relatively new demands for novice college students. Such symptom endorsements may not have validity across time or across settings, and therefore it is presumed that the individuals who endorse less temporally or situationally
stable ADHD characteristics would also not endorse significant functional impairment related to these symptoms.

The symptom-endorcing group might also contain individuals who have another psychological or health disorder that may produce symptoms or levels of distress that resemble the clinical symptomatology of ADHD. Many of the symptoms of ADHD are common to other psychiatric and health disorders, most notably depression, anxiety, substance use, hypothyroidism, sleep difficulties, and head injury (Roy-Byrne et al., 1997; Searight et al., 2000). Thus, a portion of this group may represent individuals without ADHD who are bothered by symptoms that resemble ADHD characteristics, but who possess other psychiatric or health disorders that better account for their distress and symptoms. Prior research has demonstrated that adult ADHD rating scales assessing current symptoms tend to produce poor diagnostic specificity when used with clinical samples composed of adults with internalizing disorders, particularly major depressive disorder (e.g., Harrison, 2004; McCann & Roy-Byrne, 2004; Roy-Byrne et al., 1997). As one means of investigating this possibility in the current sample, scores on the BDI-II were correlated with the scores on the CAARS-S:L subscale G (representing total ADHD symptoms) in this group. As a whole, the correlation in this group was significant ($r = .13, p = .04$) but not highly robust. However, when males and females were examined separately, only the correlation for males remained significant ($r = .30, p = .000$). Surprisingly, the correlation between depressive symptomatology and total ADHD symptomatology for females was insignificant ($r = .07, p = .44$). Thus, there is some evidence for a relationship between the concurrent presence of depressive symptoms and
ADHD symptoms; however, the nature of this relationship (e.g., whether depressive symptoms or general distress are accounting for elevated ADHD symptoms) is unclear.

Finally, it is also conceivable that some individuals in the ADHD-symptom-endorsing group do indeed fall into the category of ADHD but were either overlooked in childhood or else developed impairing symptomatology later in development (i.e., the “late onset” individuals who have recently been the subject of investigation by several research groups, e.g., Faraone et al., 2006). A number of authors have indicated that ADHD is often underdiagnosed or misdiagnosed on college campuses (e.g., Glutting, Youngstrom & Watkins, 2005; Heiligenstein & Keeling, 1995; Reilley, 2005), and thus it is possible that a subset of these non-treatment-seeking college students meets diagnostic criteria for ADHD, but for a variety of reasons has gone undiagnosed. The fact that the individuals in the ADHD-diagnosed and ADHD-symptom-endorsing group had similar symptom endorsement profiles and shared many psychosocial and academic risk factors may be construed as support for this possibility. Clearly, further assessment of impairment and evidence of a developmental pattern of ADHD symptomatology would better clarify the nature and composition of this group of individuals. It should be noted that this group most likely represents a significant portion of adults who refer themselves for evaluation of ADHD symptoms in clinical settings, and who pose a particular diagnostic challenge for the clinicians who assess them.

Specificity of self-report of ADHD symptoms. Prior research using community-based, clinic-referred, and college student samples has substantiated the high-base-rate nature of ADHD symptomatology. Indeed, “it is relatively common for adults to see
themselves as having exhibited clinical levels of ADHD-type impairment during childhood and in their current lives” (Murphy et al., 2000, p. 4). Despite some claims that self-report questionnaires of childhood and current ADHD symptomatology are valid indicators of ADHD diagnostic status in the absence of collateral information, results of the present study strongly suggest that this is not the case. First, self-report of current ADHD symptomatology proved not to be specific to ADHD-diagnosed individuals, as over 17% of this non-treatment-seeking sample endorsed clinically elevated levels (i.e., above the 95th percentile) of ADHD symptoms. These findings generally coincide with other studies that have examined rates of ADHD symptom endorsement in community samples and college student samples using standardized adult ADHD rating scales (e.g., DuPaul et al., 2001; Harrison, 2004; Murphy & Barkley, 1996; Murphy et al., 2000; Weyandt et al., 1995).

Furthermore, analysis of the data from the self-report measure of childhood ADHD characteristics (the WURS) indicates both low sensitivity and specificity to the disorder. For example, when asked to report on their recollection of ADHD symptomatology in their childhood using the WURS, only 33% of individuals with an ADHD diagnosis endorsed symptoms that exceeded the recommended cutoff for establishing the presence of the disorder in childhood. While the percentage of ADHD-diagnosed individuals with high WURS scores significantly exceeded the percentage of high WURS scores from both the ADHD-symptom-endorsing and normal control groups, 16.5% of ADHD-SX and 2% of NC participants still crossed the clinical cutoff on the WURS. These results confirm those obtained by a number of investigators, who have
emphasized that the use of rating scales that assess self-report of current or past ADHD symptoms will result in higher rates of symptom endorsement than expected by prevalence rates of the disorder (Harrison, 2004; Heiligenstein et al., 1999; Mannuzza et al., 2002; McCann & Roy-Byrne, 2004; Murphy et al., 2000; Roy-Byrne et al., 1997). Given the high base rates of ADHD-like characteristics in typical populations and the overlap of ADHD symptoms with other psychiatric disorders, these results are not entirely surprising. They do, however, caution against the practice of basing diagnostic decisions on self-report rating scales of current or childhood symptom presentation in both research and clinical settings.

Analysis of the data obtained from Study 1 provided evidence that individuals with a self-reported history of ADHD diagnosis strongly resemble individuals without such a history (but who currently report very high rates of ADHD symptomatology) in multiple demographic, psychosocial, and behavioral domains. Given the lack of specificity found in self-report instruments that measure retrospective and current ADHD symptomatology, along with the potential overlap in psychosocial features and impairment in ADHD-diagnosed and symptom groups, it is imperative to establish supplemental methods of evaluating adults who present in clinical settings seeking assessment for “adult ADHD.” Indeed, identifying additional tools that distinguish among individuals who endorse similar patterns on ADHD symptom rating scales or behavioral checklists will assist with diagnostic assessments in both clinical and research settings. Use of neuropsychological measures in diagnostic evaluation of adults with ADHD may be of benefit in this regard.
Examination of Neuropsychological Performance in ADHD

Results from the neuropsychological study indicated that young adults with ADHD (ADHD-DX) performed significantly worse on tests of processing speed and on one test of executive functioning than both normal control participants (NC) and ADHD-symptom-endorsing participants (ADHD-SX). Specifically, ADHD-DX individuals demonstrated poorer performance on TMT-A, Digit-Symbol Coding, and the SCWT-Color, -Word, and -Color/Word trials. No differences in neuropsychological performance between groups were observed on measures assessing attention, response inhibition, working memory, verbal learning and memory, or risky decision making. Furthermore no differences in neuropsychological performance were observed between NC participants and ADHD-SX participants in any domain of functioning. Results from the current study partially supported the original hypotheses, which predicted that ADHD-DX individuals would perform more poorly than both NC and ADHD-SX individuals in all aforementioned neuropsychological domains. However, as expected, ADHD-SX participants did not differ from NC participants in neuropsychological functioning.

Implications of Neuropsychological Results

Several interpretations can be offered to account for the neuropsychological findings obtained in the current study. The first and most theoretically plausible explanation for the results concerns the pattern of symptom endorsement in the ADHD-DX group. Participants in the ADHD-DX group disproportionately endorsed inattentive symptoms over hyperactive-impulsive symptoms and tended to self-identify as having the
The present results demonstrating weaknesses in processing speed and executive functioning coincide with both theoretical accounts of subtyping in ADHD and the growing empirical literature that examines neuropsychological functioning in relation to symptom profiles in both child and adult samples.

Although the neuropsychological literature has not consistently supported distinct cognitive profiles for the different subtypes of ADHD (e.g., Hinshaw, Carte, Sami, Treuting, & Zupan, 2002; Murphy et al., 2001), there is some convincing evidence demonstrating specific relationships between symptom profiles and neuropsychological functioning (Gansler et al., 1998; Nigg et al., 2005; Solanto et al., 2007). In particular, a number of studies in both the child and adult literature have shown that the inattentive symptoms of ADHD are most consistently related to neuropsychological weaknesses, particularly in the domains of attention, working memory, processing speed, and executive functioning (e.g., Chhabildas, Pennington, & Willcutt, 2001). When symptoms of hyperactivity-impulsivity are related to neuropsychological deficits, it tends to be in the domains of response inhibition and sustained attention (e.g., Malloy-Diniz et al., 2007). Furthermore, when using performance on neuropsychological tests as a predictor of ADHD symptom dimensions, studies have shown that measures of processing speed represent some of the best predictors of inattentive symptoms in ADHD, regardless of subtype (Chhabildas et al., 2001; Rucklidge & Tannock, 2002; Weiler et al., 2000). Thus, it appears that DSM-IV defined symptoms of inattention may have the strongest relationship with poor neuropsychological performance, irrespective of subtype.
classification. However, studies continue to investigate the potential for delineating neuropsychological profiles based on subtype status in adults.

In one of the largest neuropsychological studies of adult ADHD to date, Nigg and colleagues (2005) compared the neuropsychological performance of a large sample of adults with ADHD ($n = 105$) with control participants in two broad conceptual domains: executive functioning and processing speed. Using many measures contained in the present study, Nigg et al. found that ADHD adults performed more poorly on both executive functioning and speed measures relative to normal controls, after controlling for gender, IQ, and comorbid psychological disorders. More importantly, they also found that executive functioning weaknesses were related to symptoms of inattention-disorganization (I-D; a composite domain they created) but not symptoms of hyperactivity-impulsivity (H-I). Their findings confirmed the results of several previous investigations (e.g., Dinn et al., 2001; Jenkins et al., 1998; Johnson et al., 2001; Lovejoy et al., 1999; Murphy et al., 2001; Riordan et al., 1999) that found that weaknesses in executive functioning continue into adulthood. Furthermore, Nigg and colleagues suggested that their results support what they called the “two factor theory” of ADHD, in which “executive deficits contribute primarily to symptoms of I-D and problems in reward-response contribute primarily to symptoms of H-I” (Nigg et al., 2005, p. 714). In predicting ADHD subtype membership based on executive functioning or processing speed variables, they determined that ADHD-Combined was predicted by poor executive functioning, and that membership in the other ADHD group (mostly composed of ADHD-Primarily Inattentive) was predicted by slow response speed. Thus, it may be the
case that deficits in executive functioning contribute primarily to the combined subtype, and slow psychomotor speed (perhaps related to sluggish cognitive tempo) may contribute to the primarily inattentive subtype. This interpretation supports the findings of the current study, and offers a cogent account for potentially specific effects of neuropsychological functioning on symptom profiles.

Neuropsychological findings that demonstrate specific correlates as a function of subtype align with the burgeoning literature in other functional domains that show phenotypic differences between subtypes. Such differences are seen in age of onset, developmental course, psychiatric comorbidities, psychosocial characteristics, and adaptive impairment (Faraone, Biederman, Weber, & Russell, 1998; Hartman, Willcutt, Rhee, & Pennington, 2004; Lahey et al., 1994; McBurnett, Pfiffner, & Frick, 2001; Milich, Balentine, & Lynam, 2001; Stavro, Ettenhofer, & Nigg, 2007). Thus, the current results are in line with a substantial body of literature that suggests specific relationships between symptom profiles or subtypes and psychosocial, behavioral, and neuropsychological outcomes. However, more evidence in the area of neuropsychological functioning is required to determine more precisely the neuropsychological correlates of clearly defined ADHD subtypes and symptom profiles.

In contrast to the explanation that argues for relationships between symptom profiles and specific patterns of neuropsychological functioning, a competing explanation relies on the lack of specificity that can be attributed to the measures of processing speed included in the current study. That is to say, the construct of processing speed is broad, and tests that measure processing speed tend to be sensitive to a variety of different
medical, psychological, and neurodevelopmental conditions (Lezak et al., 2004). As some of the more sensitive tests to both subtle and diffuse conditions, measures of processing speed could be expected to display group differences, compared to other measures that may be less effective in detecting subtle group differences. This explanation can also be supported by the neuropsychological literature in ADHD populations that argues that the weaknesses in cognitive functioning seen in both children and adults with ADHD tend to be diffuse, with no reliable pattern of performance in neuropsychological domains (e.g., Hervey et al., 2004; Lovejoy et al., 1999). Thus, if neuropsychological functioning in ADHD is best characterized as diffuse impairment rather than impairments in specific domains, one would expect to see decrements in performance on tasks of processing speed.

Given the symptom-endorsement patterns and self-reported subtype status of the ADHD group, it was somewhat surprising that attention and working memory tasks, particularly those using verbal stimuli (e.g., Letter-Number Sequencing, Arithmetic, and AVLT) did not discriminate among groups. Recent reviews of neuropsychological functioning in adult ADHD (e.g., Hervey et al., 2004; Woods, Lovejoy, & Ball, 2002) have called attention to patterns of deficits on tasks that use verbal versus visual cues, even within the same domain of functioning. Tasks that rely on the “phonological loop” in Baddeley and Hitch’s conceptualization of working memory seem to show the most pronounced impairments in ADHD, suggesting that subtle disruptions in verbal processing may play a role in the observed difficulties in verbal learning/memory, working memory, and even executive functioning (Baddeley & Hitch, 1994; Hervey et
Research in both child and adult studies of ADHD have produced evidence that would support a relationship between impairments in working memory and inattentive symptomatology. However, a final explanation that views the findings in the context of the sample composition is of merit: It is possible that the educational attainment of the participants may have masked any decrements in working memory (and other measures of interest) that may be present in the larger population of adults with ADHD. Supporting this interpretation, several authors have noted that young adults with ADHD who advance to college or university settings represent a higher functioning group of ADHD adults who may not demonstrate the constellation of associated psychosocial, academic, and neuropsychological impairments that characterize this population (e.g., Murphy & Barkley, 1996; Nigg et al, 2005). Thus, the current results that failed to find widespread differences in the domains of interest may be a product of the higher-functioning sample of college students. The possibility also exists that there may be certain patterns of neuropsychological performance that are more likely to manifest in college students with ADHD in comparison to typical ADHD adults in the community, whose history of academic impairments precluded them from attending college.

In contrast to prior studies of neuropsychological functioning in adult ADHD, the present study also addressed the clinical significance of the findings using three different methods. Receiver operating characteristics (ROC) analyses on measures reaching statistical significance revealed generally poor sensitivity of the measures to reliably identify individuals with a diagnosis of ADHD. However, use of an impairment index
(representing the incremental sum of neuropsychological measures on which participants scored significantly below clinical norms) showed promise in identifying individuals with ADHD. Specifically, individuals with ADHD were significantly more likely than either control group to score in the impaired range on two or more neuropsychological measures, showing that ADHD is indeed associated with cognitive weaknesses that in some cases can be construed as impaired. Further, results suggest that a pattern of impairments in the domains tested by these measures (i.e., processing speed and executive functioning) may be specific to ADHD.

Overall, results from the neuropsychological study provided evidence that slowed processing speed and weaknesses in executive functioning are not simply a product of ADHD symptom-reporting, and instead appear to be related more specifically to an established diagnosis of ADHD. Indeed, it should be emphasized that high symptom reporting was not associated with diminished neuropsychological performance in any domain of functioning assessed in the current study. Thus, although similar in self-reported measures of psychological and behavioral functioning, the ADHD-DX and ADHD-SX group were distinguishable by their performance on selected cognitive measures.

Limitations

The findings from the current should be interpreted in the context of several notable limitations. First, participants did not undergo a thorough diagnostic assessment to evaluate for ADHD or other potential comorbid psychological disorders. Instead, participants were assigned to groups on the basis of self-report of ADHD diagnostic
status, self-reported current and past ADHD symptoms, and parent confirmation of the presence or absence of ADHD diagnosis and symptomatology. This method of group assignment posed certain problems, in that evaluating impairment, identifying subtype status, and thoroughly assessing for comorbid conditions were not possible. Thus, diagnostic accuracy may be in question, particularly for those in the ADHD-SX group.

Second, the individuals who participated in the current study consisted of young adults who were undergraduate students attending a four-year university. As such, this participant group may not be representative of the larger population of young adults with ADHD who present in clinical settings or who live in the community. Thus, the neuropsychological findings of the study, as well as the broader information related to psychosocial and behavioral factors that may differentiate among groups, may not generalize to young adults with ADHD outside of the college setting. However, the current study did generate findings that partially supported the hypotheses regarding neuropsychological functioning in adults with ADHD. Furthermore, as noted earlier, young adult college students with ADHD are an understudied population of ADHD individuals, and certainly warrant empirical investigation in their own right.

An additional limitation of the current study involves the exclusion/inclusion criteria related to comorbid psychological difficulties. With regard to exclusionary criteria, individuals with self-reported head injury, learning disorders, substance abuse disorders, and psychotic disorders were excluded from participation in the study. Given the high comorbidity between ADHD and learning disorders, excluding individuals with a diagnosis of ADHD who also had a comorbid learning disability may have limited the
generalizability of the findings. However, psychological disorders such as depression and anxiety were not considered exclusionary criteria, and a small number of individuals who endorsed past or current diagnoses of anxiety and depression were represented in each participant group. However, statistical analyses that examined neuropsychological functioning with comorbid cases excluded did not yield different results. Furthermore, correlational analyses examining the relationship between current depressive symptoms and performance on neuropsychological measures failed to reach statistical significance.

Finally, the current study included individuals in both the ADHD-DX and ADHD-SX group who demonstrated substantial variability in their symptom endorsement patterns and profiles. This heterogeneity in the composition of both ADHD groups may have reduced our ability to detect group differences on neuropsychological measures that may be more sensitive to certain constellations of ADHD symptoms. While the ADHD group comprised individuals who tended to endorse inattentive over hyperactive/impulsive symptoms, the symptom profile of the group was by no means uniform. The issue of group variability in the study of ADHD is common to many research projects and is difficult to surmount, particularly given the challenges with accurate diagnosis of adult ADHD. However, a more robust research design would allow for separate examination and comparison of the neuropsychological correlates of each ADHD subtype. The most rigorous approach would entail a longitudinal examination of behavioral and neuropsychological correlates of ADHD, taking into account each participant’s current symptomatic profile and subtype, as well as the developmental progression of the symptom profile. In this way, cognitive functioning of individuals
with ADHD can be studied in the context of the developmental course of the disorder, which is characterized by changes in the relative rates of inattentive versus hyperactive/impulsive symptoms over time. Despite the heterogeneity in ADHD groups, the present study yielded findings that supported the developmental trajectory of ADHD symptomatology and identified neuropsychological correlates that may characterize this population of ADHD-diagnosed individuals.

Conclusion

While the methods and aims of Study 1 and Study 2 differed, both yielded important findings that have the potential to inform assessment and diagnostic practices in adult ADHD. The present results helped to refine our understanding of the presentation of ADHD in young adulthood, particularly given the explicit comparison that was made with a group of high-symptom-endorsing individuals. In light of the many similarities between these two groups on self-report and neuropsychological measures, the combined results confirm the need for clinicians and researchers to obtain collateral information regarding past and present ADHD symptomatology along with evidence of impairment across time and in multiple settings when making a diagnosis of ADHD in adults. This corroboration ideally would come from a third-party source who knows the individual well, as well as from objective sources such as school records, medical records, or employer evaluations.

Results from the current study also support the utility of neuropsychological evaluation in assessment of adult ADHD, providing initial evidence that selected measures of processing speed and executive functioning, as well as the use of an
impairment index, may assist in the diagnostic process. In particular, findings suggest that neuropsychological measures may be useful in distinguishing between adults with a true diagnosis of ADHD and those who report current ADHD characteristics for reasons other than ADHD. As such, the study highlights the evolving role of neuropsychological testing as part of the larger assessment process in diagnosing ADHD in adults, particularly with young adults presenting for evaluation in university clinics. Furthermore, although this non-treatment-seeking sample performed adequately on the test of effort included in the neuropsychological battery, enough evidence has accrued in other investigations of the potential for malingering in adult ADHD assessment that supports the regular inclusion of a measure of effort when evaluating adults with ADHD (e.g., Harrison, 2004; Sullivan et al., 2007).

The outcomes of the study, as well as its limitations, also point to opportunities for future investigations in the field. First, the findings of the present study need to be replicated and extended, using both college students and community-based samples of ADHD-diagnosed and ADHD-symptom-endorsing individuals. Obtaining a larger cohort of individuals will provide sufficient statistical power to examine the potential effects of subtype differences on neuropsychological measures of interest. An additional methodological consideration would be to assess specifically for characteristics related to sluggish cognitive tempo, which are thought to represent the thinking style of a subset of individuals with the primarily inattentive subtype, but that do not load onto the DSM-IV-TR inattentive symptoms (Nigg et al., 2005). Characteristics of sluggish cognitive tempo include physical hypoactivity, tendency to become confused, lack of mental alertness,
and frequent daydreaming, all of which are symptoms unlikely to be found in the ADHD-Combined and ADHD-Hyperactive/Impulsive subtypes (Lahey et al., 1994; Hartman et al., 2004). Screening participants for characteristics of sluggish cognitive tempo may help to identify a subset of ADHD-diagnosed individuals who best represent the “pure” subtype of ADHD-Inattentive type, and who may demonstrate neuropsychological correlates that are truly distinct from other subtypes.

Another suggestion for future research is to develop and validate a self-report measure of impairment for adult ADHD. Identifying functional impairment related to ADHD in children has proven to be one of the most effective practices in the assessment process (e.g., Pelham, Fabiano, & Massetti, 2005). An adult ADHD impairment measure that is tied to indices of ADHD symptomatology would hold the potential to enhance the sensitivity and specificity of these instruments. In particular, the use of an impairment measure may help to address the problem of universality of ADHD symptoms by eliminating the “symptom magnifiers” from consideration for an ADHD diagnosis, since it may be less likely that this group of high symptom endorsers would report similarly high levels of impairment related to these characteristics. An informal impairment measure has been incorporated in at least one study of neuropsychological and adaptive functioning in adult ADHD (Stavro et al., 2007). Construction and validation of a formal impairment measure would be a useful clinical and research tool for evaluation of ADHD in adulthood.

Clearly, results of the present study attest to the need to identify more powerful ways to differentiate individuals who truly have ADHD from those who present as
symptom magnifiers in clinical settings. Enhanced understanding of both types of patient groups is crucial for accurate diagnostic and treatment practices as well as valid empirical investigations of adult ADHD.
References


*Applied Neuropsychology, 14*, 189-207.


Wasserstein, J. (2005). Diagnostic issues for adolescents and adults with ADHD.


Appendix A: Copies of Original or Amended Measures

Demographic Questionnaire

ID#: ____________  Age: __________  Sex (circle one):  Male  /  Female

Year in college (circle one):  Freshman  Sophomore  Junior  Senior

Race/Ethnicity:  _____  Native American or Alaskan Native
                _____  Asian or Pacific Islander
                _____  Black, not of Hispanic origin
                _____  Hispanic
                _____  Hispanic
                _____  White, not of Hispanic origin
                _____  Other (please describe: ________________)

What was your high school GPA?
____ less than or equal to 2.5 (less than a C)
____ 2.51 to less than 3.0 (C to B)
____ 3.0 or greater (B or better)

What is your current overall college GPA?
____ less than or equal to 2.5 (less than a C)
____ 2.51 to less than 3.0 (C to B)
____ 3.0 or greater (B or better)

Have you ever repeated a grade in elementary, middle, or high school?

____ Yes.  What grade? ____________
____ No

____________________________________  _______________
Signature        Date

As part of the study, we would like to send a short questionnaire home to your parent(s) or guardian(s). The questionnaire contains items that assess the presence of behaviors and characteristics related to ADHD, and it is the same one that you will be completing as part of this study. Please provide the address to which the questionnaire should be mailed.

Name:

Address:

Town/State/Zip:
Personal Health History Questionnaire

1. Have you ever been diagnosed with ADHD or ADD?
   ____ Yes. If so, age at diagnosis _______
   ____ No

2. If you know your specific ADHD diagnosis (i.e., subtype), please indicate below (circle):
   ADHD Combined Type   ADHD Inattentive Type   ADHD Hyperactive-Impulsive Type

3. Do you have a current diagnosis of ADHD or ADD?
   ____ Yes.
   ____ No

4. What treatment have you received for your ADHD symptoms? (check all that apply)
   ____ Ritalin
   ____ Adderall
   ____ Strattera
   ____ Dexedrine
   ____ Concerta
   ____ Metadate
   ____ Cylert
   ____ Focalin
   ____ Other (describe: ____________________________________________)

5. Are you currently taking medication to address symptoms of ADHD?
   ____ Yes. If so, please describe: ______________________________
   ____ No

6. How have your ADHD symptoms affected your:
   Academic work ______________________________________________________
   Work/occupation _____________________________________________________
   Interpersonal relationships _____________________________________________
7. Do you feel your ADHD symptoms have had a significant negative effect on your school work, ability to function at a job, or your social relationships?
   ____ Yes
   ____ No

8. Has anyone in your family been diagnosed with ADHD?
   ____ Yes. If so, describe: ________________________________
   ____ No

9. Do you have current difficulties with drug or alcohol use?
   ____ Yes. If so, describe: ________________________________
   ____ No

10. Have you ever been diagnosed with depression, anxiety, or other psychological condition?
    ____ Yes. If so, describe: ________________________________
    ____ No

11. Have you ever received treatment (e.g., prescription medication, counseling, herbal supplements) for depression, anxiety, or other psychological condition?
    ____ Yes. If so, describe: ________________________________
    ____ No

12. Are you currently diagnosed with depression, anxiety, or other psychological condition?
    ____ Yes. If so, describe: ________________________________
    ____ No

13. Are you currently receiving treatment (e.g., prescription medication, counseling, herbal supplements) for depression, anxiety, or another psychological condition?
    ____ Yes. If so, describe: ________________________________
    ____ No

14. Have you been diagnosed with a learning disability?
    ____ Yes. If so, describe: ________________________________
    ____ No
15. Have you ever received a blow to the head that caused you to lose consciousness for more than 30 minutes?
   _____ Yes
   _____ No
AUDIT

Please circle the answer that is correct for you:

1. How often do you have a drink containing alcohol?
   Never    Monthly or less 2-4 times a month 2-3 times a week 4 or more times a week

2. How many drinks containing alcohol do you have on a typical day when you are drinking?
   1 or 2      3 or 4      5 or 6      7 or 9      10 or more

3. How often do you have six or more drinks on one occasion?
   Never    Less than monthly Monthly Weekly Daily or almost daily

4. How often during the last year have you found that you were not able to stop drinking once you had started?
   Never    Less than monthly Monthly Weekly Daily or almost daily

5. How often during the last year have you failed to do what was normally expected of you because of drinking?
   Never    Less than monthly Monthly Weekly Daily or almost daily

6. How often during the last year have you needed a drink first thing in the morning to get yourself going after a heavy drinking session the night before?
   Never    Less than monthly Monthly Weekly Daily or almost daily

7. How often during the last year have you had a feeling of guilt or remorse after drinking?
   Never    Less than monthly Monthly Weekly Daily or almost daily

8. How often during the last year have you been unable to remember what happened the night before because you had been drinking?
   Never    Less than monthly Monthly Weekly Daily or almost daily

9. Have you or someone else been injured as a result of your drinking?
   No      Yes, but not in the last year Yes, during the last year
10. Has a relative, friend, doctor, or any other health worker been concerned about your drinking or suggested you cut down?

No     Yes, but not in the last year     Yes, during the last year
Letter to Parents

Dear Parents:

Your son/daughter has expressed an interest in participating in our study that investigates psychological characteristics in college students and their relationship to certain aspects of physical and psychological health history. Ohio University’s Institutional Review Board has approved this study. The goal of our research is to understand how the symptom patterns commonly associated with Attention-Deficit/Hyperactivity Disorder (ADHD) are related to past and present physical and psychological functioning. In writing to you we are seeking to confirm the presence or absence of ADHD symptoms in your son/daughter through the use of a brief questionnaire that contains a list of behaviors for you to rate. Since it is standard procedure for parental questionnaires to be used in the assessment of symptoms of inattention and hyperactivity/impulsivity, we must contact the parents of all participants to request additional information to complete this study. When completing the questionnaire, please consider your son/daughter’s functioning when he/she is not on medication (if he or she has been prescribed medication to address symptoms of ADHD). Your responses to this questionnaire will not be shared with your son/daughter.

Your help in completing our investigation would be greatly appreciated. We ask that you take a few minutes to complete the attached questionnaire and return it in the enclosed postage-paid envelope. All responses to the questionnaire remain strictly confidential. To help ensure confidentiality, each questionnaire is identified with a numerical code only. This number is used to combine your responses with the information provided by your son/daughter.

By completing the enclosed questionnaire, it is understood that you are consenting to the use of this information in our research project. You are, of course, under no obligation to complete this questionnaire. Further, if your son/daughter attends Ohio University, his/her grades are in no way related to this decision.

I would like to thank you for your kind attention to this letter. Please accept the enclosed $2.00 as an expression of our thanks for your time and effort in completing the questionnaire. If you require any further information, please do not hesitate to call me at (740) 593-1091.

Sincerely,

Julie Suhr, Ph.D.
Associate Professor
Department of Psychology
Parent Mailing Enclosure

ID# _____________________

1. If the characteristics listed on the rating scale strongly apply to your son or daughter, please circle when they first appeared:

   Before Elementary School

   Elementary School

   Middle School

   High School

   College

   These characteristics do not apply to my son/daughter

2. Please indicate if your son or daughter has ever received a diagnosis of:

   Attention Deficit/Hyperactivity Disorder  _____ Yes  _____ No

   Oppositional Defiant Disorder (ODD)  _____ Yes  _____ No

   Conduct Disorder (CD)  _____ Yes  _____ No
Laboratory Session Questionnaire

1. Have you consumed any caffeine in the past 3 hours?  YES  NO
   If yes, please describe:_________________________________________________

2. Have you consumed any alcohol in the past 24 hours?  YES  NO
   If yes, please indicate the number and type(s) of alcoholic drinks consumed:
   _____________________________________________________________________

3. Have you used any recreational drugs in the past 24 hours?
   If yes, please indicate the type of drug and quantity used:
   _____________________________________________________________________

4. Have you taken any prescription medication within the past 24 hours?  YES  NO
   If yes, please describe:_________________________________________________

5. Have you taken any non-prescription medication within the past 24 hours?  YES  NO
   If yes, please describe:_________________________________________________
Appendix B: Psychometric Properties of Instruments

Beck Depression Inventory-Second Edition (BDI-II; Beck, Steer, & Brown, 1996). The BDI-II is a self-administered, 21-item instrument that measures the presence and severity of depressive symptoms in adolescents and adults ages 13 and older. Items on the BDI-II have been designed to correspond to criteria for diagnosing unipolar depressive disorders found in the DSM-IV (1994). For each item, participants are asked to select one of four statements that best characterizes their mood and functioning during the past two weeks. Items are summed to yield a total depression score, with higher scores representing greater symptom severity. The BDI-II has demonstrated sound psychometric properties in multiple research studies and with multiple adult populations (Beck et al., 1996; Groth-Marnat, 2003).

The BDI-II has been found to have high internal consistency, yielding a coefficient alpha of .93 for outpatients and .92 for college students (Beck et al., 1996). One-week test-retest reliability in a clinical sample was .93 (Beck et al., 1996). The BDI-II demonstrates adequate construct validity, showing satisfactory correlations with other scales rating depressive symptoms (e.g., .71 correlation with the Revised Hamilton Psychiatric Rating Scale; Beck et al., 1996). The BDI-II also demonstrates acceptable discriminant validity. Results of studies indicate that it has been able to differentiate between psychiatric and nonpsychiatric populations, and it demonstrates lower correlations with measures of anxiety (e.g., .47 with the Hamilton Rating Scale for Anxiety) than it does with measures of depression (Beck et al., 1996).
Alcohol Use Disorders Identification Test. (AUDIT; Saunders, Aasland, Babor, de la Fuente, & Grant, 1993). The AUDIT is a 10-item screening measure designed to assess alcohol intake, alcohol dependence, and adverse consequences from alcohol consumption. Scores range from 0 to 40, and a cutoff of 8 has been shown to discriminate reliably between individuals with and without alcohol use problems (Aertgeerts et al., 2000; Kills Small, Simons, & Stricherz, 2007; Saunders et al., 1993). Studies using college students (e.g., Aertgeerts et al., 2000; Kills Small et al., 2007; Kokotailo et al., 2004) have found that a cutoff score of 8 yields a sensitivity of .70 and above, and a specificity of .85 and above.

A recent research review of the AUDIT conducted by Reinert and Allen (2007) indicated that the AUDIT demonstrates strong internal consistency in a variety of populations and settings, with a median reliability coefficient of .83. The AUDIT has also shown strong criterion validity, yielding strong correlations with other well-established methods of identifying alcohol use disorders (Reinert & Allen, 2007). The AUDIT has demonstrated very strong psychometric properties in multiple populations, including primary care patients, veterans, and college students (e.g., Aertgeerts et al., 2000; Fleming, Barry & McDonald, 1991; Kokotailo et al., 2004; Reinert & Allen, 2002). Furthermore, it has consistently shown better performance as a screening tool for alcohol dependence and abuse than other self-report questionnaires of alcohol use (Kills Small et al., 2007; Reinert & Allen, 2007).

S:L; Conners et al., 1999) consists of 66 items that assess the core symptoms of ADHD as well as problematic behaviors related to ADHD. The long version yields four factor-derived subscales (Inattention/Memory Problems, Hyperactivity/Restlessness, Impulsivity/Emotional Lability, and Problems with Self-Concept) and three DSM-IV ADHD Symptom Subscales (Inattentive, Hyperactive-Impulsive, and Total ADHD symptoms). The CAARS – S:L also contains an Inconsistency Index, to gauge the consistency of endorsement patterns, as well as an empirically derived ADHD Index. The ADHD Index score is composed of 12 CAARS items that have been shown to successfully discriminate between ADHD and nonclinical groups. Sensitivity and specificity of the ADHD Index are 71% and 75%, respectively, with an overall correct classification rate of 73% (Conners et al., 1999).

Participants are instructed to rate the items according to a 4-point Likert-type scale (ranging from “0” for “not at all true” to “3” for “very much true”). In this way, the scale is designed to assess both the presence and severity of the primary ADHD characteristics, with higher scores representing increasing symptom levels. Participants were instructed to rate his/her own behavior without the effects of medication, if they happened to be taking medication to address symptoms of ADHD.

The Conners’ Adult ADHD Rating Scale Observer: Screening Version (CAARS – O:SV) was mailed to the parents of participants. This measure, which asks an observer to rate the behaviors of the individual in question, contains items that are similar to the self-report rating scale but is shorter in length. The CAARS – O:SV yields three DSM-IV ADHD Symptom Subscales (Inattentive, Hyperactive-Impulsive, and Total ADHD
symptoms) as well as the ADHD Index. In a cover letter, parent observers were instructed to rate behavioral characteristics as observed when their child is not on medication.

The reliability and validity of the CAARS factor scores for the self-report version are satisfactory, with internal reliability coefficients for 18-29 year-olds ranging from .64 to .89. Internal reliability coefficients for the observer version are also adequate, with internal reliability coefficients ranging from .80 to .92 for 18-29 year-olds. The test-retest reliability of the CAARS – S:L was computed for the four factor-derived subscales and the ADHD Index after a one-month testing interval. Test-retest correlations were high, ranging from .88 for the Inattention/Memory Problems subscale to .91 for the Problems with Self-Concept subscale. Test-retest reliabilities for the CAARS observer version (with a two-week testing interval) were also high, ranging between .89 and .95. Validity data generated for the CAARS are strong, with the instrument demonstrating good factorial, discriminant, and construct validity. For instance, the CAARS – S:L was shown to correctly classify 85% of ADHD patients and normal control adults, showing adequate discriminant validity (Erhardt et al., 1999). Furthermore, the correlations between self-report and observer ratings on the four factor-derived subscales were found to be in the moderate to high range for both males and females (Conners et al., 1999).

*Wender Utah Rating Scale* (WURS; Ward, Wender, & Reimherr, 1993). The 25-item version of the WURS was administered a self-report measure of childhood ADHD symptomatology. The original WURS, designed as a retrospective measure of childhood ADHD characteristics, consisted of 61 items evaluating both the presence and severity of
ADHD-relevant behaviors and symptoms. The original WURS was later shortened to a version containing the 25 items that best discriminated between ADHD patients and nonclinical controls. Participants are instructed to rate each item on a 0 to 4 scale (“not at all or very slightly” to “very much”), and items are summed to compute a total score ranging from 0 to 100. A score of 46 or greater is typically used as a cutoff score for identifying adults with ADHD (Ward et al., 1993).

An initial validity study of the 25-item WURS found that the measure adequately distinguished ADHD patients from nonclinical controls as well as patients with unipolar depression (Ward et al., 1993). When compared with each control group, ADHD participants demonstrated significantly higher mean total scores and greater mean differences for each item. When a cutoff score was used to predict group assignment, investigators found that a cutoff score of 46 correctly identified 86% of ADHD patients, 99% of normal controls, and 88% of depressed patients (Ward et al., 1993). Subsequent studies examining the validity of the WURS largely supported the construct validity of this instrument (e.g., Weyandt, Linterman, & Rice, 1995) but tended to generate substantially lower classification scores (McCann, Scheele, Ward, & Roy-Byrne, 2000). The WURS demonstrates good reliability, with split-half reliability coefficients equaling .90 for nonclinical participants (Ward et al., 1993). Other studies have confirmed adequate internal consistency and good temporal stability of the WURS (Rossini & O’Connor, 1995; Stein et al., 1995).

**Word Memory Test.** The Word Memory Test (WMT; Green, 2003) is a measure of verbal memory that allows for the empirical measurement of effort, which is a crucial
factor in determining the validity of neuropsychological test results. To the author’s knowledge, no studies of neuropsychological functioning in adult ADHD have considered effort when interpreting results of neuropsychological performance in this population. The WMT is a computerized task that presents a sequence of 20 word pairs (one pair every six seconds) that the participant is instructed to read and memorize. Participants will be tested on immediate recognition of correct words, recognition of correct words after a 30-minute delay, and recognition of word pairs after a 30-minute delay. The four outcome measures to be used are the immediate recognition subtest score, delayed recognition subtest score, consistency score comparing performance on immediate and delayed recognition subtests, and multiple choice subtest score (i.e., recognition of word pairs). These four measures constitute the basic effort measures for this instrument. It was proposed that participants whose performance on the WMT suggested poor effort (as determined by specific cutoff scores for each of the four effort measures) would not be considered for inclusion in the final data analysis. However, all participants who completed the neuropsychological study gave sufficient effort, as measured by the WMT.

The WMT has been subjected to extensive clinical validation studies. Data from numerous populations, including neurological patients, psychiatric patients, adults with mild and severe brain injury, children with ADHD, mentally retarded adults, and disability claimants have been collected to use as comparative groups for performance on this measure (Green, 2003). The split-half reliability of the WMT is very high, with effort measures within the test correlating with each other between .86 and .90 (Green,
Within a given test session, the effort measures correlate highly. However, because effort can vary from one session to another, test-retest correlations were modest (e.g., .43 for Immediate Recall and .33 for Delayed Recall). Multiple studies assessing the accuracy of the WMT in discriminating between simulatoirs of cognitive dysfunction and healthy controls have demonstrated sensitivity and specificity levels at or near 100% (Green, 2003). The WMT’s validity as a measure of effort has also been demonstrated using the WMT as a predictor of performance on other neuropsychological measures (Green, Rohling, Lees-Haley, & Allen, 2001). In one study (Green et al., 2001), the WMT effort scores predicted 50% of the variance of neuropsychological test results generated from over 30,000 patients.

Matrix Reasoning. The Matrix Reasoning (MR) subtest from the Wechsler Abbreviated Scale of Intelligence (WASI) is a test of perceptual reasoning ability without a speeded component. As a broad measure of nonverbal reasoning, MR was used as a rough estimate of general intelligence. MR is an untimed task that consists of a series of increasingly complex colored patterns that have a component part missing. Participants must select the one component from an array of 5 choices that best completes the matrix. MR has acceptable reliability and validity: the internal reliability coefficient for the age group most representative of the proposed sample (ages 20-24) is .88, and the test-retest reliability coefficient for the 17-54 age group is .72 (The Psychological Corporation, 1999). The MR T-score was used as the dependent measure.

Digit Symbol-Coding. The Digit Symbol-Coding subtest from the Wechsler Adult Intelligence Scale-III (WAIS-III) was used as a measure of processing speed. In
this task participants are given a sheet of paper with rows of squares that are blank on the bottom and contain numbers (1 through 9) on the top. Participants are asked to refer to a key at the top of the page that pairs each number with a different nonsense symbol and copy the symbols that have been paired with the numbers as quickly as possible within a two-minute time period. In addition to processing speed, the test is thought to involve attentional skills, psychomotor speed, cognitive flexibility, and nonverbal working memory (Lezak et al., 2004; Sattler & Dumont, 2004). Test-retest reliability is considered good, with the stability coefficient of the 16-29 year age group equaling .81 (The Psychological Corporation, 1997). Scores on the Digit Symbol-Coding test have been found to be vulnerable to brain damage of most types, and a review of the literature suggests that Digit Symbol-Coding is the most sensitive of all WAIS-III subtests to cognitive dysfunction (Lezak et al., 2004). The dependent measure on this task was the age-corrected scaled score.

Stroop Color and Word Test. The Stroop Color and Word Test (SCWT; Golden, 1978) is a measure of selective attention and cognitive flexibility. There are three parts to the test. In Part 1, participants are instructed to read aloud as quickly as they can the color names (blue, red, green) printed in black ink. In Part 2, participants identify the color of the X’s printed in colored ink (blue, red, green). In Part 3, participants are asked to name the color of the ink that the color names are printed in, while ignoring the verbal content of the words. In this final task, participants must suppress a learned response (reading a word) and produce a less habitual response (naming the color of ink the word is printed in). A decrease in color-naming speed is expected, referred to as the “color-
word interference effect.” Test-retest reliability is high—above .80 for the three parts of the test (Spreen & Strauss, 1998). Factor analytic studies suggest that the SCWT measures processing speed and ability to divide attention as well as aspects of planning and organization of behavior (Spreen & Strauss, 1998). This task has been shown to be effective in identifying and distinguishing among diffuse neurological conditions. Several measures of performance from this task were used, including the $T$-score for each component (word, color, and color-word).

**Trail-making Test.** The Trail-making Test (TMT; Parts A and B) is a timed test that measures attention, sequencing ability, mental flexibility, visual scanning, and motor function. In Part A of the TMT, participants draw lines connecting 25 encircled numbers in order that are randomly distributed on a piece of paper. In Part B of the TMT, participants draw lines connecting 25 encircled numbers and letters in alternating order on a piece of paper. Retest reliability up to one year is good for both parts, with Part A ranging from .64 to .94 and Part B ranging from .66 to .86 (Spreen & Strauss, 1998). Because Parts A & B correlate only moderately (.49) with each other, they are thought to measure somewhat different cognitive functions (Spreen & Strauss, 1998). Factor analytic studies indicate that Parts A and B generally load on factors of rapid visual search and visuospatial sequencing, while Part B alone has been found to load on a focused mental processing speed factor. Both parts of the TMT have demonstrated sensitivity to various types of brain damage, with Part B generally showing more utility in discriminating among patients with neuropsychological deficits (Spreen & Strauss, 1998). Time (in seconds) to complete each part was the dependent measure.
**Spatial Span.** Nonverbal working memory was assessed using the Spatial Span subtest from the Wechsler Memory Scale-III (WMS-III). In this task, participants touch a series of blocks that are fixed on a horizontal board in the pattern presented to them by the examiner. Sequences become longer as the task proceeds. Participants are first instructed to tap the blocks in the pattern presented to them, and then they are instructed to tap the blocks in the reverse order presented to them by the examiner. Split-half reliability coefficients for this test were moderately high, averaging .79 across age groups, and test-retest reliability was good, with the stability coefficient for the 16-54 age group equaling .72 (The Psychological Corporation, 1997). Spatial Span loads on a working memory factor (Spreen & Strauss, 1998) and is thought to tap an individual’s ability to hold visual-spatial sequences in working memory (The Psychological Corporation, 1997). The dependent measure on this task was the age-corrected scaled score.

**Conners’ Continuous Performance Test.** Conners’ Continuous Performance Test Computer Program (CPT; Conners, 1995) was used to measure attention, vigilance, and response inhibition. This task, which is administered on a desktop computer, requires participants to press the space bar or click the mouse button when any letter except for the target letter “X” appears on the screen. Participants are told to respond as quickly and accurately as possible. Three-hundred sixty letters, approximately one inch in size, appear on the screen one at a time for approximately 250 milliseconds. Letters are presented in six time blocks, with each time block containing different combinations of inter-stimulus intervals (1, 2, or 4 seconds between letter presentations). The order in
which the inter-stimulus intervals are presented varies between blocks. The entire task
takes 14 minutes to complete. Performance on the CPT is measured by rates of errors of
omission (number of letters to which the participant did not respond); errors of
commission (number of times the participant incorrectly responded to the target letter
“X”); hit reaction time (mean response time for all target responses over all six blocks);
hit reaction time standard error (consistency of response times), and perceptual
discrimination (“d prime,” which is a measure of how well the participant discriminates
between targets and non-targets). All aforementioned measures from the CPT were used
as dependent variables.

The CPT was normed using data from both clinical and nonclinical populations
across the developmental spectrum. Although reliability data for the original CPT were
not reported, split-half reliability coefficients generated from the updated CPT-II
(Conners, 2002) for the dependent measures cited above were high, ranging from .83 for
d prime and errors of commission to .95 for hit reaction time (Conners, 2002). Test-retest
stability coefficients for a considerably smaller standardization sample (n=23) were
moderate, ranging from .55 for hit reaction time to .84 for errors of omission. Using
normative data from clinical cases, Conners (1995) demonstrated that the CPT
discriminated between an ADHD group, an ADHD plus comorbid disorders group, and a
mixed psychiatric group on all dependent measures of interest, with the ADHD only
group scoring significantly worse than the other two groups. The CPT and its successor,
the CPT-II, are used frequently in investigations of the core deficits of ADHD in both
child and adult populations, with most studies detecting significant differences between ADHD patients and nonclinical subjects on the primary outcome measures.

Rey Auditory Verbal Learning Test. The Rey Auditory Verbal Learning Test (AVLT) assesses learning, immediate memory, delayed recall, and susceptibility to interference through the use of a 15-word list. Participants are read a list of 15 nouns over 5 trials, and after each trial they are asked to recall as many words as they can remember. A second 15-word list is then presented as an interference trial, with recall of this list assessed. Following the interference list, participants are asked to recall the words from the original list. Free recall and recognition of the original word list are examined after a delay of 30 minutes. This test, as well as its alternate forms, possesses moderate test-retest reliability over one year, with correlation coefficients ranging from .38 to .70 (Lezak et al., 2004). It also correlates significantly (between .50 and .65) with other tasks of learning and memory (Lezak et al., 2004). Factor analytic studies indicate that the AVLT loads on a verbal as well as nonverbal memory factor (Spreen & Strauss, 1998). The AVLT has also demonstrated sensitivity to neurological impairment and is effective in differentiating among memory disorders in various patient groups, including those with frontal lobe impairments (Lezak et al., 2004; Spreen & Strauss, 1998). For this study, the dependent measures included the sum of words correctly recalled on learning trials 1 through 5, immediate free recall, 30 minute delayed free recall, and 30 minute delayed recognition.

Arithmetic. The Arithmetic subtest from the WAIS-III requires participants to answer orally administered math and numerical reasoning questions without using pencil
and paper. This subtest is a timed task that measures mental computation abilities, concentration, and working memory. WAIS-III factor analytic studies demonstrate that the Arithmetic subtest loads highly on a working memory factor (The Psychological Corporation, 1997). Arithmetic demonstrates good internal reliability (.88 when averaged across age groups) and test-retest reliability (.86 for the 16-29 year age group). Neuropsychological studies have shown that performance on the Arithmetic subtest is vulnerable to multiple types of neurological injuries and disorders (Lezak et al., 2004). The age-corrected scaled score was used as the dependent measure.

*Letter-Number Sequencing.* The Letter-Number Sequencing (LNS) subtest from the WAIS-III requires participants to mentally rearrange and repeat a sequence of orally administered letters and numbers. Participants must first arrange the numbers in ascending order and then the letters in alphabetical order. The sequences become longer as participants progress through the task. Split-half reliability is good (.82 averaged across age groups), as is test-retest reliability (.70 for the 16-29 year age group (The Psychological Corporation, 1997). WAIS-III factor analytic studies show LNS to load on a working memory factor (The Psychological Corporation, 1997). The age-corrected scaled score was used as the dependent measure on this task.

*Controlled Oral Word Association.* Verbal association fluency was measured using the Controlled Oral Word Association test (COWA). This test requires participants to generate orally as many words as possible that begin with a given letter in one minute. Participants are presented the letters F, A, and S in separate trials, and they are asked to say as many words as they can that begin with the designated letter, excluding proper
nouns, numbers, and the same word with a different suffix. Inter-rater reliability is close to perfect, and retest reliability in adults after approximately one month has been reported as .88. (Spreen & Strauss, 1998). The task has been found to load on several factors, such as verbal knowledge and abstract mental operations. Performance on the test has also been associated with tasks of naming, oral spelling, problem solving, and memory (Spreen & Strauss, 1998). Studies of neurological populations indicate that COWA is sensitive to a variety of impairments, ranging from mild head injury to dementia (Spreen & Strauss, 1998). Studies using brain-imaging techniques demonstrate frontal and temporal lobe involvement during task completion, and performance on the task is sensitive to any type of frontal lobe damage (Spreen & Strauss, 1998). The number of admissible words generated on all three trials was used as the measure of performance.

*Stop-Signal Task.* The Stop-Signal Task is an experimental computerized task that will be used as a measure of response inhibition. In this task, the participant is asked to respond to two letters that appear on the computer screen (“X” and “O”) by pressing two designated keys on the computer keyboard as quickly as possible. However, on approximately 25% of the trials, the participant will hear a tone immediately following the presentation of the target letter that serves as a signal to inhibit his/her response on that trial. The “stop signal” tone will occur unpredictably throughout the task. The delay between the presentation of the letter and the stop signal starts at 250 ms and will vary according to the participant’s performance, so that the participant will be able to inhibit responding on approximately half of the trials in which the tone is played. If a participant successfully inhibits his/her response on a stop signal trial, the delay will be reset so that
it appears 50 ms later on the subsequent stop trial. If the participant fails to inhibit on a stop signal trial, the delay will appear 50 ms earlier. The Stop-Signal Task consists of four blocks of 24 trials (18 “go” trials and 6 “stop” trials). Stop Signal Reaction Time (SSRT), which measures the speed of the inhibition process, is the primary dependent variable. Because the SSRT is unobservable, it is estimated by subtracting the mean delay between the onset of the target stimulus and the onset of the tone, from the mean reaction time for the go trials. Individuals who exhibit inhibitory deficits will demonstrate a longer SSRT compared to individuals with good inhibitory control (Schachar et al., 2000).

This task has been used in multiple studies investigating children with ADHD and several adult studies, many of which have demonstrated the task’s ability to discriminate between ADHD patients and normal controls (Aman et al., 1998; Murphy, 2002b; Nigg et al., 2005; Oosterlaan et al., 1998; Ossmann & Mulligan, 2003; Schachar et al., 2000). Substantial evidence has accumulated indicating that individuals with ADHD exhibit deficits in the ability to inhibit responses using the stop-signal paradigm relative to non-ADHD individuals. Moreover, research with ADHD children suggests that poor inhibitory control on the Stop Signal Task may be specific to ADHD: compared to children with ADHD, children with conduct disorder, learning disabilities, and anxiety disorders have SSRT’s that approximate those of typically developing control children (Schachar & Logan, 1990; Schachar et al., 2000; Schachar, Tannock, Marriott, & Logan, 1995). Although the Stop-Signal Task has been used less frequently in studies of adult
ADHD, existing findings indicate that this paradigm shows significant promise in
discriminating between adults with ADHD and normal controls.

*Iowa Gambling Task.* A computerized version of the Iowa Gambling Task was
administered as an experimental measure to all participants (Bechara et al., 2000). The
gambling task was designed as a means to study deficits in decision making exhibited by
certain neurological and psychiatric patients, and it was used in this study to investigate
potential differences in decision making between individuals with and without a
diagnosis of ADHD.

For this task, participants are seated at a desktop computer and shown four decks
of cards on the computer screen. Each deck, labeled A, B, C, and D, contains 60 cards.
The four decks are designed so that consistent selection from decks A and B will result in
a net loss of money, and consistent selection from decks C and D will result in a net gain
of money. However, decks A and B have larger immediate wins of money, making them
appear to be superior when participants first select from them. The schedule of
immediate rewards and future punishments is not obvious, but participants are informed
at the start of the game that some decks are worse than others, and they are generally
expected to detect the pattern over the course of the task. Participants are provided with
$2000 in play money and informed that the goal of the task is to win as much money as
possible, or lose the least amount of money possible. Participants are instructed to select
one card at a time from any deck, using a mouse to click on their card of choice. Each
time the participants select a card, the computer will inform them that they have won or
lost a certain sum of money. Participants are able to switch from one deck to another at
any point in the task. The computer ends the task automatically when participants have completed 100 selection trials. The dependent measure used in this task was the proportion of selections from the advantageous decks as a function of training trials (computed by dividing selection trials into quintiles and examining change in performance across time).

Although experimental in nature, this neuropsychological measure has been used in multiple studies with neurological and psychiatric populations in which it has demonstrated strong construct validity (e.g., Bechara, 2003; Bechara et al., 1994; Bechara et al., 2000; Busemeyer & Stout, 2002). Results of studies using the gambling task (in both its original and computerized forms) have shown that patients with frontal lobe dysfunction perform significantly worse on the task than normal controls or neurological patients without frontal lobe dysfunction. Specifically, findings generally indicate that patients with orbitofrontal cortex damage persist in selecting from the disadvantageous decks, which provide high immediate reward but long-term negative consequences. Bechara and colleagues interpret this preference for immediate gain as an insensitivity to future consequences (Bechara et al., 2000). Other patient populations, such as those with drug abuse problems, behavior disorders, and antisocial personality disorder, have demonstrated similar performance deficits on the gambling task (Bartzokis et al., 2000; Bechara, 2003; Ernst et al., 2003; Mezas, Finn, & Steinmetz, 2000). For these patient populations, orbitofrontal cortex abnormalities have been observed, further implicating the role of the prefrontal cortex in decision-making behavior.
Table 1

*Sequence of Tasks in the Laboratory Session*

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-10</td>
<td>Written Informed Consent and Laboratory Questionnaire</td>
</tr>
<tr>
<td>7</td>
<td>Word Memory Test</td>
</tr>
<tr>
<td>7</td>
<td>Matrix Reasoning Test^a</td>
</tr>
<tr>
<td>3</td>
<td>Digit Symbol Coding^b</td>
</tr>
<tr>
<td>3</td>
<td>Stroop Color and Word Test</td>
</tr>
<tr>
<td>3</td>
<td>Trail-making Test, Parts A &amp; B</td>
</tr>
<tr>
<td>5</td>
<td>Spatial Span^c</td>
</tr>
<tr>
<td>5</td>
<td>Word Memory Test (30’ recall)</td>
</tr>
<tr>
<td>14</td>
<td>Continuous Performance Test</td>
</tr>
<tr>
<td>7</td>
<td>Rey Auditory Verbal Learning Test</td>
</tr>
<tr>
<td>7</td>
<td>Arithmetic^b</td>
</tr>
<tr>
<td>5</td>
<td>Letter-Number Sequencing^b</td>
</tr>
<tr>
<td>4</td>
<td>Controlled Oral Word Association</td>
</tr>
<tr>
<td>10</td>
<td>Stop-Signal Task</td>
</tr>
<tr>
<td>3</td>
<td>Rey Auditory Verbal Learning Test (30’ recall)</td>
</tr>
<tr>
<td>10</td>
<td>Iowa Gambling Task</td>
</tr>
<tr>
<td>3</td>
<td>Debriefing</td>
</tr>
</tbody>
</table>

^a Subtest from Wechsler Abbreviated Scale of Intelligence (WASI). ^b Subtest from Wechsler Adult Intelligence Scale-III (WAIS-III). ^c Subtest from Wechsler Memory Scale-III (WMS-III).
Table 2

Demographic and Descriptive Data by Group – Study 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADHD Diagnosis (n=114)</th>
<th>ADHD Symptom (n=265)</th>
<th>Controls (n=1272)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>47.4%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>47.5%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>70.4%</td>
</tr>
<tr>
<td>Male</td>
<td>52.6%</td>
<td>52.5%</td>
<td>29.6%</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African-American</td>
<td>&lt; 1%</td>
<td>3.4%</td>
<td>5.3%</td>
</tr>
<tr>
<td>Asian</td>
<td>&lt; 1%</td>
<td>1.1%</td>
<td>1%</td>
</tr>
<tr>
<td>Caucasian</td>
<td>93%</td>
<td>90.0%</td>
<td>90.5%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>2.6%</td>
<td>2.7%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Native American/Alaskan Native</td>
<td>0%</td>
<td>1.1%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Other</td>
<td>2.6%</td>
<td>&lt;1%</td>
<td>1.3%</td>
</tr>
<tr>
<td>College GPA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above 3.0</td>
<td>47.8%</td>
<td>39.7%</td>
<td>54.7%</td>
</tr>
<tr>
<td>2.51-3.0</td>
<td>31.2%</td>
<td>40.1%</td>
<td>32.8%</td>
</tr>
<tr>
<td>Less than 2.5</td>
<td>21%&lt;sup&gt;b&lt;/sup&gt;</td>
<td>20.2%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.5%</td>
</tr>
<tr>
<td>History of psychological disorder (% endorsing)</td>
<td>36.8%&lt;sup&gt;a,b,c&lt;/sup&gt;</td>
<td>15.8%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.0%</td>
</tr>
<tr>
<td>Current treatment for psychological disorder (% endorsing)</td>
<td>17.5%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.9%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.1%</td>
</tr>
<tr>
<td>% scoring above BDI-II cutoff of 19</td>
<td>20.5%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.7%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.3%</td>
</tr>
<tr>
<td>% scoring above WURS cutoff of 46</td>
<td>33.3%&lt;sup&gt;a,b,c&lt;/sup&gt;</td>
<td>16.5%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.0%</td>
</tr>
</tbody>
</table>
Table 2 (Continued)  

<table>
<thead>
<tr>
<th></th>
<th>M (SD)</th>
<th>M (SD)</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=113)</td>
<td>(n=265)</td>
<td>(n=1271)</td>
</tr>
<tr>
<td>Age</td>
<td>19.08 (1.01)</td>
<td>19.19 (1.07)</td>
<td>19.02 (1.15)</td>
</tr>
<tr>
<td></td>
<td>(n=112)</td>
<td>(n=259)</td>
<td>(n=1263)</td>
</tr>
<tr>
<td>BDI-II</td>
<td>11.75(^a) (8.91)</td>
<td>13.03(^a) (8.59)</td>
<td>7.11 (6.28)</td>
</tr>
<tr>
<td></td>
<td>(n=94)</td>
<td>(n=197)</td>
<td>(n=966)</td>
</tr>
<tr>
<td>AUDIT score</td>
<td>11.50(^a) (6.00)</td>
<td>11.76(^a) (6.54)</td>
<td>8.75 (5.64)</td>
</tr>
<tr>
<td></td>
<td>(n=108)</td>
<td>(n=230)</td>
<td>(n=1143)</td>
</tr>
<tr>
<td>WURS score</td>
<td>36.44(^{a,c}) (18.41)</td>
<td>28.92(^a) (16.80)</td>
<td>13.79 (11.82)</td>
</tr>
</tbody>
</table>

*Note.* BDI-II = Beck Depression Inventory-II; AUDIT = Alcohol Use Disorder Identification Test; WURS = Wender Utah Rating Scale.

\(^a\)For pairwise comparison vs. Controls, \(p \leq .001\)

\(^b\)For pairwise comparison vs. Controls, \(p \leq .05\)

\(^c\)For pairwise comparison vs. ADHD-SX, \(p \leq .001\)
### Table 3

**CAARS-S:L Scores by Group – Study 1**

<table>
<thead>
<tr>
<th>CAARS-S:L T scores</th>
<th>ADHD Diagnosis (n=112)</th>
<th>ADHD Symptom (n=265)</th>
<th>Controls (n=1245)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inattention/Memory</td>
<td>54.78&lt;sup&gt;a&lt;/sup&gt; (11.88)</td>
<td>61.80&lt;sup&gt;a,b&lt;/sup&gt; (9.02)</td>
<td>45.53 (7.26)</td>
</tr>
<tr>
<td>Scale B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyperactivity/Restlessness</td>
<td>53.58&lt;sup&gt;a&lt;/sup&gt; (9.64)</td>
<td>57.24&lt;sup&gt;a,c&lt;/sup&gt; (9.16)</td>
<td>45.86 (7.23)</td>
</tr>
<tr>
<td>Scale C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impulsivity/Emotional Lability</td>
<td>50.35&lt;sup&gt;a&lt;/sup&gt; (11.53)</td>
<td>54.20&lt;sup&gt;a,c&lt;/sup&gt; (9.53)</td>
<td>43.38 (7.36)</td>
</tr>
<tr>
<td>Scale D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problems with Self-Concept</td>
<td>50.24&lt;sup&gt;a&lt;/sup&gt; (10.28)</td>
<td>53.84&lt;sup&gt;a,c&lt;/sup&gt; (10.08)</td>
<td>44.36 (8.26)</td>
</tr>
<tr>
<td>Scale E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSM-IV Inattentive Symptoms</td>
<td>64.16&lt;sup&gt;a&lt;/sup&gt; (14.14)</td>
<td>72.34&lt;sup&gt;a,b&lt;/sup&gt; (9.29)</td>
<td>48.02 (7.74)</td>
</tr>
<tr>
<td>Scale F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSM-IV Hyperactive/Impulsive Symptoms</td>
<td>54.63&lt;sup&gt;a&lt;/sup&gt; (12.73)</td>
<td>60.69&lt;sup&gt;a,b&lt;/sup&gt; (11.37)</td>
<td>44.00 (7.66)</td>
</tr>
<tr>
<td>Scale G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADHD Symptoms Total</td>
<td>61.31&lt;sup&gt;a&lt;/sup&gt; (14.02)</td>
<td>70.15&lt;sup&gt;a,b&lt;/sup&gt; (8.96)</td>
<td>45.91 (7.92)</td>
</tr>
<tr>
<td>Scale H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADHD Index</td>
<td>53.62&lt;sup&gt;a&lt;/sup&gt; (10.89)</td>
<td>59.09&lt;sup&gt;a,b&lt;/sup&gt; (7.92)</td>
<td>43.94 (7.11)</td>
</tr>
</tbody>
</table>

*Note. CAARS-S:L = Conners’ Adult ADHD Rating Scale – Self-Report: Long Version
<sup>a</sup>For pairwise comparison vs. Controls, p < .001
<sup>b</sup>For pairwise comparison vs. ADHD-DX, p < .001
<sup>c</sup>For pairwise comparison vs. ADHD-DX, p < .01*
Table 4

Demographic and Descriptive Data by Group – Study 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADHD-DX (n=28)</th>
<th>ADHD-SX (n=28)</th>
<th>Controls (n=31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>35.7%</td>
<td>53.6%</td>
<td>38.7%</td>
</tr>
<tr>
<td>Male</td>
<td>64.3%</td>
<td>46.4%</td>
<td>61.3%</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African-American</td>
<td>0%</td>
<td>0%</td>
<td>6.5%</td>
</tr>
<tr>
<td>Asian</td>
<td>0%</td>
<td>3.6%</td>
<td>0%</td>
</tr>
<tr>
<td>Caucasian</td>
<td>96.4%</td>
<td>96.4%</td>
<td>83.8%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>0%</td>
<td>0%</td>
<td>6.5%</td>
</tr>
<tr>
<td>Other</td>
<td>3.6%</td>
<td>0%</td>
<td>3.2%</td>
</tr>
<tr>
<td>College GPA</td>
<td>(n=27)</td>
<td>(n=28)</td>
<td>(n=27)</td>
</tr>
<tr>
<td>Above 3.0</td>
<td>48.1%</td>
<td>53.6%</td>
<td>74.1%</td>
</tr>
<tr>
<td>2.51-3.0</td>
<td>37%</td>
<td>35.7%</td>
<td>22.2%</td>
</tr>
<tr>
<td>Less than 2.5</td>
<td>14.9%</td>
<td>10.7%</td>
<td>3.7%</td>
</tr>
<tr>
<td>Handedness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>92.9%</td>
<td>100%</td>
<td>87.1%</td>
</tr>
<tr>
<td>Left</td>
<td>7.1%</td>
<td>0%</td>
<td>12.9%</td>
</tr>
<tr>
<td>Current psychological disorder (% endorsing)</td>
<td>17.9%</td>
<td>3.6%</td>
<td>6.5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>M (SD)</th>
<th>M (SD)</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>19.21 (.77)</td>
<td>19.25 (1.38)</td>
<td>19.16 (1.10)</td>
</tr>
<tr>
<td>BDI-II on day of testing</td>
<td>8.89 (6.98)</td>
<td>7.93 (6.51)</td>
<td>5.30 (5.04)</td>
</tr>
<tr>
<td>AUDIT score</td>
<td>12.56 (6.24)a</td>
<td>10.41 (6.07)</td>
<td>7.71 (5.35)</td>
</tr>
<tr>
<td>WURS score</td>
<td>38.61bc (15.94)</td>
<td>24.11a (12.13)</td>
<td>14.29 (9.21)</td>
</tr>
<tr>
<td>Matrix Reasoning T score</td>
<td>54.50 (5.04)</td>
<td>53.64 (5.31)</td>
<td>55.06 (5.57)</td>
</tr>
</tbody>
</table>
Table 3 (Continue)

*Note.* ADHD-DX = ADHD Diagnosis Group; ADHD-SX = ADHD Symptom Group; BDI-II = Beck Depression Inventory-II; AUDIT = Alcohol Use Disorder Identification Test; WURS = Wender Utah Rating Scale.

*For pairwise comparison vs. Controls, p ≤ .01
*For pairwise comparison vs. Controls, p ≤ .001
*For pairwise comparison vs. ADHD-SX, p ≤ .001
Table 5

**CAARS-S:L Scores by Group – Study 2**

<table>
<thead>
<tr>
<th>CAARS Self-Report T scores</th>
<th>ADHD-DX (n=28)</th>
<th>ADHD-SX (n=28)</th>
<th>Controls (n=31)</th>
<th>Omnibus F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale A Inattention/Memory</td>
<td>61.79&lt;sup&gt;a&lt;/sup&gt;</td>
<td>59.93&lt;sup&gt;a&lt;/sup&gt;</td>
<td>41.35</td>
<td>59.87</td>
<td>.000</td>
</tr>
<tr>
<td>(9.16)</td>
<td>(8.85)</td>
<td>(5.71)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale B Hyperactivity/Restlessness</td>
<td>55.82&lt;sup&gt;a&lt;/sup&gt;</td>
<td>58.96&lt;sup&gt;a&lt;/sup&gt;</td>
<td>41.87</td>
<td>34.25</td>
<td>.000</td>
</tr>
<tr>
<td>(9.48)</td>
<td>(9.69)</td>
<td>(6.05)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale C Impulsivity/Emotional Lability</td>
<td>52.32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>53.75&lt;sup&gt;a&lt;/sup&gt;</td>
<td>42.13</td>
<td>14.19</td>
<td>.000</td>
</tr>
<tr>
<td>(10.76)</td>
<td>(9.92)</td>
<td>(6.65)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale D Problems with Self-Concept</td>
<td>52.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>51.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>41.35</td>
<td>15.90</td>
<td>.000</td>
</tr>
<tr>
<td>(7.42)</td>
<td>(10.91)</td>
<td>(5.78)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale E Inattentive Symptoms</td>
<td>74.21&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>67.71&lt;sup&gt;a&lt;/sup&gt;</td>
<td>44.26</td>
<td>110.07</td>
<td>.000</td>
</tr>
<tr>
<td>(9.40)</td>
<td>(9.58)</td>
<td>(5.13)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale F Hyperactive/Impulsive Symptoms</td>
<td>60.75&lt;sup&gt;a&lt;/sup&gt;</td>
<td>62.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>43.48</td>
<td>31.96</td>
<td>.000</td>
</tr>
<tr>
<td>(13.44)</td>
<td>(9.20)</td>
<td>(6.86)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale G ADHD Symptoms Total</td>
<td>70.93&lt;sup&gt;a&lt;/sup&gt;</td>
<td>68.14&lt;sup&gt;a&lt;/sup&gt;</td>
<td>43.42</td>
<td>103.35</td>
<td>.000</td>
</tr>
<tr>
<td>(10.95)</td>
<td>(6.72)</td>
<td>(6.10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale H ADHD Index</td>
<td>56.86&lt;sup&gt;a&lt;/sup&gt;</td>
<td>57.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40.97</td>
<td>48.27</td>
<td>.000</td>
</tr>
<tr>
<td>(8.24)</td>
<td>(7.95)</td>
<td>(5.92)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. CAARS-S:L = Conners’ Adult ADHD Rating Scale – Self-Report: Long Version; ADHD-DX = ADHD Diagnosis Group; ADHD-SX = ADHD Symptom Group*

<sup>a</sup>For pairwise comparison vs. Controls, *p* ≤ .001

<sup>b</sup>For pairwise comparison vs. ADHD-SX, *p* ≤ .01
Table 6

*CAARS-O:SV Scores by Group – Study 2*

<table>
<thead>
<tr>
<th>CAARS – Observer T scores</th>
<th>ADHD-DX (n=23)</th>
<th>ADHD-SX (n=28)</th>
<th>Controls (n=31)</th>
<th>Omnibus</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale A</td>
<td>67.78&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>45.39</td>
<td>42.61</td>
<td>121.79</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Inattentive Symptoms</td>
<td>(7.58)</td>
<td>(5.58)</td>
<td>(5.58)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale B</td>
<td>55.04&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>42.61</td>
<td>40.03</td>
<td>25.67</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Hyperactive/Impulsive</td>
<td>(12.51)</td>
<td>(5.86)</td>
<td>(4.56)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symptoms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale C</td>
<td>63.26&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>43.61</td>
<td>40.55</td>
<td>92.11</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>ADHD Symptom Total</td>
<td>(7.79)</td>
<td>(6.18)</td>
<td>(5.48)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale D</td>
<td>61.00&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>42.46</td>
<td>38.87</td>
<td>87.05</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>ADHD Index</td>
<td>(7.53)</td>
<td>(6.42)</td>
<td>(5.35)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* CAARS-O:SV = Conners’ Adult ADHD Rating Scale – Observer: Screening Version; ADHD-DX = ADHD Diagnosis Group; ADHD-SX = ADHD Symptom Group

<sup>a</sup>For pairwise comparison vs. Controls, *p* ≤ .001

<sup>b</sup>For pairwise comparison vs. ADHD-SX, *p* ≤ .001
Table 7

**Neuropsychological Test Scores by Group**

<table>
<thead>
<tr>
<th>Neuropsychological Domain</th>
<th>ADHD-DX M (SD)</th>
<th>ADHD-SX M (SD)</th>
<th>Controls M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attention</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPT omission errors</td>
<td>(n=25)</td>
<td>(n=27)</td>
<td>(n=30)</td>
</tr>
<tr>
<td>ADHD-DX</td>
<td>3.88 (3.19)</td>
<td>4.14 (3.16)</td>
<td>4.10 (3.60)</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPT hit reaction time SE</td>
<td>(n=27)</td>
<td>(n=29)</td>
<td>(n=30)</td>
</tr>
<tr>
<td>ADHD-DX</td>
<td>6.38 (2.13)</td>
<td>5.84 (2.56)</td>
<td>5.08 (2.06)</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPT d prime</td>
<td>(n=28)</td>
<td>(n=31)</td>
<td>(n=33)</td>
</tr>
<tr>
<td>ADHD-DX</td>
<td>2.70 (0.98)</td>
<td>2.67 (0.87)</td>
<td>2.75 (0.69)</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Response Inhibition</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPT commission errors</td>
<td>(n=26)</td>
<td>(n=28)</td>
<td>(n=30)</td>
</tr>
<tr>
<td>ADHD-DX</td>
<td>13.96 (7.40)</td>
<td>13.34 (6.38)</td>
<td>12.33 (5.28)</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stop Signal Reaction Time</td>
<td>(n=27)</td>
<td>(n=29)</td>
<td>(n=31)</td>
</tr>
<tr>
<td>ADHD-DX</td>
<td>291.40 (67.25)</td>
<td>290.16 (62.53)</td>
<td>277.94 (74.64)</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Working Memory</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arithmetic scaled score</td>
<td>(n=28)</td>
<td>(n=30)</td>
<td>(n=33)</td>
</tr>
<tr>
<td>ADHD-DX</td>
<td>11.36 (2.91)</td>
<td>11.11 (2.32)</td>
<td>11.65 (2.61)</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LNS scaled score</td>
<td>(n=29)</td>
<td>(n=31)</td>
<td>(n=33)</td>
</tr>
<tr>
<td>ADHD-DX</td>
<td>10.89 (2.41)</td>
<td>10.50 (1.91)</td>
<td>11.29 (2.25)</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial Span scaled score</td>
<td>(n=30)</td>
<td>(n=32)</td>
<td>(n=34)</td>
</tr>
<tr>
<td>ADHD-DX</td>
<td>11.29 (2.16)</td>
<td>11.57 (2.78)</td>
<td>10.87 (2.51)</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Verbal Learning &amp; Memory</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVLT trials 1-5</td>
<td>(n=29)</td>
<td>(n=31)</td>
<td>(n=33)</td>
</tr>
<tr>
<td>ADHD-DX</td>
<td>51.32 (8.90)</td>
<td>52.82 (5.88)</td>
<td>53.97 (6.71)</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVLT immediate recall</td>
<td>(n=30)</td>
<td>(n=32)</td>
<td>(n=34)</td>
</tr>
<tr>
<td>ADHD-DX</td>
<td>11.29 (2.69)</td>
<td>11.00 (1.98)</td>
<td>11.90 (2.29)</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVLT delayed free recall</td>
<td>(n=31)</td>
<td>(n=33)</td>
<td>(n=35)</td>
</tr>
<tr>
<td>ADHD-DX</td>
<td>10.36 (2.82)</td>
<td>10.11 (2.42)</td>
<td>11.03 (2.88)</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVLT delayed recognition</td>
<td>(n=32)</td>
<td>(n=34)</td>
<td>(n=36)</td>
</tr>
<tr>
<td>ADHD-DX</td>
<td>13.89 (1.23)</td>
<td>14.07 (1.09)</td>
<td>14.03 (1.43)</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Processing Speed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit Symbol scaled score</td>
<td>(n=31)</td>
<td>(n=33)</td>
<td>(n=35)</td>
</tr>
<tr>
<td>ADHD-DX</td>
<td>9.43 c,d (2.64)</td>
<td>10.82 (2.17)</td>
<td>11.26 (2.10)</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 7 (Continue)

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SCWT word T score</td>
<td>42.64c,e (7.22)</td>
<td>50.32 (6.67)</td>
<td>48.00 (7.88)</td>
</tr>
<tr>
<td>SCWT color T score</td>
<td>44.64f,g (8.52)</td>
<td>51.71 (7.92)</td>
<td>53.29 (7.44)</td>
</tr>
<tr>
<td>TMT-A time in seconds</td>
<td>24.64c,g (6.71)</td>
<td>20.62 (5.33)</td>
<td>20.22 (4.93)</td>
</tr>
<tr>
<td><strong>Executive Functioning</strong></td>
<td>(n=28)</td>
<td>(n=28)</td>
<td>(n=31)</td>
</tr>
<tr>
<td>TMT-B time in seconds</td>
<td>54.01 (16.27)</td>
<td>48.46 (15.06)</td>
<td>44.88 (15.65)</td>
</tr>
<tr>
<td>SCWT color/word T score</td>
<td>49.50f,d (10.22)</td>
<td>56.79 (11.15)</td>
<td>59.68 (10.16)</td>
</tr>
<tr>
<td>COWA total # of words</td>
<td>41.14 (10.92)</td>
<td>38.18 (7.96)</td>
<td>43.39 (9.88)</td>
</tr>
</tbody>
</table>

*Note.* ADHD-DX = ADHD Diagnosis Group; ADHD-SX = ADHD Symptom Group; CPT = Continuous Performance Test; SE = standard error; LNS = Letter-Number Sequencing; AVLT = Auditory Verbal Learning Test; WAIS-III = Wechsler Intelligence Scale, Third Edition; SCWT = Stroop Color and Word Test; TMT-A = Trail-making Test, Part A; TMT-B = Trail-making Test, Part B; COWA = Controlled Oral Word Association

aRaw scores reported
bTotal number of words reported
cFor pairwise comparison vs. Controls, *p* ≤ .01 (1-tailed)
dFor pairwise comparison vs. ADHD-SX, *p* ≤ .05 (1-tailed)
eFor pairwise comparison vs. ADHD-SX, *p* ≤ .001 (1-tailed)
fFor pairwise comparison vs. Controls, *p* ≤ .001 (1-tailed)
gFor pairwise comparison vs. ADHD-SX, *p* ≤ .01 (1-tailed)
Table 8

*Performance on Iowa Gambling Task*

<table>
<thead>
<tr>
<th>IGT Quintile Scores</th>
<th>ADHD-DX (n=28)</th>
<th>ADHD-SX (n=28)</th>
<th>Controls (n=31)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
</tr>
<tr>
<td>IGT Quintile 1</td>
<td>-5.21 (8.01)</td>
<td>-4.36 (9.52)</td>
<td>-3.55 (6.90)</td>
</tr>
<tr>
<td>IGT Quintile 2</td>
<td>2.14 (9.12)</td>
<td>4.00 (8.68)</td>
<td>1.94 (7.62)</td>
</tr>
<tr>
<td>IGT Quintile 3</td>
<td>5.71 (8.77)</td>
<td>4.79 (7.43)</td>
<td>4.45 (7.08)</td>
</tr>
<tr>
<td>IGT Quintile 4</td>
<td>3.93 (9.42)</td>
<td>6.21 (9.76)</td>
<td>7.35 (7.87)</td>
</tr>
<tr>
<td>IGT Quintile 5</td>
<td>10.21 (10.38)</td>
<td>3.00&lt;sup&gt;a,b&lt;/sup&gt; (11.40)</td>
<td>9.68 (8.08)</td>
</tr>
</tbody>
</table>

*Note.* ADHD-DX = ADHD Diagnosis Group; ADHD-SX = ADHD Symptom Group; IGT = Iowa Gambling Task

<sup>a</sup>For pairwise comparison vs. ADHD-DX, *p* < .01

<sup>b</sup>For pairwise comparison vs. Controls, *p* < .01
Table 9  

*Clinical Significance: Percentage above Clinical Cutoff*

<table>
<thead>
<tr>
<th>Measures</th>
<th>ADHD-DX (n=28)</th>
<th>ADHD-SX (n=28)</th>
<th>Controls (n=31)</th>
<th>$\chi^2$ (2, N=87)</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit Symbol</td>
<td>21.4%</td>
<td>7.1%</td>
<td>3.2%</td>
<td>5.71</td>
<td>.06</td>
</tr>
<tr>
<td>SCWT – Word</td>
<td>14.3%</td>
<td>0%</td>
<td>6.5%</td>
<td>4.47</td>
<td>.11</td>
</tr>
<tr>
<td>SCWT – Color</td>
<td>14.3%</td>
<td>0%</td>
<td>0%</td>
<td>8.84</td>
<td>.01</td>
</tr>
<tr>
<td>TMT-A</td>
<td>17.9%</td>
<td>3.6%</td>
<td>0%</td>
<td>8.02</td>
<td>.02</td>
</tr>
<tr>
<td>SCWT – Color/Word</td>
<td>3.6%</td>
<td>3.6%</td>
<td>0%</td>
<td>1.13</td>
<td>.57</td>
</tr>
</tbody>
</table>

*Note.* ADHD-DX = ADHD Diagnosis Group; ADHD-SX = ADHD Symptom Group; SCWT = Stroop Color and Word Test; TMT-A = Trail-making Test, Part A
Table 10

Clinical Significance: Impairment Index

<table>
<thead>
<tr>
<th>Number of Impaired Measures</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADHD-DX</td>
<td>17</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>ADHD-SX</td>
<td>24</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Controls</td>
<td>28</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note. ADHD-DX = ADHD Diagnosis Group; ADHD-SX = ADHD Symptom Group