Lecture Note-taking in Postsecondary Students

with Self-Reported Attention-Deficit/Hyperactivity Disorder

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ABSTRACT

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Taking and reviewing lecture notes is a prevalent activity that is related to higher test performance in higher education. Yet few studies have focused on the underlying cognitive variables related to lecture note-taking. The current study is an extension of previous studies on lecture note-taking (Peverly & Garner, 2010; Peverly et al., 2007; Peverly et al., 2010) to a disability population, specifically students reporting clinically significant symptoms of ADHD. The primary purpose of this dissertation was to determine if disability differences in lecture note-taking exist, and if they do, to examine the cognitive variables that might explain them.

Participants included 22 postsecondary students with self-reported ADHD and 50 postsecondary students who served as controls. Students took notes on a videotaped lecture, reviewed their notes, and took a written recall test. The independent variables included disability status (i.e., self-reported ADHD and non-ADHD), attention, transcription fluency, verbal working memory, and listening comprehension. The dependent variables were quality of notes and essay performance. All measures were group administered.

Results revealed that attention and listening comprehension were the only predictors of quality of notes, and disability status, quality of notes, and listening comprehension all predicted essay performance. Students with self-reported ADHD obtained lower scores on a written recall test and a measure of transcription fluency compared to non-ADHD peers, but did not differ in terms of quality of notes, attention, verbal working memory, or listening comprehension. There

were also differences between males and females in terms of notes' quality and essay performance. Future research should examine the present findings in postsecondary students with confirmed ADHD to test for possible differences in outcomes due to confirmed versus self-reported diagnoses.

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Chapter I

Introduction

The number of students with disabilities in postsecondary education has been steadily increasing over the years. According to one report by the National Council on Disability (2003), the percentage of college freshmen with a disability has more than tripled over the last 20 years (3% in 1978 to over 9% in 1998). Despite a definite increase in enrollment, estimates of the current number of individuals with disabilities in postsecondary settings vary. One survey reported about 6% of first-time, full-time freshmen attending four-year institutions in 2000 self-reported a disability (Henderson, 2001). Another report estimated students with disabilities represent nearly 10% of all college students (National Council on Disability, 2003). The most recent profile of undergraduates in U.S. postsecondary institutions included information collected from a sample of approximately 80,000 undergraduates, representing students in public and private two-year and four-year institutions and community colleges, with 11.3% reporting some type of disability (Horn & Nevill, 2006). The variability in prevalence estimates is likely due to differences in measurement of disability type, accuracy of diagnosis, level of postsecondary education, and compositions of sample populations. There are currently no epidemiological studies documenting students with disabilities in graduate schools; however, the number of students with disabilities going on to some form of graduate school is likely to be lower than the number of students with disabilities in college settings. The increase in enrollment of students with disabilities in higher education is undeniable and worthy of scholarly attention.

Types of disabilities self-reported by individuals enrolled in postsecondary institutions range from hearing, speech, orthopedic, health-related, partially sighted or blind, to other conditions including "hidden disabilities" (Wolf, 2001). These "hidden disabilities" constitute the greatest increase in enrollment in higher education, and include attention disorders (Wolf, 2001). Attention-Deficit/Hyperactivity Disorder (ADHD), one such attention disorder and the focus of this dissertation, is characterized by persistent patterns of inattention, hyperactivity, or impulsivity, which interfere with an individual's academic, occupational, and/or social functioning (American Psychiatric Association, 2000, p. 85). Research suggests that adults with ADHD demonstrate signs of inattention, verbal impulsivity, and an internal form of hyperactivity (Barkley, 2006). Along with the primary symptoms of inattention, impulsivity, and hyperactivity, many associated impairments in the areas of academic, emotional, and social functioning have been identified in individuals with ADHD.

Enrollment of individuals with an ADHD diagnosis is on the rise at postsecondary institutions. In fact, many individuals first receive the diagnosis only after entering college. A report by the National Council on Disability (2003) stated, "When declaring a primary disability, 44% of the participants with an attention deficit disorder were first identified at the postsecondary level." Estimates from epidemiological studies in postsecondary settings have found that 2% to 11% of students reported clinically significant levels of ADHD symptoms (DuPaul et al., 2001; Heiligenstein, Conyers, Berns, & Smith, 1998; Horn & Nevill, 2006; McKee, 2008; Norvilitis, Ingersoll, Zhang, & Jia, 2008; Pope et al., 2007; Weyandt, Linterman, & Rice, 1995).

While it is apparent from the epidemiological research that students presenting with ADHD symptoms are pursuing higher education, substantial gaps remain between these individuals and their peers in terms of educational achievement, despite strong gains in enrollment (Blackorby & Wagner, 1996; Tincani, 2004). Research indicates that postsecondary students with significant ADHD symptoms generally obtain lower GPAs, receive more special education services, are more likely to be on academic probation, and are less likely to graduate with a degree when compared to students without ADHD symptoms (Barkley, 2006; Barkley, Murphy, & Fischer, 2008; DuPaul, Weyandt, O'Dell, & Varejao, 2009; Heiligenstein, Guenther, Levy, Savino, & Fulwiler, 1999; Kaminski, Turnock, Rosen, & Laster, 2006; Lewandowski, Lovett, Codding, & Gordon, 2008; Murphy, Barkley, & Bush, 2002; Norwalk, Norvilitis, & MacLean, 2008; Weyandt & DuPaul, 2006; Wolf, 2001). Specific factors that may contribute to academic failure in postsecondary students with ADHD symptoms include: impaired organizational and planning abilities, deficits in working memory, poor study skills and time management techniques, difficulty with goal-setting, inadequate academic coping strategies, and/or difficulties with behavioral and emotional self-regulation.

The reduction or elimination of support services during the transition from secondary education to higher education (National Council on Disability, 2003) or fewer individualized services in the absence of a mandated process for identifying and serving students with disabilities in many postsecondary institutions (Tincani, 2004) may explain some of the discrepancies in achievement between postsecondary students with and without ADHD. Yet approximately 25% of students receiving disability support services are comprised of students receiving accommodations for ADHD (Wolf, 2001); therefore, it is more likely that students with ADHD are not receiving appropriate or effective services. Disability services vary across universities but may include academic accommodations, such as, extra time, note-taking services (e.g., designated note-takers, copies of lecture notes, recording lectures), and remedial coursework. While these accommodations are widely employed, there is little empirically validated research demonstrating the effectiveness of these accommodations in populations of postsecondary students with ADHD (Barkley, 2006; Stodden & Dowrick, 1999; Weyandt & DuPaul, 2006). Furthermore, accommodations only provide external aids for students with disabilities, not adequately substituting for the benefits inherent in actively participating in course activities, such as lecture note-taking (Suritsky & Hughes, 1991). Isolating the determinants that contribute to lower academic performance in students with ADHD symptoms when compared to students without ADHD is essential to developing targeted remediation programs and providing effective accommodations. Yet few researchers have focused on the specific factors that contribute to the academic success of students with ADHD in higher education.

Research suggests that low academic achievement among postsecondary students is partly due to inadequate study skills (Allsopp, Minskoff, & Bolt, 2005; Crede & Kuncel, 2006; Kaminski et al., 2006; Norwalk et al., 2008; Reaser, Prevatt, Petscher, & Proctor, 2007). The preferred and most prevalent method of studying in higher education is taking and reviewing lecture notes (Armbruster, 2009). Lecturing is the dominant form of instruction beyond elementary school, and postsecondary students typically spend 80% of class time listening to lectures (Armbruster, 2009; Titsworth & Kiewra, 2004). Research has shown that recording and reviewing notes from lectures is related to higher test performance than not taking and reviewing notes (Baker & Lombardi, 1985; Barnett, Di Vesta, & Rogozinski, 1981; Fischer & Harris, 1973; Kiewra & Benton, 1988; Kiewra et al., 1991; Norton & Hartley, 1986; Nye, Crooks, Powley & Tripp, 1984; Peverly, Brobst, Graham, & Shaw, 2003; Peverly et al., 2007; Titsworth & Kiewra, 2004; Williams & Eggert, 2002b).

While research has begun to emerge on study skills and academic achievement, limited research has focused on the cognitive variables that underlie lecture note-taking. Lecture note-taking is a highly demanding cognitive skill. Specifically, students must hold lecture information in verbal working memory, select important information from memory, quickly transcribe the most salient information from memory, and still pay attention to the lecture (Peverly et al., 2007). Breakdowns in this process could occur at any level. Postsecondary students with ADHD may find lecture note-taking too cognitively demanding because of the huge burden on attention, verbal working memory (the mental ability to temporarily store and manipulate information), transcription fluency (handwriting speed), and/or listening comprehension ability.

Deficits in attention are inherent in ADHD, even though the specific dimension(s) of attention affected may vary. Additionally, research suggests secondary deficits in working memory are implicated in ADHD (Barkley, 1997, 2006; Gallagher & Blader, 2001; Hervey, Epstein, & Curry, 2004; Marchetta, Hurks, Krabbendam, & Jolles, 2008; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; McInnes, Humphries, Hogg-Johnson, & Tannock, 2003; Quinlan & Brown, 2003). According to one model, attention may affect working memory through proactive interference, allowing less information to be encoded (Engle, 2002).

Aside from attention and working memory, handwriting speed is also implicated in lecture note-taking. Transcription fluency, the number of letters an individual can write in a minute, has been shown to significantly predict quality of notes (Peverly & Garner, 2010; Peverly et al., 2007; Peverly & Sumowski, in press; Peverly et al., 2010). While there is no information on transcription fluency within an ADHD postsecondary population, research has shown deficits in motor output and overall writing quality in individuals with ADHD (Barkley, 2006; Gregg, Coleman, Stennett, & Davis, 2002; Wolf, 2001).

Finally, many researchers believe students must first comprehend the lecture before they can write down any notes (Piolat, Olive, & Kellogg, 2005). This implies that the process of taking notes from lectures cannot simply be equated to copying down what is heard, but entails some form of comprehension and paraphrasing first. Some evidence suggests that children and adolescents with ADHD present with weaknesses in reading and listening comprehension despite average decoding and word identification abilities (Aaron, Joshi, Palmer, Smith, & Kirby, 2002; Brock & Knapp, 1996; Ghelani, Sidhu, Jain, & Tannock, 2004; Javorsky, 1996; McInnes et al., 2003). However, listening comprehension has not been examined in postsecondary students with ADHD.

As a result of impairments in underlying cognitive variables, poor lecture note-taking skills are likely to negatively affect the test performance of postsecondary students with ADHD, thereby lowering their overall academic achievement. However, limited research has focused on individual differences in lecture note-taking, especially among students with disabilities. A review of two studies by Hughes and Suritsky (1993) found that college students with learning disabilities had significant problems with lecture note-taking compared to nondisabled college students, with nondisabled college students recording 60% to 70% more lecture information. Although a few researchers have looked at study skills in college students with ADHD (Allsopp et al., 2005; Reaser et al., 2007) and at the efficacy of lecture note-taking instruction in adolescents with ADHD (Evans, Pelham, & Grudberg, 1994), no research is currently available on the cognitive variables underlying lecture note-taking within a postsecondary context.

Purpose and Research Questions

The current study investigated three principal questions: (1) Are there significant differences between self-reported ADHD and non-ADHD postsecondary students, specifically in terms of attention, handwriting speed, verbal working memory, listening comprehension, quality of notes, and/or essay performance? (2) What variables contribute to differences in quality of lecture notes? (3) What variables contribute to differences in essay performance?

Chapter II

Attention-Deficit/Hyperactivity Disorder (ADHD) in Postsecondary Students

The recognition of ADHD as a valid diagnosis in late adolescence and adulthood is a recent development since ADHD has traditionally been regarded as a childhood disorder. The following section reviews the scientific literature on ADHD in the adult population, with a primary focus on postsecondary students.

History

The cluster of symptoms known today as ADHD was first recognized in European children by George Still in 1902 (Barkley, 2006). Still described a new behavioral condition consisting of problems with sustained attention, the need for immediate gratification, heightened emotionality, and major deficits in moral control (Barkley). Initial descriptions of ADHD in North America came as a result of an outbreak of encephalitis, with surviving children reportedly displaying impairments in attention, regulation of activity, impulse control, and other cognitive abilities (Barkley). While early descriptions contained evidence of problems with attention and regulation of behavior, hyperactivity or excessive activity became the primary characteristic associated with ADHD. In fact, the behavioral condition first identified by Still was often referred to as hyperkinetic impulse disorder or hyperactivity syndrome (Barkley).

Official classification of the condition known today as ADHD was introduced in the second edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*) and underwent many transformations before its current classification in the *DSM-IV-TR*. Hyperkinetic Reaction of Childhood was the first officially recognized diagnosis, in the *DSM-II*, where it was characterized by overactivity, restlessness, distractibility, and a short attention span (Barkley, 2006). The disorder was noted to occur in young children and usually diminish by adolescence. By the 1970s, hyperactivity was no longer central to clinical presentations. The *DSM-III* reclassified the condition as Attention Deficit Disorder with or without hyperactivity, with the new emphasis on sustained attention and impulsivity (Barkley). The current triad of primary symptom clusters (i.e., inattention, impulsivity, and hyperactivity) was not described until the *DSM-III-R* revised the classification of the syndrome to Attention Deficit Hyperactivity Disorder (Barkley). Currently, the *DSM-IV-TR* defines ADHD as a two-factor model, grouping symptoms under inattention or hyperactivity/impulsivity and additionally subtypes the disorder into three groups: ADHD – Combined Type, ADHD – Predominantly Inattentive Type, and ADHD – Predominantly Hyperactive-Impulsive Type (American Psychiatric Association, 2000).

As summarized above, the early history of ADHD predominantly involved cases with children. It wasn't until the late 1960s and 1970s that the possibility of hyperactivity in adults was even considered (Barkley, 2006), and the scientific community did not seriously recognize the adult equivalent to childhood ADHD until much more recently. The validity of ADHD as a disorder in late adolescence and adulthood has been established due to a consistent pattern of research (Barkley, 2006; Barkley, Fischer, Smallish, & Fletcher, 2002; Barkley et al., 2008; Faraone, Biederman, & Mick, 2006; Faraone et al., 2000; Wolraich et al., 2005). The *DSM-IV-TR* now recognizes the disorder in adolescents and adults (American Psychiatric Association, 2000).

In summary, ADHD is now recognized as a disabling and chronic condition that impacts older adolescents and adults as well as children.

Epidemiology

Despite the establishment of ADHD as a valid disorder in late adolescence and adulthood, epidemiological research for these populations is still emerging and findings thus far have been equivocal. Research has established estimates of ADHD in 3% to 7% of school-age children (American Psychiatric Association, 2000). However, rates of ADHD in late adolescence and adulthood are much more difficult to collect due to variations in inclusion/exclusion criteria, the lack of standardized diagnostic tools for adults, differences in obtaining symptom information (e.g., self-reports, collateral reports, evaluations), and differences in longitudinal and cross-sectional research. The epidemiological research in the field is divided into controlled longitudinal studies focusing on the occurrence and persistence of hyperactive ADHD from childhood into adolescence and adulthood and cross-sectional studies of prevalence in clinic-referred adults and other subgroups, such as college students.

Prevalence estimates in the general adult population. The research with follow-up studies on the occurrence and persistence of ADHD into adulthood indicates that many individuals diagnosed as children continue to display symptoms into adulthood. However, only four controlled longitudinal studies have retained at least 50% of their original sample at follow-up, reporting that 3% to 66% of children continued to display symptoms of ADHD as adults (Barkley, 2006; Barkley et al., 2008). As stated earlier, differences in estimates are likely due to several factors, such as, variations in inclusion/exclusion criteria and self-report versus informant ratings. For example, Barkley et al. (2002) looked at differences between persistence estimates of ADHD in the presence and absence of a developmentally referenced criterion (DRC) measure. The authors established a developmentally appropriate threshold two standard deviations above the mean of the control group on a *DSM-III-R* symptom list. The development of a DRC was in response to concerns about the validity of a fixed symptom threshold across ages (Barkley et al., 2002). The authors reported persistence estimates of clinically significant ADHD symptoms between 5% (using individuals' self-reports) to 46% (using parent reports) in the absence of age-based comparisons, and between 12% (using self-reports) and 66% (using parent reports) when using a DRC. Barkley et al. concluded that the persistence of ADHD symptoms varied according to source of information (i.e., self-report versus parent report) and approach taken in determining the disorder (i.e., *DSM* or DRC).

ADHD is a developmental disorder, meaning its symptoms occur to a degree that is developmentally inappropriate. Therefore, ADHD must be diagnosed based on symptom inappropriateness compared to same-age peers. However, the *DSM* does not provide age-based comparisons for diagnostic symptom lists with adults (Barkley et al., 2002). The *DSM-IV-TR* criteria are entirely child-focused, no adults were used in the clinical field trials to establish these criteria, and the age-of-onset criterion was not based on empirical data but utilized to establish ADHD as a developmental disorder (Barkley et al., 2008; Reilley, 2005). In the UMASS study, which included 146 clinic-referred ADHD adults, 97 clinic-referred non-ADHD clinical controls, and 109 non-referred community controls, only 34% of ADHD adults had a prior history of ADHD, with males more likely to have a prior history of the disorder than females (Barkley et al., 2008).

These limitations of the *DSM* are further highlighted by a meta-analytic review by Faraone et al. (2006). They found occurrence estimates from 15% to 60% at age 25 when pooling data across follow-up studies. The authors attributed lower estimates to participants who met the stringent criteria for the *DSM-IV* and higher estimates to participants who were consistent with the criteria for *DSM-IV'*s partial remission category, and concluded that the *DSM-IV* might not be sufficiently sensitive to developmental variations in symptom expression in adults (Faraone et al., 2006). Furthermore, clinical field trials for the *DSM-IV-TR* ADHD criteria included predominantly male samples, whereas in adult populations, symptoms are just at frequent in females as males (Barkley et al., 2008; Farone et al., 2000). Finally, research has shown that cutoff scores of four versus six symptoms were best at discriminating ADHD in adults (Heiligensten et al., 1998; Ricco et al. as cited in Barkley et al., 2008). Thus, *DSM-IV-TR* criteria may not be sensitive to the manifestation of the disorder in adults, especially, postsecondary students. Despite these limitations, Barkley et al. (2008) concluded that 3.3-5.3% of adults are likely to have ADHD, not taking into account any new cases of the disorder arising from acquired injuries.

Prevalence estimates in postsecondary education. While a substantial amount of epidemiological research has looked at estimates of ADHD in follow-up studies with children and adolescents into adulthood, fewer studies have examined the prevalence of ADHD in postsecondary students. While fewer adolescents with ADHD attend postsecondary institutions, and of those that do attend, fewer complete degree programs relative to their non-ADHD peers (Barkley et al., 2008), the number of students with ADHD symptoms enrolling in postsecondary institutions has risen. Prevalence estimates within higher education have just recently started to emerge. Postsecondary students with ADHD represent a mixed cohort with some individuals diagnosed with the condition as a child, while others are first identified only after entering higher education. A report by the National Council on Disability (2003) stated, "When declaring a primary disability, 44% of the participants with an attention deficit disorder were first identified at the postsecondary level." Research suggests individuals reporting ADHD symptoms are definitely pursuing the option of higher education.

A study conducted by the National Center for Education Statistics provides an estimate of the number of college students with an attention disorder based on self-reports. According to this report, 11% of undergraduate students with disabilities in the U.S. reported having an attention deficit disorder (Horn & Nevill, 2006). Weyandt et al. (1995) surveyed 770 college students across 59 majors and found 4% to 7% self-reported difficulties with attention, impulsivity, and hyperactivity. Another study of 468 college students at a Midwestern University found 4% of college students self-reported symptoms that met *DSM-III-R* criteria for ADHD (Heiligenstein et al., 1998). The authors warned that this might be an underestimate due to the decline of hyperactive-impulsive symptoms with age and the lack of appropriate age-based symptom comparisons in the *DSM*. Pope et al. (2007) looked at the prevalence of self-reported ADHD symptoms in a sample of 1,182 undergraduate psychology students in the United Kingdom using the *Conners' Adult ADHD Rating Scales-Short Form*, and found that approximately 6.9% of the sample reported symptoms meeting the clinically significant threshold. Furthermore, self-reported ADHD symptoms were negatively and significantly correlated with performance on core psychology course examinations (-.15 to -.23). Finally, McKee (2008) administered the *College ADHD Response Evaluation* (*CARE*) to 1,096 first-year students and found that approximately 7% met threshold for *DSM-IV* criteria based on self-reported ADHD symptoms. Collectively, a review of the literature by DuPaul et al. (2009) found that 2% to 8% of college students across multiple studies self-reported clinical symptoms associated with ADHD.

Postsecondary students reporting symptoms of ADHD is not just an American-based phenomenon. Evidence for ADHD symptoms in higher education is also evident in other countries and across gender. DuPaul et al. (2001) compared self-reports of a sample of 1,029 university students across three countries. They found 2.9% of men from a United States sample, 7.4% of men from a New Zealand sample, and 8.1% of men from an Italian sample reported ADHD symptoms; whereas, 3.9% of women from a United States sample, 1.7% of women from a New Zealand sample, and no women from an Italian sample reported symptoms of ADHD. It is interesting to note that slightly more women than men reported symptoms of ADHD in the United States sample. Research indicates that while in childhood males outnumber females in terms of diagnosis, the unequal gender ratio decreases or disappears in adults (Barkley & Murphy, 2006; Barkley et al., 2008).

Most prevalence studies have relied on students' self-reports of symptoms, but some have also looked at the number of students seeking support services for ADHD. Approximately 25% of college students receiving disability support services have ADHD (Wolf, 2001). These numbers may also underestimate the actual number of students with ADHD since individuals are not required to report disability status in higher education or seek out support services. In summary, epidemiological studies on college students with ADHD symptoms provide estimates from 2% to 11%, but these studies are not without limitations. One study that examined prevalence of ADHD symptoms using multiple respondents (i.e., self and parent report) produced an estimate of less than 1%, suggesting previous studies may have provided an overestimate of students with ADHD symptoms in postsecondary settings (Lee, Oakland, Jackson, & Glutting, 2008).

Regardless, all these prevalence studies were completed with non-referred, non-diagnosed students who self-reported symptoms rather than with college students with documented ADHD (Weyandt & DuPaul, 2006). Yet there is some validity support for studies consisting of individuals with ADHD by self-report only. Richards, Rosen, and Ramirez (1999) found significant similarities in psychological functioning, as measured by the *Symptom Checklist-90-R*, between college students with confirmed ADHD and college students with self-reported symptoms of ADHD and significant differences between both groups when compared to a control group of students without ADHD, suggesting that students who self-report symptoms of ADHD may have the disorder or are experiencing similar symptomatology. Furthermore, several studies have also examined self-reported ADHD symptoms in college students recruited through offices of disability services, who reported more academic concerns, lower GPAs and a greater number of ADHD symptoms than age-matched controls (Gropper & Tannock, 2009; Lewandowski et al., 2008). Finally, while self-report symptom checklists do not typically assess the degree of impairment experienced by individuals, studies have documented strong significant correlations between degree of impairment and number of ADHD symptoms endorsed by male adults diagnosed with ADHD in childhood (.83-.85; Mannuzza et al., 2011) and males and females diagnosed in adulthood (.70-.84; Barkley et al., 2008). Thus, some evidence does exist that postsecondary students with self-reported ADHD may present with a similar psychological and educational profile as those with confirmed ADHD.

The suggested best practice for ADHD assessment in adults emphasizes a multimodal approach which includes clinical interviews with the individual and significant others, self-report and informant reports of current and childhood ADHD and related symptomatology, review of school records, review of areas of impairment, and possibly psychological and educational testing (DuPaul et al., 2009). Yet diagnosis of ADHD in adulthood relies heavily on the self-reported symptoms of the client (DuPaul et al., 2001) and some research suggests informant-report should be used to obtain additional information on symptoms and impairment, not to question diagnosis (Katz et al., 2009). However, caution should be used in relying too heavily on self-reported symptoms of ADHD as symptoms may be better accounted for by another disorder. In the UMASS study, 22% of individuals in the non-ADHD clinical control group met criteria for ADHD based on patient report, but were not found to have a diagnosis of ADHD based on clinical judgment (Barkley et al., 2008). Furthermore, students may feign symptoms of ADHD for access to accommodations or stimulant medications (Booksh, Pella, Singh, & Gouvier, 2010; Sollman, Ranseen, & Berry, 2010).

Primary Clinical Presentation

Aside from prevalence, research has also begun to explore the clinical manifestations of ADHD and related impairments in adulthood and within postsecondary students. The clinical picture of ADHD in late adolescence and adulthood has some commonalities with manifestations of the disorder in childhood. According to the *DSM-IV-TR*, ADHD is a disorder characterized by persistent patterns of inattention, hyperactivity or impulsivity, which interfere with an individual's academic, occupational, and/or social functioning (American Psychiatric Association, 2000, p. 85). In addition to the presence of at least six inattentive and/or hyperactive-impulsive symptoms, criteria for ADHD requires the onset of the disorder before the age of seven, evidence of the disorder in a maladaptive form in at least two settings for six months, and the symptoms to not be better accounted for by another disorder (American Psychiatric Association).

Adults continue to show the core symptoms of inattention, impulsivity, and hyperactivity, and also demonstrate impairments in multiple domains of functioning (Faraone et al., 2000). Inattention in adults is manifested by failing to give close attention to details, difficulty with organization, frequent careless mistakes, difficulty completing projects, problems sustaining attention, and being easily distracted and forgetful (American Psychiatric Association, 2000). Inattention predominates with age as tasks in school and work tax attentional capacities (Faraone et al., 2006). Verbal impulsivity, such as interrupting others (Barkley, 2006), and hyperactivity, limited to subjective feelings of restlessness (American Psychiatric Association, 2000), are also a part of the clinical picture in adults. One study stated that symptoms of hyperactivity or restlessness appeared to collectively reflect problems with cognitive disinhibition, which includes internal distractibility, internal restlessness, internal impulsivity, and internal disorganization (Weyandt et al., 2003). These symptoms generally manifest as internal restlessness, fidgetiness, daydreaming, internal distractions, and excessive speech rather than the motor hyperactivity seen in children with ADHD (Barkley, 2006; Weyandt et al., 2003).

Inattention, impulsivity, and hyperactivity are identified as the behavioral characteristics seen in individuals with ADHD, yet underlying many of these symptoms is a central deficit in attention. Attention is a multi-dimensional phenomenon that depends on a number of underlying processes. It can be broadly defined as "the ability to routinely filter the vast amount of information around us at all times" (Nigg, 2006, p. 75). Attention is regarded as a complex cognitive process influenced by cognition as well as motivation and emotion (Ruff & Rothbart, 1996). Individual differences in attention are related to differences in emotional tone, self-regulation, motivation, fatigue as well as the presence or absence of ADHD. ADHD by definition is a disorder affecting attention; however, there is much variability in attentional functioning among individuals with ADHD. Neuropsychological findings show inconsistent results about attentional deficits in adults with ADHD, indicating impairments in different functions (Armstrong, Hayes, & Martin, 2001). Researchers have found impairment across several dimensions of attention as well as cases of a pervasive failure of attentional functions when compared to comparison groups (Hervey et al., 2004; Mirsky & Duncan, 2001; Mirsky, Pascualvaca, Duncan, & French, 1999).

The three most commonly identified and assessed functions or subdomains of attention are: selective attention, sustained attention, and alternating attention. Selective attention, also referred to as the focus, orient, or execute function, refers to concentrating attention on a specific task while screening out distracting stimuli (Mirsky et al., 1999). Sustained attention, also called persist, maintain, or stability function, is defined as the ability to stay on task for an appreciable amount of time (Mirsky et al., 1999). Finally, alternating attention, also known as mental shifting or flexibility, is the ability to shift from one task requirement to another when these have different cognitive requirements (Baron, 2004). Deficits in sustained attention and selective attention are the most characteristic of ADHD (Barkley, 2006).

Subtypes. The three subtypes of ADHD described in the *DSM-IV-TR* (Combined, Predominantly Inattentive, and Predominantly Hyperactive-Impulsive) have been documented within adolescent and adult samples. Some researchers have posited that the predominantly inattentive subtype is characterized by deficits in information processing and selective attention, while the combined type involves deficits in sustained attention and behavioral inhibition (Barkley, 1997; Naglieri & Goldstein, 2006). Others have also argued that the predominantly inattentive subtype represents a separate disorder with a true deficit in attention termed sluggish cognitive tempo (Barkley, 2006; Eme, 2007).

Actual differences in clinical presentations by subtype have been noted in a few studies. DuPaul et al. (2001) found differences in self-reported descriptions of predominantly inattentive and hyperactive-impulsive subtypes in college students. The predominantly inattentive subtype was characterized by difficulties with task completion, sustaining attention, memory, and organization, while the hyperactive-impulsive subtype included difficulties with self-control, such as, excessive talking and impulsivity (DuPaul et al., 2001). Another study found that in comparison to the ADHD-Predominantly Inattentive subtypes, adults with the ADHD-Combined Type were more likely to experience interpersonal hostility and paranoia, to have attempted suicide, and to have been arrested (Murphy et al., 2002). Finally, studies have also found that the ADHD-Combined Type generally presented as more severe with greater incidences of co-morbidity with Oppositional Defiant Disorder, Conduct Disorder, and Antisocial Personality Disorder (Barkley, 2006; Murphy et al., 2002; Wolraich et al., 2005).

The research on prevalence of various subtypes in the adult and postsecondary populations has been mixed. The majority of studies have found a higher prevalence of combined and inattentive subtypes with hyperactive symptoms decreasing with age (Barkley et al., 2008; Heiligenstein et al., 1998, Kaminiski et al., 2006; McKee, 2008; Murphy, Barkley, & Bush, 2001). However, a few studies have noted a higher prevalence of the hyperactive-impulsive subtype in adults and postsecondary students (DuPaul et al., 2001; Smith & Johnson, 1998).

Despite the above differences, several similarities also exist across subtypes. All individuals with ADHD are at greater risk for a substance use disorder (Barkley, 2006; Faraone et al., 2000; Wolf, 2001; Wolraich et al., 2005). Adults with ADHD are also likely to present with deficits in executive functioning regardless of subtype classification, though executive system deficits may differ by symptom constellation (Gansler et al., 1998; Nigg et al., 2005). Additionally, academic functioning appears to be impacted in all individuals with ADHD regardless of subtype classification and/or presence or absence of comorbid disorders (Eme, 2007; Faraone et al., 2000; Heiligenstein et al., 1999; Murphy et al., 2002). In their study comparing clinic-referred ADHD adults to clinical controls and community controls, Barkley et al. (2008) found that educational functioning presented as the most impaired area of functioning across all subtypes. Since this study focuses mainly on academic functioning, it will not differentiate between subtypes of ADHD.

Etiology and Theoretical Models

Research suggests that ADHD is a polygenic disorder with genes accounting for 80% of the variation in symptom expression (Barkley, 2006; Durston, 2003). Additionally, imaging studies have shown neurological differences in brain structure in individuals with ADHD (Barkley, 2006; Durston, 2003). ADHD is likely to have multiple etiological pathways and so it is not surprising that several theoretical models of ADHD have emerged. Over the years the disorder has been conceptualized through a brain damage paradigm, a motivational framework, an attentional deficits model, and more recently a behavioral inhibition model (Barkley, 2006). The attentional deficits model is currently reflected in the *DSM-IV-TR*, which holds that ADHD is based in a deficit in the ability to filter the vast amount of information around us at all times (Eme, 2007). Neurological research supports this interpretation to some degree (Durston, 2003). However, some believe that attentional deficits are not central to the disorder. The clinical concept of sustained attention deficit and distractibility are not confirmed by cognitive assessments of ADHD individuals (Swanson et al., 2004). This may be explained by the fact that the symptoms used to diagnosis ADHD are behavioral and do not always correspond with cognitive constructs. For instance, impulsive responding in individuals with ADHD is described as *fast* and inaccurate responding behaviorally; however, this type of responding is actually *slow* and inaccurate when measured on a cognitive level (Swanson et al., 2004).

Other researchers have also noted that the deficit in children and adults with ADHD is not primarily one of attention (i.e., a short supply of resources) as implied by the name of the disorder, but rather a deficit in the allocation of attentional resources, more broadly referred to as an executive function deficit (Cutting & Denckla, 2003). Barkley (1997, 2006) was the first to introduce a comprehensive theoretical model for ADHD with a central impairment in behavioral inhibition. In Barkley's (1997, 2006) model, ADHD is seen as a disorder of inhibiting behavior, as such, it disrupts the development and effective performance of some key executive functions: verbal and nonverbal working memory, the self-regulation of affect/motivation/arousal, and reconstitution, the ability to break down observed behaviors into component parts and recombine them into new behaviors. Thus, behavioral inhibition is the central impairment that leads to secondary deficits in these neuropsychological abilities, which then lead to decreased control of motor behavior and self-directed action (Barkley, 1997). Some convincing neuropsychological evidence that poor inhibitory or cognitive control may be central to ADHD has recently emerged (Barkley, 2006; Durston, 2003). Despite differences in theoretical models, the cognitive functions of attention and working memory appear to be impaired in ADHD whether they are characterized as primary or secondary manifestations of the disorder.

Comorbid Disorders

Similar to children with ADHD, adults also show a high prevalence of comorbid disorders. In the UMASS study, at least 80% of clinic-referred ADHD individuals had one other disorder (Barkley et al., 2008). These included depressive disorders, disruptive disorders (i.e., oppositional defiant disorder and conduct disorder), and substance use disorders. Research has documented all individuals with ADHD are at greater risk for a substance use disorder (Barkley, 2006; Faraone et al., 2000; Wolf, 2001; Wolraich et al., 2005). Additionally, there is a strong link between ADHD and learning disorders in adults (Barkley et al., 2008; McGillivray & Baker, 2009).

In terms of postsecondary students with ADHD, research examining prevalence estimates of comorbidity has been more limited. Heilingstein and Keeling (1995) conducted a retrospective chart review of 42 college students diagnosed with ADHD at a university medical center. Fifty-five percent of students reported a comorbid disorder, which included depressive disorders (26%), drug or alcohol dependence (26%), anxiety disorders (5%), learning difficulties (2%), and eating disorders (2%; Heilingstein & Keeling, 1995). While ADHD-related deficits on neuropsychological tests may be exacerbated by the presence of comorbid disorders, poor educational performance is evident in adults with ADHD even without the presence of comorbid disorders (Faraone et al., 2000). More research is needed on the impact of comorbid disorders in postsecondary students with ADHD; however, the examination of comorbidity was beyond the scope of this dissertation.

Academic Functioning and Educational Outcomes in Higher Education

Along with the primary symptoms of inattention, impulsivity and hyperactivity, many individuals with ADHD are affected by associated impairments. While some adults with ADHD experience social and psychological impairments, difficulties in academic functioning appear to be pervasive and sometimes even more pronounced in adulthood. Impaired functioning in academics is a major complaint of adults with ADHD (Wilens, Faraone, & Biederman, 2004). In fact, a review of the current literature about the clinical prognosis of adolescents and young adults with ADHD concluded that academic problems usually become more visible later in schooling since cognitive demands increase and more independent work is required (Wolraich et al., 2005). Furthermore, as many as 30% to 50% of adults with ADHD in a follow-up study reported having been retained at least once and 25% to 36% reported never having completed high school (Barkley & Murphy, 2006, p. 6).

Despite the educational difficulties experienced by many individuals with ADHD, several public laws (e.g., Section 504 of the Rehabilitation Act, Individuals with Disabilities Education Act, Americans with Disabilities Act) within the past 25 years have increased educational access and mandated services for all individuals with disabilities. As a result, high school graduation rates among individuals with disabilities have risen by nearly 31%, and a larger number of these individuals are going on to attend college (Wolf, 2001). Overall, enrollment rates in higher education are up for individuals with ADHD. Yet enrollment (Barkley, 2006) and overall academic functioning, including college graduation rates (Frazier, Youngstrom, Glutting, & Watkins, 2007; Wolf, 2001), are lower for students with ADHD. Fewer adults with ADHD graduate from college than age-matched non-ADHD peers or adults with other psychiatric disorders (Barkley et al., 2008).

Research related to academic achievement and college students with ADHD is still in its infancy, but a few general findings have emerged. In general, college students with ADHD are at increased risk for academic problems compared to their non-ADHD peers. A review of the literature suggests that college students with both significant self-reported and confirmed ADHD symptoms generally obtain lower GPAs, receive more special education services, are more likely to be on academic probation, and are less likely to graduate with a degree when compared to non-ADHD peers (Barkley, 2006; Barkley et al., 2008; Blaise et al., 2009; DuPaul et al., 2009; Heiligenstein et al., 1999; Kaminski et al., 2006; Lewandowski et al., 2008; Murphy et al., 2002; Norwalk et al., 2008; Weyandt & DuPaul, 2006; Wolf, 2001). These outcomes hold true even in the absence of intellectual or other psychological problems. Several studies have found that independent of IQ, postsecondary students with ADHD experience more problems than other students throughout their educational careers, such as, lower grades, more grades failed or repeated, and overall fewer years of education completed (Barkley, 2006; Kaminski et al., 2006; Reaser et al., 2007). Barkley et al. (2008) noted no differences between SAT scores of adults with ADHD and their non-ADHD peers. Thus, while most postsecondary students with ADHD have intellectual profiles comparable to their non-ADHD peers, they still experience worse educational outcomes. Weyandt et al. (1995) hypothesized that these intellectually capable students with ADHD are adequate achievers during the elementary and secondary school years but struggle when faced with the demands of advanced education (e.g., lectures, substantial amounts of reading, time management).

Psychiatric issues do not fully account for disparities in academic outcomes between individuals with ADHD and individuals without ADHD. Poor educational performance, as shown by long-term histories of school failure, is evident in adults with ADHD even without the presence of comorbid disorders (Faraone et al., 2000). Heiligenstein et al. (1999) looked at a sample of college students with ADHD and non-ADHD controls and found that the students with ADHD did not differ from their non-ADHD peers on measures of psychological problems. Thus, the main problem experienced by students with ADHD appears to be academic not intellectual or psychiatric in nature. This is consistent with research documenting educational functioning as the most highly reported area of impairment in clinic-referred adults with ADHD (Barkley et al., 2008).

Academic vulnerability appears to be highest in the first two years of college, especially among ADHD and LD individuals (Wolf, 2001). School problems most commonly recorded by adolescents and young adults with ADHD include poor performance on tests, missing assignments, careless work, and poor writing (Wolraich et al., 2005). Based on descriptive studies like the ones cited above, impaired organizational skills, study skills deficits, executive function deficits, and other cognitive deficits have been hypothesized to impact academic achievement in postsecondary students with ADHD (Weyandt & DuPaul, 2006).

Researchers have attempted to test many of these hypothesized variables, including poor study skills. One study looked at coping resources that differentiated high-achieving ADHD students from low-achieving ADHD students at a highly selective liberal arts college with documented ADHD diagnoses (Kaminski et al., 2006). The authors found that 40% of their sample reported using study skills as a common coping method and 12% reported an inability to use study skills consistently. The authors concluded that study skills are likely to be more predictive of educational outcomes than innate abilities and severity of disorder (Kaminski et al., 2006). A study by Reaser et al. (2007) evaluated learning styles of 50 students with documented ADHD compared to 50 non-ADHD and 50 documented LD students using the *Learning and Study Strategies Inventory*, *2nd edition* (*LASSI-2*). The study found several differences between students with ADHD and LD and between non-ADHD students and students with ADHD. The authors concluded that students with ADHD suffered from poor concentration, inability to self-regulate, difficulty managing time, difficulty focusing on details, inability to identify important points, trouble planning work, and difficulty understanding what is being asked (Reaser et al., 2007).

Zwart and Kallemeyn (2001) also noted difficulties with time management and study skills on the *LASSI* in a college sample of 42 students with documented ADHD. However, their study did not include a comparison group. Finally, a three-year intervention study involving the development and field-testing of an individualized course-specific strategy instruction model, which included informal assessment of a student's individual learning needs, selection of learning strategies to meet the unique needs of the student, teaching learning strategies using systematic explicit instruction within the context of particular courses, and evaluation of the strategy instruction was tested with 46 college students (Allsopp et al., 2005). Twenty-six students had diagnoses of LD, 10 students had diagnoses of ADHD, eight students had diagnoses of LD and ADHD, and two students had other diagnoses. The authors found that the group as a whole improved their grades and sustained this improvement over time as a result of the intervention (Allsopp et al., 2005). Although the research is limited, study skills seem to play an important role in the educational functioning of many postsecondary students with ADHD.

In summary, global factors, such as, various attentional deficits, difficulties with executive functioning, problems with self-regulation, and poor study skills have been consistently associated with academic functioning in ADHD. Further research is needed to uncover the specific determinants of academic success in postsecondary students with significant symptoms of ADHD. However, in order to do so, we must first establish what is required to be academically successfully in most postsecondary institutions.

Academic Achievement and Study Skills

Postsecondary institutions often rely on predictor variables such as high school GPA and SAT scores as initial measures of academic success in college. The combination of high school GPA and SAT scores has been found to predict from 25% to 41% of the variance in college GPA (Ramist, Lewis, & McCamley, 1990; Wolfe & Johnson, 1995). Although the exact predictive potential of SAT scores and high school GPA is unclear, it is certain that a large percentage of variance remains unaccounted for. Researchers have therefore looked into other variables that may impact academic performance. Some of the variables associated with academic achievement include psychosocial factors (e.g., social support, coping mechanisms), health-related variables (e.g., smoking, drinking, and fitness habits), demographic variables (DeBerard, Spielmans, & Julka, 2004), personality variables, such as, self-control (Wolfe & Johnson, 1995), and study skills and study habits (Crede & Kuncel, 2006). In one meta-analytic study that reviewed nine broad psychosocial and study skill factors (i.e., achievement motivation, academic goals, institutional commitment, perceived social support, social involvement, academic self-efficacy, general self-concept, academic-related skills, and contextual influences) across 109 individual studies involving full-time four-year higher education students, academic-related skills accounted for 5.08% of the variance in college retention and 23.86% of the variance in college GPA according to meta-analytic results (Robbins et al., 2004). Academic-related skills or study skills, defined as “those activities necessary to organize and complete schoolwork tasks and to prepare for and take tests,” (Robbins et al., 2004, p. 264) included areas such as time management, preparing for and taking exams, using informational resources, taking class notes, and communicating with teachers and advisors. In addition, research by Kiewra and Benton and Kiewra et al. has shown that students’ notes predict academic performance better than either verbal ability and GPA (as cited in Peverly et al., 2007) or class attendance and critical thinking skills (Worth, as cited in Williams & Eggert, 2002a). It is likely then that study skills contribute to some of the unaccounted variance of academic success.

Lecture Note-Taking

Taking notes from lectures and reviewing those notes in preparation for exams is a pervasive form of studying at institutions of higher learning. The prevalence of taking and reviewing notes may partly be due to the fact that lecturing is a widespread method of dispensing information in postsecondary institutions. Titsworth and Kiewra (2004) reported that 83% of higher education faculty use lecturing as their main method of instruction. Armbruster (2009) estimates that undergraduate students spend typically 80% of class time listening to lectures. And in a survey of 223 American college students by Palmatier and Bennett, as cited in Dunkel and Davy (1989), 99% of students surveyed indicated they regularly took lecture notes. In a survey of 53 faculty members, 83% stated they expected students to take notes (Landrum, 2010). Furthermore, students attempt to record notes on lectures even when not explicitly told to do so (Williams & Eggert, 2002a). Not only do postsecondary students spend a great deal of time taking notes, they place great value on note-taking. According to one study, 94.4% of American students and 92.2% of International students stated that note-taking is an important activity (Dunkel & Davy, 1989). The researchers of this same study also looked qualitatively at why 164 college students justified taking notes from lectures. The results indicated that students took notes to review material for examinations, to organize presented material, and to get a better grade on the exam (Dunkel & Davy). Aside from complementing the frequently utilized lecture format and a useful method of studying in higher education, taking notes from lectures is a practical, fairly inexpensive and versatile way to acquire information.

Numerous studies have examined the relationship between taking and reviewing notes and test performance using a variety of outcome measures (e.g., multiple-choice items, short-answer tests and long essay formats) and research conditions (e.g., experimental, quasi-experimental and correlational). Significant correlation coefficients between quality of notes and test performance across studies in the research literature range from .24 to .74 (Baker & Lombardi, 1985; Kiewra & Benton, 1988; Norton & Hartley, 1986; Nye et al., 1984; Peverly et al., 2007; Titsworth & Kiewra, 2004; Williams & Eggert, 2002b). The range in correlation coefficients is likely due to the variable used to measure quality of lecture notes (e.g., total words, number of propositions, number of main ideas, accuracy of notes) and the variable used to measure test performance (e.g., multiple-choice, short-answer, essay recall, factual items, inference items). The highest correlations occurred when notes' format and content matched method of recall. Despite this range, these studies establish the positive link between students' notes and students' performance on tests.

The research also highlights some major points about the quantity and quality of notes. Williams and Eggert (2002a) reviewed studies completed within the context of regular college courses and found that the predictive potential of notes is related to the specificity and completeness of notes. The most effective notes are those than can easily be followed by someone unfamiliar with the notes. Additionally, the more details included in one's notes, the higher the performance on exams, especially as time from taking notes to testing increases (Baker & Lombardi, 1985; Nye et al., 1984). As Kiewra (1985) summed up, quantity and quality of notes are both related to better academic performance.

Further support for the positive relationship between taking and reviewing notes and academic achievement is provided by an overview of effect sizes, which measure the strength of association between notes and performance. Kobayashi (2006) completed a meta-analysis of 33 studies in order to examine how much the combination of taking and reviewing notes contributes to school learning, which was defined as knowledge acquisition from a lecture or text measured by a variety of posttests. Kobayashi found effect sizes approaching the large range (.75 to .77) when students took and reviewed their own notes compared to control groups where students did not take notes and did not engage in any review or mentally reviewed lecture material, suggesting students greatly benefit from taking and reviewing notes due to the contribution notes provide to the learning process.

Despite its widespread popularity, prevalence, and positive effect on academic achievement, few people have received formal instruction in lecture note-taking. Additionally, few students take complete notes. According to Kiewra et al., studies have found that students often record fewer than 40% of lecture ideas (as cited by Armbruster, 2009). For example, one study found that most students did little more than copy down the key terms and topic headings with the exception of some remarkably thorough note takers (Baker & Lombardi, 1985). Typically students record between 30% to 40% of lecture points, documenting general rather than specific ideas (Williams & Eggert, 2002a); however, there is some variation in amount of notes recorded between the best and worst note-takers. In a field study involving 75 lectures, Nye et al. (1984) found that the top eight students averaged 62% more notes than the bottom eight students at each lecture. And in Williams and Eggert's (2002a) review of the literature, the percentage of ideas recorded across studies and across populations ranged from 11% to 72%.

Individual differences in note-taking also exist between students with and without disabilities. In one study comparing the notes of 30 students with a learning disability and 30 students without a learning disability, the non-LD group recorded 60-70% more information units (Hughes & Suritsky, 1993). LD students were interviewed about the most difficult aspects of taking notes and reported that writing fast enough, deciding what information was important enough to include in their notes, making sense of their notes when they used them to study, and paying attention during lectures were the most important skills to master (Hughes & Suritsky, 1993). Learning disabled students have been reported to take fewer and more ambiguous notes than their nondisabled peers due to slower handwriting speed and poorer attentional abilities (Hughes & Suritsky, 1993; Suritsky & Hughes, 1991; Williams & Eggert, 2002a).

In spite of variability in individual note-takers, note-taking interventions have focused mainly on lecture variables. Experimental studies have focused on lecturer presentation rate (Peters, 1972; Suritsky & Hughes, 1991), spoken organizational lecture cues (Titsworth & Kiewra, 2004), and the organizational format of notes, such as conventional notes, matrix notes, and outlines (Kiewra et al., 1991; Peverly et al., 2010). However, the interventions used in these studies focused on external factors instead of internal cognitive constructs that may better explain differences in quantity and quality of notes among note-takers.

Di Vesta and Gray (1972) established two functions of lecture note-taking in their seminal study: encoding and external storage, also referred to as the process and product functions of note-taking. The process function is supported by research that compares the achievement of students who take notes versus those who do not take notes. Of the 56 studies related to the process function of note-taking that Kiewra (1985) reviewed, 33 found greater rates of achievement in groups of students that took notes, 21 found no difference between groups of students, and two reported adverse effects on achievement for students taking notes. While taking notes aids but doesn't necessarily guarantee recall, not taking notes will almost certainly result in an inability to recall information after some delay (Carrier & Titus, 1979; Kiewra, 1985).

Several studies have also examined the differences between taking and reviewing personal notes versus not taking notes and reviewing provided notes. The results are equivocal. Some studies reported that taking and reviewing personal notes led to better test performance than not taking and reviewing provided notes (Fisher & Harris, 1973; Kiewra et al., 1991; Norton & Hartley, 1986; Titsworth & Kiewra, 2004). However, Kiewra et al. (1991) only noted significant differences between personal and provided notes on a cued recall test not on a free recall test, while Titsworth and Kiewra (2004) only found significant differences on a detail test when students were provided with organizational cues during the lecture. Other studies have found no significant differences between test performance when reviewing personal notes or provided notes (Barnett et al., 1981; Evans et al., 1994; Marsh & Sink, 2010). Finally, some studies have found better test performance when students were provided notes to review rather then taking notes (Hadwin, Kirby, & Woodhouse, 1999; Marsh & Sink, 2010).

Instructor-provided lecture notes or copies of other students' notes are a common accommodation in higher education since it is believed that providing students with lecture notes eases the burden on dividing attention between taking notes and encoding lecture information (Marsh & Sink, 2010). However, there are concerns about providing complete notes to students with disabilities, including the effect of not having to take notes on attendance, engagement, attention, and learning. Professors in higher education believe providing students with lecture notes will decrease attendance at lectures (Landrum, 2010). Additionally, those who take notes may be more active than those who simply listen to a lecture (Carrier & Titus, 1979), often adding more information from class discussions and making their own connections to the material (Stefanou, Hoffman, & Vielee, 2008). In a set of studies by Evans et al. (1994), taking notes significantly increased the on-task behavior of adolescents with ADHD. Providing partial notes instead of complete notes may be a better option (Neef, McCord, & Ferreri, 2006); however, the use of partial notes assumes students with ADHD will know when to record additional information to fill in the gaps (Huxbaum, 2010). Due to the equivocal findings on providing complete notes and the benefits in taking notes on students' engagement with the material, it is important to continue to study the factors related to taking lecture notes.

This study primarily focuses on the cognitive process of encoding using a limited capacity framework. Limited capacity implies that there is a relatively fixed quantity of cognitive resources that limits an individual's cognitive processing and output. The function of the encoding process is to gather information from a lecture, but this cognitively demanding process cannot be equated to simply copying down what is heard. According to Piolat et al. (2005), note-taking requires more cognitive effort than learning or comprehending.

The process of taking notes from lectures entails several steps. During the encoding or process phase of lecture note-taking, students must attend to the lecture, hold lecture information in verbal working memory, select the most salient pieces of information from the lecture and transcribe the information onto paper, all while attending and maintaining the continuity of the lecture (Peverly et al., 2007). Thus, note-taking implies activating simultaneous processes related to attention (orienting to lecture, inhibiting other information), working memory (holding information in memory), comprehension (understanding lecture content, paraphrasing using one's own words), and transcription (writing down information quickly). Therefore, a deficit in any one of these processes may negatively impact quality of notes. The literature related to attention, working memory, transcription fluency and comprehension are reviewed below.

Attention. As stated earlier, during the encoding or process phase of lecture note-taking, students must attend to the lecture, which requires orienting to the lecture by listening, inhibiting other distractions not directly related to the lecture, and maintaining attention for the entirety of the lecture. Unless the student's attention is focused on what the instructor is saying at the moment, there is little chance that meaningful processing and note-taking will follow (Williams & Eggert, 2002a). However, an informal analysis of listening patterns reveals that as few as 10% or as many as 98% of students could report what instructors had just said at any given point in a lecture, suggesting that there is a lot of variability across individual students in terms of orienting to the lecture (Williams & Eggert, 2002a).

Additionally, there is variability between individuals and within individuals when it comes to attention. Yet most studies fail to account for individual differences in attention when listening to a lecture (Wilson & Horn, 2007). One study reported a relationship between test performance in a college course and impulsivity, a characteristic possibly affected by attentional resources. Spinella and Miley (2003) examined college students' grades based on three exams and students' self-ratings of impulsivity. They found that students with higher self-reports of impulsivity had lower academic performance. The authors hypothesized that greater impulse control may allow an individual to stay focused on the delayed, long-term goals and rewards associated with paying attention to lectures and studying (Spinella & Miley, 2003). One study recently completed examined the role of attention to expertise in lecture note-taking (Peverly & Garner, 2010). Results from this study found that attention significantly correlated to and predicted quality of students' notes, indicating that attention is in fact implicated in note-taking.

Although the role of attention or the different dimensions of attention have just begun to be examined empirically in lecture note-taking, inattention is strongly associated with academic difficulties and students' response to intervention (Rogevich & Perin, 2008) and is likely to negatively affect the process of taking notes from lectures.

Research has examined deficits in attention in adults through the use of continuous performance tests where students are asked to respond to certain target stimuli. Omission errors are defined as instances when students fail to respond to target stimuli and are indicative of gaps in sustained attention or vigilance, while commission errors are defined as instances when students respond to non-target stimuli and are indicative of lack of inhibition. Studies have documented significantly higher omission errors in adults with ADHD compared to controls (Hervey et al., 2004; Johnson et al., 2001; Murphy et al., 2001), while others have found no differences on omission or commission errors (Holdnack, Moberg, Arnold, Gur, & Gur, 1995; Rapport, VanVoorhis, Tzelepis, & Friedman, 2001). The above studies used a visual version of the continuous performance test. One study that utilized an auditory version of a continuous performance test with 64 unmedicated adults with ADHD and 73 non-ADHD controls found ADHD adults were significantly impaired on omission errors but not on commission errors (Seidman, Biederman, Weber, Hatch, & Faraone, 1998). These effects remained even after controlling for psychiatric comorbidity, gender, and age. Taken together, it appears adults with ADHD have deficits in vigilance or sustained attention. However, limited research exists on attentional deficits in postsecondary students.

Verbal working memory. Working memory is defined as the mental ability to temporarily store and manipulate information. It is central to all information processing and is involved in a wide range of complex cognitive behaviors (Baron, 2004; Buhner, Konig, Pick, & Krumm, 2006; Conway et al., 2005; Engle, 2001), including a variety of academic skills (e.g., reading and writing; Conway et al., 2005).

Working memory has been conceptualized through many different models, some capacity-based, some domain-based, and others executive or attention-based (Peverly, 2006). Yet all models characterize working memory as comprised of two functions: a storage component and a processing component (Cohn, Cohn, & Bradley, 1995; Conway et al., 2005). Despite differences in theoretical models, most researchers utilize a version of the complex span task to measure working memory. Complex span tasks tax both the processing and storage functions of working memory. Span refers to the ability to hold an adequate amount of information in working memory (Baron, 2004). Working memory complex span tasks (e.g., counting span, operation span, and reading span) have been shown to be reliable and valid (Conway et al., 2005; Engle, 2001). A commonly used version of the complex span task is the reading or listening span task, which entails participants reading or listening to a set of sentences, judging whether each sentence is true or false, and at the end of each set recalling the last word of each sentence (Daneman & Carpenter, 1980).

As discussed earlier, lecture note-taking is hypothesized to be an activity that strongly depends on the central executive functions of working memory to manage comprehension, selection, and production processes concurrently (Piolat et al., 2005). According to Kiewra and Benton (1988), " the effective notetaker uses working-memory capacity to attend, store, and manipulate information selected from the lecture simultaneously, while also transcribing ideas just previously presented and processed" (p. 35). However, the role of working memory in predicting quality of notes has not yet been clearly established due to equivocal findings in the research literature. Two earlier studies characterizing working memory as information-processing ability found significant correlations between number of words, ideas/propositions and information-processing ability (Kiewra & Benton, 1988; Kiewra, Benton, & Lewis, 1987). However, as Peverly et al. (2007) pointed out, the materials used to assess working memory in both studies were visually present for all the participants during the entire task, thus the studies may not have measured working memory span or processing as it is typically defined in the literature.

Hadwin et al. (1999) employed the more commonly used reading span task in their study and found that working memory accounted for a significant amount of variance in quality of notes. However, the authors pointed out that some of this variance is due to the overlap of working memory with verbal ability and prior knowledge, suggesting a weaker correlation between working memory and quality of notes (Hadwin et al.). Finally, Piolat (2007) also employed a reading span task to separate note-takers into two conditions based on working memory capacity (high-span and low-span). The study found that working memory span was an important influence on lecture note-taking, with high-span note-takers writing down more words than low-span note-takers when listening to a lecture (Piolat).

Yet other studies have failed to show a significant relationship between working memory and quality of notes. A study involving college students in economics' courses found that working memory, as measured by three complex span tasks, was not related to either quality of notes or the number of words recorded in a student's notes (Cohn et al., 1995). Several recent studies measuring auditory verbal working memory through a listening span task indicated that verbal working memory was not significantly related to quality of notes (Peverly & Garner, 2010; Peverly et al., 2007; Peverly & Sumowski, in press; Peverly et al., 2010). However, one of these studies found that working memory was related to test performance on a test of memory-based comprehension questions (Peverly & Sumowski, in press). In summary, while it is hypothesized that working memory is implicated in taking notes from lectures, the results from several studies are inconclusive and further research in this area is needed.

According to Barkley's (1997) behavioral inhibition model of ADHD, working memory should be impacted when more and more complex information must be held in mind and processed, especially over a lengthy delay period. Thus, it is hypothesized that working memory is affected by memory load or span and may be highly vulnerable to disruption by an attentional or neurological disorder (Baron, 2004). Several findings have emerged in the research literature about individuals with ADHD and the construct of working memory.

The research on children and adolescents with ADHD has shown core deficits in working memory (Johnson et al., 2001; Klingberg et al., 2005; Martinussen et al., 2005; McInnes et al., 2003). However, some researchers have found the central deficit to be with nonverbal working memory (Martinussen et al., 2005), whereas others have identified larger problems with verbal working memory (McInnes et al., 2003).

Research involving adults with ADHD has shown a pattern of converging evidence for deficits in verbal working memory and short-term memory (Barkley, 2006; Buhner et al., 2006; Gallagher & Blader, 2001; Gropper & Tannock, 2009; Hervey et al., 2004; Holdnack et al., 1995; Johnson et al., 2001; Marchetta et al., 2008; Murphy et al., 2001; Nigg, 2006; Quinlan & Brown, 2003). The research findings suggest a deficit in verbal not visual working memory when utilizing digit span or list learning tasks. Therefore, it is hypothesized that adults with ADHD have a deficit in the functioning of the phonological loop component of working memory as characterized by Baddeley and Hitch's model (as cited in Hervey et al., 2004). Thus, when demand on verbal working memory tasks is high, adults with ADHD may experience significant difficulty with the task (Hervey et al., 2004). Additionally, one study found that working memory predicted multi-tasking speed in adults with ADHD, providing further support for the role of working memory in complex cognitive tasks (Buhner et al., 2006).

However, one study including adults with ADHD and adults without ADHD matched for age, years of education, gender and IQ found no differences in verbal working memory between the groups (Rapport et al., 2001). This study used a letter-number span task to assess working memory, which may have been too easy to allow for enough variance among participants. In other studies, differences in verbal working memory between adults with and without ADHD disappeared once controlling for IQ (Murphy et al., 2001), yet remained when controlling for comorbid disorders (Marchetta et al., 2008; Murphy et al., 2001). Thus, there may be an overlap between working memory and IQ, which decreases the variance of working memory when matching for IQ. Yet others have suggested that lower IQ scores are caused by the same underlying factors of ADHD that contribute to poorer performance on tests of working memory (Hervey et al., 2004). In summary, the bulk of the research literature demonstrates adults with ADHD show mild to significant impairments in working memory on simple span tasks, such as, digit span or list learning tasks.

Transcription fluency. Transcription fluency or handwriting speed is defined as the rate of written word production and can be measured as the number of letters an individual writes within a specified time limit (Peverly et al., 2007). Typically, handwriting speed increases gradually with age, often marked by spurts and plateaus (Graham, Berninger, Weintraub, & Schafer, 1998; Graham & Weintraub, 1996).

Transcription fluency has been related to different writing outcomes among both children and adults. Many researchers have looked at the relationship between automaticity of handwriting and students' overall performance on written compositions. In both children and adults, research indicates that the faster the handwriting fluency, the higher the essay quality (Connelly, Dockrell, & Barnett, 2005; Connelly, Campbell, MacLean, & Barnes, 2006; Jones & Christensen, 1999; Peverly, 2006). In one study with second-graders, 53% of the variance in written expression scores was accounted for by handwriting speed and accuracy when controlling for reading scores (Jones & Christensen, 1999). The same also holds true for adult populations. In a study conducted with college students in the United Kingdom, 40% of the variance in the overall rubric score was accounted for by handwriting speed (Connelly et al., 2005). Finally, one group of researchers looked at the relationship between essay quality and handwriting speed in college students with dyslexia. They reported that handwriting fluency accounted for 20.8% of the variance in essay quality and concluded that the basic skill of getting the letters and words onto the page quickly and efficiently was just as important at the university level (Connelly et al., 2006).

These studies suggest that in limited capacity tasks, such as complex cognitive tasks, automaticity of handwriting is highly important because it frees up working memory and attentional resources enabling simultaneous processing by higher order processes (Graham & Weintraub, 1996; Peverly, 2006).

Handwriting speed can also affect an individual's facility at taking notes. Taking notes from lectures consumes at least as many resources as composing a text (Piolat et al., 2005). Note-taking often occurs under severe time pressures, thus, students must write quickly or shorten and reduce information. Handwriting speed is about 0.2 to 0.3 words per second whereas speaking speed is about two to three words per second (Foulin, as cited in Piolat et al., 2005). Therefore, note-takers are constrained by the rate of speech of the lecturer as well as their own handwriting speed (Piolat et al., 2005). The limited research on transcription fluency and lecture note-taking shows handwriting speed significantly predicts quality of notes (Peverly & Garner, 2010; Peverly et al., 2007; Peverly & Sumowski, in press; Peverly et al., 2010). According to four studies completed with college students, handwriting fluency accounted for 4.7% to 11.6% of the variance in quality of notes (Peverly & Garner, 2010; Peverly et al., 2007; Peverly & Sumowski, in press; Peverly et al., 2010). Furthermore, transcription fluency was the only significant predictor of quality of notes in two of these studies. Although the research is in its early stages, it is likely that handwriting fluency is a valid cognitive construct underlying quality of notes.

There is no research on the relationship between ADHD and transcription fluency, but some research exists on handwriting, motor output, and composition writing in individuals with

ADHD. Handwriting has often been found to be less mature in children with ADHD (Barkley, 1997). Additionally, poor motor output and speed have been observed in clinical populations of children and adults with ADHD (Barkley, 2006; Wolf, 2001). A study by Gregg et al. (2002) looked at expository writing in college students with ADHD, other disabilities, and a control group. They found that college students with ADHD scored significantly lower on a timed essay than controls and had a lower overall word count. However, it is unclear why some individuals with ADHD experience difficulties with handwriting and composition. Barkley (1997) hypothesized that handwriting is the execution of novel and complex motor sequences, which are controlled by executive functions disrupted by poor behavioral inhibition. More research is needed on the relationship between transcription fluency and ADHD.

Listening comprehension. Comprehension is the ability to understand spoken language (listening comprehension) or written language (reading comprehension). Comprehension, when defined in terms of reading ability, is highly related to verbal intelligence at the college level (Perfetti, 1986). Furthermore, there is a high correlation (.90) between listening and reading comprehension at the college level (Gernsbacher, as cited in Perfetti, Landi, & Oakhill, 2005), and individual differences in comprehension at the college level are due to language ability (Daneman & Carpenter, 1980). The study proposed here used a measure of listening comprehension because it is more ecologically valid in the context of lecture note-taking. However, research findings on reading comprehension can be extrapolated to listening comprehension due to the significant relationship between the two constructs.

With regard to lecture note-taking, the role of comprehension is unclear. While some researchers characterize note-taking as a complex process involving both the comprehension and production of written output (Kiewra & Benton, 1988; Piolat et al., 2005), others stipulate that it is possible to hear what an instructor says, even repeat what the instructor said, with minimal understanding of the instructor's comment (Williams & Eggert, 2002a). Yet, reframing a lecturer's comments in one's own words may reflect a deeper level of processing and produce more meaningful notes (Kiewra, 1985). Thus far, two studies have demonstrated significant correlations between reading comprehension and quality of notes. In a college-level study by Peverly et al. (2010) reading comprehension weakly correlated (.28) with quality of lecture notes and moderately correlated (.48) with performance on an essay test. Furthermore, reading comprehension was only one of two predictor variables to significantly predict quality of notes in a regression analysis (Peverly et al., 2010). A moderate correlation of .43 was observed in another study evaluating the relationship between reading comprehension and quality of text notes (Peverly & Sumowski, in press). No studies thus far have examined the role of listening comprehension in lecture note-taking.

In regards to ADHD, limited research on weaknesses in reading and listening comprehension abilities has been observed in the literature. Studies have shown that children and adolescents with ADHD (Aaron et al., 2002; Brock & Knapp, 1996; Ghelani et al., 2004; Javorsky, 1996) and incarcerated male adults (Samuelsson et al., 2004) do not show deficits in decoding, word identification, or phonological processing. Instead, when these are controlled for, weaknesses in reading comprehension and/or listening comprehension have been noted. Reading comprehension abilities of children and adolescents with ADHD were significantly lower than comparison groups in several studies (Brock & Knapp, 1996; Ghelani et al., 2004; Javorsky, 1996). Despite lower reading comprehension scores compared to adolescents without ADHD, adolescents with ADHD still showed average ability in one study (Ghelani et al., 2004). McInnes et al. (2003) found mixed results when reviewing the comprehension abilities of children with ADHD. While children with ADHD comprehended factual details on narrative and expository passages as well as normal children, they had significantly more difficulty with subtle aspects of comprehension, such as making inferences from expository information (McInnes et al.).

Finally, one study looked directly at differences in reading and listening comprehension in children with the predominantly inattentive subtype of ADHD while comparing them to children with a reading disorder, children with ADHD and a reading disorder, and a control group (Aaron et al., 2002). The authors found that children with ADHD exhibited average reading comprehension abilities but significantly lower listening comprehension abilities (approaching the below average range) in comparison to the control group (Aaron et al.). The authors concluded that the listening task required more sustained attention than the reading task; and therefore, was more affected by a diagnosis of ADHD (Aaron et al.). The research on comprehension in adults with ADHD is limited; therefore, it is unclear whether adults with ADHD exhibit deficits in listening comprehension.

Summary and Hypotheses

Taking and reviewing lecture notes is the preferred and most prevalent method of studying in higher education. Yet few studies have focused on the underlying cognitive variables related to lecture note-taking, especially in the context of postsecondary students with self-reported ADHD. The current study aimed to extend the findings from previous studies on lecture note-taking (Peverly & Garner, 2010; Peverly et al., 2007; Peverly & Sumowski, in press; Peverly et al., 2010) to a disability population, specifically students with self-reported ADHD diagnoses. The current study investigated three principal questions: (1) Are there significant differences between self-reported ADHD and non-ADHD postsecondary students, specifically in terms of attention, transcription fluency, verbal working memory, listening comprehension, quality of notes, and/or essay performance? (2) What variables contribute to differences in quality of lecture notes in a group of postsecondary students with self-reported ADHD and without ADHD? (3) What variables contribute to differences in essay performance in a group of postsecondary students with self-reported ADHD and without ADHD? This study proposed the following hypotheses:

H1: Attention, transcription fluency, and disability status will significantly predict quality of notes.

H2: Quality of notes and disability status will significantly predict essay performance.

H3: Students with self-reported ADHD will have lower means than students without ADHD on measures of attention and verbal working memory and on notes' quality and essay performance.

Chapter III

Method

Participants

All participants were recruited in accordance with institutional review board procedures. Participants were undergraduate and graduate students (*n* = 72) from multiple universities in the northeastern United States (e.g., Columbia College, New York University, Pace University, Teachers College, and several other institutions). Participants were recruited from offices of disability services or counseling centers, university courses, department emails, referrals, and through postings of fliers. The current author initially intended to recruit all participants from a single university's office of disability services but had to expand recruitment efforts to include multiple universities, multiple sources of recruitment, and a graduate population due to difficulty obtaining an adequate sample size of undergraduate students with self-reported ADHD from one university. Furthermore, as the current study involved multiple performance measures rather than use of surveys, participants had to schedule a two-hour slot and travel to a separate location to complete the study. These factors may have contributed to a low response rate. While several students contacted the primary researcher to express interest in participating, many failed to schedule a date to complete the study. Out of 73 undergraduate students scheduled, 43 participants actually showed up to participate on the day of the study (58.9%). This rate improved to 66.7% with the inclusion of graduate students.

The mean age for the sample was 22.62 years (*SD* = 3.68) and ranged from 18.26 to 36.61 years (median age was 21.41). Sixty-eight percent (*n* = 49) of participants were female and 11.1% (*n* = 8) identified as nonnative English speakers. Race/ethnicity reported by participants was as follows: White American (55.6%), Asian American/Pacific Islander

(16.7%), Black/African-American (6.9%), Latino/a (2.8%), Non-US Citizen (1.4%), Other (2.8%), and membership in more than one of the above groups (12.5%). A majority of the participants were undergraduate students (*n* = 49; 68.1%). The majority of participants were recruited from New York University (*n* =37) or Teachers College (*n* = 21), with the remaining participants coming from six other universities (*n* = 14). Less than half of all participants identified as psychology majors (41.7%), although 73.6% had taken at least one psychology course (6.36; *SD* = 8.14). Referral sources of recruitment reported by participants included: referral from a friend (43%), other source, such as email posting, university course, or flier (42%), or email from university's office of disability services (15%).

All participants received $20 to complete the study and participants who referred another student to the study received an additional five dollars.

ADHD self-report group. Participants in the ADHD group made up 30.6% of the larger sample (*n* = 22). This group consisted of 50% females and 72.7% undergraduates with an average age of 23.63 years (*SD* = 4.17). Participants were non-clinic referred individuals with a self-reported diagnosis of ADHD recruited through university offices for disability services, counseling centers, university courses, and fliers. Within this group, 64% were registered with their school's office of disability services. Based on criteria listed on each university's office of disability services' website, students registered with the offices had to file appropriate documentation of a disability which included: a clear and specific diagnosis of ADHD using *DSM-IV* criteria; evidence of a substantial limitation to academic functioning; and a list of recommended accommodations in the current academic setting. Each university requested comprehensive evaluations conducted within the past three years using reliable, valid, and standardized measurements and completed by a qualified evaluator. Due to the extensive criteria set by offices of disability services and the time limitations of the current study, clinical interviews were not administered to confirm the diagnosis of ADHD. However, since recruitment efforts were expanded to sources outside offices of disability services due to difficulties in securing an adequate sample size, a small percentage of the current sample (36%) were not registered at any office of disability services. The two groups (i.e., registered at office of disability services and not registered) were compared in terms of all independent and dependent variables. A one-way MANOVA was conducted to simultaneously compare the means of participants who were registered at offices of disability services and those not registered at offices of disability services on measures of attention, transcription fluency, verbal working memory, listening comprehension, notes' quality, and essay performance. The assumption of equal covariance matrices was met. The multivariate test was not significant (Wilks' $\lambda = .82$, $F(6,15) = .55$, $p = .766$, observed power = .16).

As a further check of self-reported ADHD symptoms, the *Conners' Adult ADHD Rating Scale-Short Self-Report Form* was administered to each participant. Table 1 in Appendix A reports means, standard deviations, and ranges for participants in the ADHD group across the five subscales. Another one-way MANOVA was conducted to simultaneously compare the means of participants who were registered at offices of disability services and those not registered at offices of disability services on the five scales of the *CAARS*. The assumption of equal covariance matrices was met. The multivariate test was not significant (Wilks' $\lambda = .71$, $F(6,15) = 1.29$, $p = .318$, observed power = .34). Thus, the two groups were considered homogeneous for purposes of the main analyses.

While the entire sample in the ADHD group self-reported a diagnosis of ADHD, a majority of the sample (20 out of 22 participants) was also either registered with their office of disability services ($n = 14$) and/or endorsed elevated symptoms on at least one scale of the *CAARS* ($n = 15$). See Table 2 in Appendix A. The two remaining students were not excluded from the sample as they endorsed symptoms approaching elevated scores (T-score > 61) on at least one scale of the *CAARS*. Additionally, a one-way MANOVA simultaneously comparing the means of the two students with the other 20 students in the self-reported ADHD group on measures of attention, transcription fluency, verbal working memory, listening comprehension, quality of notes, and essay quality was not significant (Wilks' $\lambda = .57$, $F(6,15) = 1.91$, $p = .144$, observed power = .52). Furthermore, as the current study did not involve testing or clinical assessment for purposes of obtaining academic accommodations or psychostimulant medication treatment (the two most commonly documented external incentives for exaggerating or feigning ADHD symptoms in postsecondary settings; Booksh et al., 2010; Sollman et al., 2010) and students in both groups were equally paid for their participation, and all research protocols were confidential, it is unlikely that any participants intentionally reported a false diagnosis of ADHD. However, since no reviews of records or clinical assessments were conducted, the current study identified participants as self-reported ADHD.

One student within this group reported a co-occurring diagnosis of a reading disability and two students reported co-occurring diagnoses of writing disability. The majority of ADHD participants reported taking medication to focus (68.2%). A discriminant function analysis with T-scores from all five scales of the *CAARS* was conducted with the entire sample after elimination of six participants with a high inconsistency index ($n = 66$). The participants eliminated for the purpose of this analysis included three students from the self-report ADHD group and three participants from the non-ADHD group. The Eigenvalue revealed one function was generated, which was significant (Wilks' $\lambda = .46$, $\chi^2 = 48.49$, $p < .001$), indicating that

CAARS scale scores significantly differentiated between non-ADHD and ADHD by self-report students. Classification results indicated an 86.4% correct classification rate for the overall sample with 68.4% sensitivity (percentage of true cases identified) and 93.6% specificity (number of true non-cases identified).

Non-ADHD group. Participants in the control group made up 69.4% of the larger sample ($n = 50$). This group consisted of 76% females, and 66% were undergraduates with a mean age of 22.18 years ($SD = 3.40$). Four students within the control group reported a prior but not current diagnosis of ADHD. None of these four students endorsed clinically elevated symptoms on the *CAARS*.

A one-way MANOVA was conducted to simultaneously compare the means of participants in the self-reported ADHD and non-ADHD groups across 12 demographic variables. The multivariate test was significant (Wilks' $\lambda = .65$, $F(12, 58) = 2.57$, $p < .01$, partial $\eta^2 = .35$, observed power = .95). Post hoc univariate analyses were examined without applying a Bonferroni correction, as this was deemed the conservative approach when examining demographic variables. Post hoc ANOVAs revealed that students in the ADHD self-report group were more likely to be referred to participate in the current study through an office of disability services ($F(1, 69) = 15.07$, $p < .001$, partial $\eta^2 = .18$), had a higher rate of reported writing disabilities ($F(1, 69) = 4.76$, $p = .033$, partial $\eta^2 = .07$), and had a higher proportion of males ($F(1, 69) = 5.67$, $p = .020$, partial $\eta^2 = .08$). See Table 3 in Appendix A. There were no significant differences between groups across other demographic variables.

A second one-way MANOVA was conducted to simultaneously compare the means of participants in the self-reported ADHD and non-ADHD groups across eight variables related to diagnosis of ADHD (i.e., past diagnosis of ADHD, medication use, registration at office of disability services, *CAARS* scale scores). The multivariate test was significant (Wilks' $\lambda = .65$, $F(12, 58) = 2.57$, $p < .01$, partial $\eta^2 = .35$, observed power = 1.00). Since multiple post hoc tests were conducted to make univariate comparisons, a Bonferroni correction was used to avoid Type I errors; therefore, the significance level for all univariate tests was set at $p \leq .006$. Post hoc ANOVAs revealed that students in the ADHD self-report group had a greater prevalence of past ADHD diagnoses ($F(1, 70) = 245.97$, $p < .001$, partial $\eta^2 = .79$), had higher rates of medication use ($F(1, 70) = 104.17$, $p < .001$, partial $\eta^2 = .60$), and endorsed more clinically elevated items on all five scales of the CAARS (Inattention/Memory Problems: $F(1, 70) = 36.54$, $p < .001$, partial $\eta^2 = .34$; Hyperactivity/Restlessness: $F(1, 70) = 34.51$, $p < .001$, partial $\eta^2 = .33$; Impulsivity/Emotional Lability: $F(1, 70) = 25.66$, $p < .001$, partial $\eta^2 = .27$; Problems with Self-Concept: $F(1, 70) = 28.50$, $p < .001$, partial $\eta^2 = .29$; ADHD Index: $F(1, 70) = 49.99$, $p < .001$, partial $\eta^2 = .42$). See Table 4 and Figure 1 in Appendix A.

Materials

The materials consisted of: a self-report behavioral rating scale, a videotaped lecture on the psychology of problem-solving, a written recall test, a measure of attention, a measure of verbal working memory, a measure of transcription fluency, and a measure of listening comprehension. All measures were group administered. Inter-rater agreement in scoring (agreement/agreement + disagreement) was used to establish reliability for total scores on all cognitive measures across 30 randomly chosen protocols and ratings from three independent graduate student raters. Inter-rater reliability for the lecture notes and the written summary was calculated by adding the number of item agreements between two independent raters over the total number of items (i.e., 15) and then taking the average of these scores across 30 randomly chosen protocols. Disagreements were settled by consensus.

Conners' Adult ADHD Rating Scale. The *Conners' Adult ADHD Rating Scale-Short Self-Report* (Conners, Erhardt, & Sparrow, 1999; *CAARS-S: S*) was used to assess how much participants reported currently being affected by symptoms of ADHD and its related impairments. The *CAARS-S: S* is a commonly used broadband rating scale (Reilley, 2005) that is part of a larger multimodal system of assessment. It is comprised of 26 items, which culminate into an ADHD Index and four other factor-derived subscales: Inattention/Memory Problems; Hyperactivity/Restlessness; Impulsivity/Emotional Lability; and Problems with Self-Concept (i.e., tendency to have poor social relationships, low self-esteem, and low self-confidence). The ADHD Index correlates significantly with the other four subscales (.67-.73) according to the test manual. Correlations with *DSM-IV* inattention, hyperactive-impulsive, and/or total symptoms range from the moderate to high range across gender for each subscale (Inattention/Memory Problems: .65-.82; Hyperactivity/Restlessness: .59-.69; Impulsivity/Emotional Lability: .48-.73; Problems with Self-Concept: .42-.70). In addition, the rating scale includes an Inconsistency Index, which may be indicative of random responding, lack of motivation, malingering, difficulty understanding subtle differences between some items, and/or poor insight or lack of self-awareness according to the test manual.

Items concerning behaviors or problems experienced by adults were presented as statements and participants were asked to rate how much or how frequently each item best described them by circling the appropriate number on a four-point Likert scale of 0 to 3. For example, one item stated, "I have trouble getting started on a task." Participants rated statements as: never/not at all true; just a little/once in a while; pretty much/often; or very much/very frequently. According to the test manual, the *CAARS-S: S* form was formatted for a fourth grade reading level; therefore, postsecondary students should be able to read and understand all items.

The *CAARS* self-report rating scales were scored by tallying raw scores for individual subscales and converting them into gender and age based linear *T*-scores with a mean of 50 (*SD* = 10). Higher scores (*T*-score > 66) signify the strong possibility of attention problems. *T*-scores from 61 to 65 are considered in above average range (86^{th}-94^{th} percentile), and indicate symptoms approaching clinically elevated levels. Inter-rater agreement across 30 randomly chosen protocols and two independent raters was 1.0.

The *CAARS* has been found to be psychometrically sound (Gallagher & Blader, 2001; Taylor, Deb, & Unwin, 2011). Items were developed from childhood rating scales using *DSM-IV* criteria, and the scale was standardized on a large sample (*n* = 1026) of nonclinical adults from several locations in the United States and Canada, stratified by age and gender. Information on specific geographic locations, race/ethnicity, or socioeconomic status was not included in the test manual so it is unclear if the sample was representative. The test manual reported good internal consistency for the *CAARS* self-report forms with coefficient alphas from .77 to .90 for male and female adults ages 18 to 39. One-month test-retest reliability was calculated with 61 individuals who attended an adult ADHD clinic using the long version of the self-report form. Reliability coefficients were high across all subscales (.80-.91). Finally, standard errors of measurement were adequate (1.15-1.63) for men and women ages 18 to 39. In summary, based on several analyses of reliability, *CAARS* self-report measures are highly consistent in measuring the constructs they were developed to measure. Internal consistency reliability was calculated with the current sample across 26 items and was .94, indicating the scale is homogenous.

In terms of validity, the test manual states that the *CAARS* results to date have demonstrated that the scales identify adult ADHD symptomatology. A confirmatory factor analysis of 66 items and the four factor-derived subscales (i.e., Inattention/Memory Problems, Hyperactivity/Restlessness, Impulsivity/Emotional Liability, and Problems with Self-concept) of the *CAARS-S* long form met standards for good fit across gender and age groups with four factors accounting for 46.8% of the variance of the items according to the test manual. The 12 items included in the ADHD Index were based on discriminant function analyses conducted after the other four scales were derived. Six of these items overlap with items from the other four scales. A principal components factor analysis was completed with the current sample on the 26 items from the *CAARS-S:S* using a standard varimax rotation. For the sample, five component factors with eignenvalues greater than 1.0 were obtained based on the Kaiser criterion, and the final factor solution represents 70.1% of the variance in the data. Refer to Table 5 and Figure 2 in Appendix A. The five factors rotated to a varimax solution. Items were examined to determine which factor they loaded on (> 0.30 based on *CAARS* manual). Seventeen items loaded on factor 1, nine items on factor 2, 12 items on factor 3, four items on factor 4, and four items on factor 5. Refer to Table 6 in Appendix A. All items loaded on at least one of the five factors, and several items loaded on more than one factor. The five-factor structure in the current sample corresponds to the *CAARS* ADHD Index and four subscale format.

The ADHD Index was developed to identify adults likely to have a diagnosis of ADHD. According to the test manual, correlations between *DSM-IV* total ADHD symptoms and the ADHD Index were in the moderate range for males (.65) and females (.77) and displayed evidence of convergent validity for the ADHD Index and the other subscales of the *CAARS-S:S*. Concurrent validity demonstrates how well the scale ratings agree with a gold standard, like the *DSM-IV*. The *CAARS* has performed the best in terms of concurrent validity compared to other scales with concurrent validity data (Cohen's kappa = .67; Taylor et al., 2011). Initial discriminant validity of the ADHD Index was calculated when developing the scale, and discriminant function scores were used to classify 78 adults into ADHD and nonclinical control groups with a 85% overall correct classification rate (sensitivity was 82% and specificity was 87%). In order to cross-validate the ADHD Index, discriminant validity was calculated based on a clinical sample, which consisted of 96 adults referred to an outpatient clinic for ADHD assessment and a nonclinical control sample that consisted of 96 adults matched for age and gender. The results revealed adequate discriminant validity with an overall correct classification rate of 73%, with 71% sensitivity and 75% specificity according to the test manual. There is no evidence reported in the test manual for discriminant validity of the ADHD Index between adults with ADHD and clinical controls. Finally, construct validity was reported to be adequate for the long version of the *CAARS* in the test manual based on acceptable correlations with the *Wender Utah Rating Scale*, a retrospective measure of childhood ADHD symptoms, and adequate correlations with the *CAARS* observer forms. Overall, the *CAARS* has good reliability and strong concurrent and content validity, was normed on a large sample of adults, and is easy to administer in a group setting (Taylor et al., 2011).

Lecture. The lecture and the scoring method used to score participants' lecture notes were taken from Brobst (1996). The videotaped lecture, read from a prepared text by Stephen T. Peverly at a rate of 2.04 words per second, was approximately 23 minutes long and summarized basic concepts and research in the psychology of problem solving. The content of the lecture was adapted from a chapter by James Voss (1989) titled "Problem Solving and the Educational Process," from a book designed for use in an undergraduate course in educational psychology (Brobst, 1996). The lecture consisted of a total of six general themes and 15 content areas. The structure and content of the chapter are detailed in Appendix B. Participants were given three sheets of blank paper and told to take notes. They were also told that they would be allowed 10 minutes to study their notes in preparation for an essay test sometime later in the study.

Participants' notes were scored for quality. Quality scores reflected the rating (0-3) given to each of the 15 content areas mentioned. No points were given for incorrect or missing information, one point was given if a topic was mentioned but not elaborated on, two points were given for an incomplete explanation, and three points were given for a complete explanation. The quality ratings given to each of the 15 topics were item specific and specified in a manual created by Brobst (1996). For example, an individual would receive one point for writing down "problem representation," one point for defining it, and/or one point for giving an example related to the concept from the lecture. Overall quality scores could range from 0 to 45. Inter-rater reliability across two independent scorers for 30 randomly chosen protocols was .87.

Written summary. Participants were instructed to write an organized summary of the videotaped lecture without referring to their notes. They were allowed 15 minutes and given two sheets of paper for the task. The same method and criteria used for scoring the notes was used to score the essays (e.g., participants' quality scores could range from 0 to 45). Across 30 randomly chosen protocols and two independent scorers, inter-rater reliability was .96.

Attention. The Lottery subtest of the *Test of Everyday Attention* (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994; *TEA*) was used to measure sustained attention, specifically the ability to maintain attention to a relatively unchanging, at times, boring task, in the absence of external cues to attend. In this task, participants listen for their winning number, which they are told ends in the number "55" (Version A), then immediately write down the two letters preceding that number. To do this, participants are required to listen to a 10-minute series of numbers of the form "BC143, LD967" presented on a compact disc. In the current study, participants were administered the Lottery subtest in a group format, while the standardized version is administered individually. While listening to the numbers, participants were required to write down the two letters preceding all numbers ending in “55.” In sum, they were required to write down a total of 10 sets of letters. To increase the variation in participants’ scores, they received one point for every correct set of letters and half a point if they wrote down at least one of the two letters in the correct place (e.g., participant writes KB instead of KC) for a maximum of 10 points. Commission errors for each participant were also noted (i.e., if a participant inserted a set of letters not included in the correct answers) but not analyzed. Raw scores were used in data analysis instead of scaled scores since standardized administration and scoring procedures were not utilized. Inter-rater agreement across 30 randomly chosen protocols ranged from .94 to .96 among three independent raters.

According to the test manual, the *TEA* was normed on 154 normal volunteers from England ranging in age from 18 to 80. The sample was stratified by four age bands, and two levels of educational attainment based on scores above or below 100 on an adult reading test. The 18- to 34-year-old and 35- to 49-year old age groups included 74 individuals. The clinical sample consisted of 80 unilateral stroke patients seen two months post-stroke. No information on socioeconomic status or race/ethnicity was reported; therefore, it is unclear if the norming sample was representative of an adult United States population (Strauss, Sherman, & Spreen, 2006).

No internal reliability or standard errors of measurement were reported in the test manual. One-week test-retest reliability was calculated for the clinical norming sample for the Lottery subtest and was adequate (.77). A coefficient alpha was calculated for the 10 items with the current study’s sample and was .55. The Lottery subtest of the *TEA* appears to have strong validity according to the test manual. The *TEA* is one of the few tests based on an established theory of attention, demonstrating evidence of content validity and is increasingly used in clinical research on attention (Strauss et al., 2006). A principal components analysis yielded a four-factor model with the Lottery subtest having a high loading for the sustained attention factor (0.70) and low loadings for the other three factors (-.10, .18, .25), which included visual selective attention/speed, attentional switching, and auditory-verbal working memory according to the test manual. Adequate discriminant validity was also described in the test manual. The correlation between the Lottery subtest and estimated verbal intelligence as measured by a reading test when age is partialled out was low (.05). Additionally, the Lottery subtest was not highly correlated to a measure of hearing impairment, thus the subtest adequately differentiates between attention and hearing deficits. Validity studies have shown that the Lottery subtest significantly discriminates between clinical and nonclinical control groups (Robertson et al., 1994; Strauss et al., 2006). In sum, the Lottery subtest of the *TEA* is an ecologically valid measure of sustained attention increasingly used in research.

Verbal working memory (VWM). The complex listening span test is based on one first used by Daneman and Carpenter (1980) to measure participants' auditory verbal working memory. The listening span task involves the simultaneous processing of information while attempting to store and rehearse additional information (Conway et al., 2005; Daneman & Carpenter, 1980). Participants were presented with 60 unrelated sentences divided into five groups of three sets of sentences each via compact disc. The first group consisted of three sets of two sentences each. The next group consisted of three sets of three sentences each, and so on until the last group, which consisted of three sets of six sentences each. Participants listened to each sentence and determined whether it made sense or not by circling "yes" or "no" on their response sheets. Participants had two seconds before the next sentence was presented. After each sentence in a set was presented, a beep prompted the participants to recall and write down the last word of each sentence in that set. After 20 seconds, another beep sounded, signaling the beginning of the next sentence set. The yes/no component was included to ensure that participants processed the entire sentence and were not just concentrating on the final word of each sentence. For example, participants heard the following sentences:

> The house quickly got dressed and went to work.
> I took a knapsack from my shovel and began removing the earth.

After hearing each of the above sentences, participants circled either "yes" or "no" in their response booklets, and at the end of the set of two sentences wrote down the final words of each sentence, "work" and "earth." Participants were given two practice items at the two- and three-sentence level before the test began and were warned not to write down any words until the end of a sentence set.

The scoring of the processing component of the listening span test followed the procedures laid out in Daneman and Carpenter (1980). The processing score is the percentage of sentences accurately identified as making or not making sense by participants. Processing scores could range from 0 to 100%. According to Conway et al. (2005), as long as participants achieve a processing score of 85% or higher, signifying that participants were engaged in the processing task, this score can be disregarded since it correlates positively with performance on the storage component and is typically close to ceiling. Therefore, participants' processing scores were checked to make sure all participants received a score of at least 85%. Six participants were eliminated from the original sample since their processing scores fell below 85% and their scores could not be included in the main analyses resulting in the current sample size of 72. All six participants were nonnative English speakers, which may have contributed to their low processing scores. For the storage component, total scores were calculated for the number of individual items correct out of a total of 15 items. Inter-rater agreement across 30 randomly chosen protocols among three independent raters ranged from .94 to .96 for the processing scores and .84 to .94 for the total scores.

Span tests are not standardized measures; however, reliability and validity information have been collected from various studies completed with these tests. Working memory span tasks "have proven to be both reliable and valid measures of working memory capacity" (Conway et al., 2005, p. 769). Working memory span tasks have shown adequate reliability based on internal consistency as measured by coefficient alphas and split-half correlations (.70-.90) for span scores (Conway et al.). Additionally, test-retest reliability was high (.70-.80) for reading span tasks when taken over minutes, weeks, months, and even a year (Conway et al.). Since the correlation between the reading and the listening span task is high (.75), we can extrapolate these findings to the listening span task (Daneman & Carpenter, 1980). Reliability coefficients have demonstrated that working memory span tasks accurately measure the construct they were developed to measure. A coefficient alpha was calculated for the current sample across the 15 items of the VWM task and internal consistency was adequate (.71).

In terms of validity, working memory span tasks have shown considerable construct validity since they predict performance on a wide variety of tasks for which control of attention and thought are important (Conway et al., 2005). Additionally, complex span tasks have demonstrated convergent validity based on the adequately high correlations among span tests and performance on tests of more complex cognition that depend on working memory (Conway et al.). Furthermore, evidence of discriminant validity has also been revealed in studies where complex span tasks did not predict performance on tasks that reflected relatively automatic and not complex processing (Conway et al.). Therefore, complex span tasks, including the listening span test used in this study, have methodologically been established as reliable and valid measures of working memory.

Transcription fluency. The alphabet task is based on one used by Berninger, Mizokawa, and Bragg (1991) that asked children to write the alphabet as quickly and accurately as they could from memory in the correct sequence in one minute. In this study, participants were given a sheet of lined paper and instructed to write the alphabet horizontally in capital or lowercase letters, starting with the letter “A,” repeatedly over the course of one minute. One point was awarded for each recognizable letter, and the points were summated to calculate participants’ total scores. Inter-rater agreement across 30 randomly chosen protocols and among three independent raters was 1.0.

Listening comprehension. The Listening Comprehension subtest of the *Kaufman Test of Educational Achievement-Second Edition* (Kaufman & Kaufman, 2004; KTEA-II) was used as a measure of participants’ listening comprehension. This subtest is typically administered in an individual format, where the examinee is required to listen to a passage presented on a compact disc, and then immediately after each passage orally answer questions presented by the examiner. Typical administration of the subtest was slightly altered from the test manual for facilitation of group administration. Participants were required to listen to six passages presented on a compact disc (Form A) that were approximately a minute in length. The passages in the Listening Comprehension subtest emphasize the ability to extract meaning from related sentences and deemphasize the measurement of vocabulary level (i.e., few words are more than one grade level higher than the target grade). Expository and narrative passages were both represented.

Based on data from pilot testing, after each passage, questions related to the passage were displayed individually on a Powerpoint slide for 30 seconds and participants were asked to write down their responses on lined spaces provided in their research packets. These modifications were necessary for group administration in order to prevent participants from reading questions before or while listening to passages and to prevent participants from going back to earlier questions. After presentation of each passage, participants answered two to four questions about each passage in their research packets. Items consisted of short-answer and multiple-choice questions, which measured either literal comprehension or inferential comprehension. Literal comprehension items required the recognition or recall of ideas, information, or events explicitly stated in the passage. Inferential comprehension items required the generation of new ideas from those stated in the passage. Each passage was presented only once and participants were given 30 seconds to answer each question.

The Listening Comprehension subtest was scored based on guidelines provided in the *KTEA-II* test manual. Participants' responses were either awarded zero or one point based on closeness to correct answers provided in the test manual. Participants could earn a total of 19 points for the 19 items. Total raw scores instead of scaled scores were used in data analysis since standard administration was not utilized. Inter-rater agreement across 30 randomly chosen protocols and among three independent raters ranged from .82 to .84.

According the test manual, standardization took place between September 2001 and May 2003. The age norm sample ($N = 3000$) consisted of ages 4-6 to 25-11, while the grade norm sample ($N = 2400$) consisted of grades kindergarten through twelfth. There was overlap between samples. The sample was collected from 39 states and Washington, D.C., and matched the US population on sex, mother's educational level, ethnicity, and geographic region. The sample aged 18 to 25 controlled for educational status using four categories: in secondary school or dropped out; graduated from high school with no postsecondary education; in two-year postsecondary program or will begin program; in four-year postsecondary program or will begin program. This sample was divided into the age ranges of 18 (n = 100), 19 (n = 80), 20-22 (n = 125), and 23-25 (n = 125) with the majority of the sample in or about to begin some type of four-year postsecondary program.

CD administration yielded higher reliabilities than oral presentation by an examiner according to the test manual. Internal consistency reliability coefficients for the Listening Comprehension subtest were high (.83-.87) across the 17 to 25-year-old age group and (0.85) grades 11-12. The test manual reported standard errors of measurement to be 5.30 (age group) and 5.90 (grade group). According to the test manual, inter-rater reliability for the subtest was high (.97). A coefficient alpha was calculated for the current sample across the 19 items and internal consistency was .62. Validity was based on correlations to cognitive and other achievement measures. Correlations were moderate (.61-.73) between the listening comprehension subtest and measures of reading comprehension from the *KTEA-II* and *WIAT-II*. The subtest also correlated with measures of verbal intelligence (.75, *WJ-III Gc* Index; .66-.67, *WISC-III* VIQ and VCI Indices). The manual included information about listening comprehension performance in a group of ADHD individuals up to age 18. The mean scores of individuals with ADHD were 6.9 points lower than individuals in the matched control group. Overall, the *KTEA-II* test manual provided evidence for the adequate reliability and validity for the Listening Comprehension subtest.

Procedure

Participants completed all measures in a group format over the course of a two-hour session. Potential participants received a packet of materials with a consent form outlining the study's purpose, procedures and materials, time involved to complete the study, and the participants' rights. Participants read the information silently as the researcher read it aloud. If participants agreed to participate, they signed the consent form, completed a short demographics questionnaire, and filled out the *CAARS-S:S*, which took approximately 15 minutes. Participants were afforded the opportunity to ask questions at the beginning of each task. Subsequently, participants watched a videotape on the psychology of problem solving (a lecture read from a prepared text), while taking notes on three pieces of paper provided in the packet of materials (23 minutes). After the lecture, participants completed the Lottery subtest of the TEA (10 minutes), the listening span task (15 minutes), and the alphabet task (one minute). Participants then had 10 minutes to review their notes before completing the Listening Comprehension subtest of the *KTEA-II* (17 minutes). Finally, participants were given 15 minutes to complete a written essay summary of the lecture. Over the course of the experiment, participants were offered sugary snacks and given a break during the review period. After collection of the packets at the end of the session, participants were thanked, paid for their participation in the study, and provided with an opportunity to ask further questions about the study. To ensure confidentiality, the consent forms, which link each participant to his/her packet, were removed from packets and stored separately.

Research Design

The present study employed a correlational design with one between-subjects' factor (disability status) and several continuous variables. The primary independent variable was disability status with two levels (ADHD by self-report or non-ADHD). The primary outcome variables were quality of notes and essay performance (written summary). Other continuous independent variables included: attention (lottery subtest), transcription fluency (alphabet task), verbal working memory (complex listening span task), and listening comprehension (listening comprehension subtest).

A power analysis was conducted to estimate sample size necessary to detect an effect when running multiple regressions with five or six independent variables. Cohen's effect size for multiple regression (f^2) was determined based on an R^2 (.175) from previous research with lecture notes, essay performance, and other similar cognitive independent variables (Peverly et al., 2010). A power analysis with statistical power at .80, an alpha level at .05, an estimated effect size at 0.21, and six predictors yielded an estimated sample size of 72 participants for a moderate effect (Cohen, 1992). The same analysis with five predictors yielded a sample size of 67 participants.

Chapter IV

Results

The current study was designed to investigate three principal questions: (1) Are there significant differences between ADHD self-report and non-ADHD postsecondary students, specifically in terms of attention, transcription fluency, VWM, listening comprehension, quality of notes, and/or essay performance? (2) What variables contribute to differences in quality of lecture notes? and, (3) What variables contribute to differences in essay performance? The dependent variables were quality of notes and essay quality. The independent variables were disability status (i.e., ADHD self-report or non-ADHD), attention, transcription fluency, verbal working memory, and listening comprehension.

Table 7 contains the means, standard deviations, range of scores in the total sample and information about the distribution for each of these variables. The variables of transcription speed, VWM, notes' quality, and essay performance met all assumptions of normality. For measures of attention and listening comprehension, the variables were slightly negatively skewed and there was evidence for positive kurtosis, indicating few participants' scores fell in the very low and very high ranges. See Figures 3 and 4 in Appendix A for distribution of these two variables. Since the variables were only slightly skewed, no transformations were performed.

Table 7
Means, Standard Deviations, Ranges, Skew, and Kurtosis for Predictor and Outcome Variables

	Mean	*SD*	*Range*	*Skew*	*Kurtosis*
Attention	8.76	1.11	5.0-10.0	-1.40(.28)	2.24(.56)
Transcription Fluency	118.92	23.24	71-176	.13(.28)	-.63(.56)
VWM	9.13	2.79	4-15	.14(.28)	-.55(.56)
Listening Comp.	14.15	2.77	4-19	-1.22(.28)	2.21(56)
Notes	22.13	6.44	8-36	.01(.28)	-.27(.56)
Essay	7.53	3.85	0-18	.41(28)	-.13(.56)

Note. VWM = verbal working memory; Listening Comp. = listening comprehension

Mutlivariate and Univariate Tests

There were 22 students in the ADHD self-report group and 50 students in the non-ADHD group. A one-way MANOVA was conducted to simultaneously compare the means between the self-reported ADHD and non-ADHD groups across measures of attention, transcription fluency, VWM, listening comprehension, notes' quality and essay quality. It was hypothesized that students with self-reported ADHD would have lower means than students without ADHD on measures of attention and verbal working memory and on notes' quality and essay performance.

The assumption of equal covariance matrices was met (Box's $M = 29.35$, $F(21, 6453) = 1.23$, $p = .210$). The multivariate test was significant (Wilks' $\lambda = .70$, $F(6, 65) = 4.73$, $p < .001$, partial $\eta^2 = .30$, observed power = .98). Since multiple post hoc tests were conducted to make univariate comparisons, a Bonferroni correction was used to avoid Type I errors; therefore, the significance level for all univariate tests was set at $p \leq .008$. All assumptions of equal variances were met except for the variable of attention ($p = .035$). Post hoc ANOVAs revealed that the transcription fluency of students in the non-ADHD group was on average higher than the students in the self-reported ADHD group ($F(1, 70) = 12.52$, $p = .001$, partial $\eta^2 = .15$). Additionally, on average, students in the non-ADHD group recorded more information in their essays than the self-reported ADHD group ($F(1, 70) = 9.89$, $p = .002$, partial $\eta^2 = .12$). Table 8 presents the results of the univariate tests. On average, students in the self-reported ADHD group recorded 48.5% of the ideas presented in the lecture, but only recalled 12.2% of those same ideas in their written summaries. Students in the non-ADHD group recorded 49.5% of the ideas presented in the lecture in their notes, but recalled a greater number of ideas in their written summaries (18.7%). Contrary to hypotheses, post hoc univariate tests revealed no significant differences between the means of self-reported ADHD and non-ADHD students on measures of attention, VWM, listening comprehension, or notes' quality. However, the means of the groups did significantly differ on the measure of attention at the .05 alpha level (p = .012). As mentioned earlier, error variances were not equal across groups for attention, which may have increased the chance of a Type II error (i.e., accepting the null hypothesis when it is false).

Table 8
Results of Univariate ANOVAs Comparing ADHD and Non-ADHD Groups Across All Measures (n = 72)

	ADHD Group (n = 22)		*Non-ADHD Group (n = 50)*		
Source	*Mean*	*SD*	*Mean*	*SD*	*Significance*
Attention	8.27	1.35	8.98	.93	.012
Transcription Fluency	105.36	25.38	124.88	19.69	.001**
VWM	8.64	2.42	9.34	2.94	.328
Listening Comp.	14.23	3.37	14.12	2.50	.881
Notes	21.82	5.58	22.26	6.83	.791
Essay	5.50	3.35	8.42	3.74	.002*

Note. VWM = verbal working memory; Listening Comp. = listening comprehension; Bonferroni Correction = .008
*$p \leq .008$, **$p = .001$

Intercorrelations

Intercorrelations for the independent and dependent variables within the total sample, within the self-reported ADHD group, and within the non-ADHD group are presented in Tables 9, 10, and 11. For the total sample, disability status was significantly negatively correlated to performance on measures of attention (-.30, $p < .05$), transcription fluency (-.39, $p < .01$), and essay quality (-.35, $p < .01$). Attention (.26, $p < .05$), transcription fluency (.24, $p < .05$), and listening comprehension (.25, $p < .05$) were all significantly correlated with quality of notes. Disability status (-.35, $p < .01$), transcription fluency (.36, $p < .01$), listening comprehension (.36, $p < .01$), and quality of notes (.59, $p < .01$) were all significantly correlated with essay quality.

For the self-reported ADHD group, transcription speed was the only variable that significantly correlated to quality of notes (.53, $p < .05$). Transcription fluency (.45, $p < .05$) and quality of notes (.46, $p < .05$) were the only variables that significantly correlated to essay quality. While in the non-ADHD group, none of the independent variables significantly correlated with quality of notes. Listening comprehension (.43, $p < .01$) and quality of notes (.68, $p < .01$) were the only variables that significantly correlated with essay quality.

Table 9

Intercorrelations Among the Independent and Dependent Variables for Entire Sample (n =72)

Variable	1	2	3	4	5	6	7
1. Disability Status	--						
2. Attention	-.30*	--					
3. Transcription Fluency	-.39**	.29*	--				
4. VWM	-.12	.11	.02	--			
5. Listening Comp.	.02	-.01	.02	.21	--		
6. Notes	-.03	.26*	.24*	-.10	.25*	--	
7. Essay	-.35**	.23	.36**	.17	.36**	.59**	--

Note. VWM = verbal working memory; Listening Comp. = listening comprehension

*$p < .05$ ** $p < .01$ ***$p < .001$

Table 10

Intercorrelations Among the Independent and Dependent Variables for the ADHD Group (n =22)

Variable	1	2	3	4	5	6
1. Attention	--					
2. Transcription Fluency	.25	--				
3. VWM	.19	.00	--			
4. Listening Comp.	.05	-.05	.13	--		
5. Notes	.28	.53*	-.28	.39	--	
6. Essay	.18	.45*	.00	.32	.46*	--

Note. VWM = verbal working memory; Listening Comp. = listening comprehension

*$p < .05$ ** $p < .01$ ***$p < .001$

Table 11
Intercorrelations Among the Independent and Dependent Variables for the non-ADHD Group (n = 50)

Variable	1	2	3	4	5	6
1. Attention	--					
2. Transcription Fluency	.16	--				
3. VWM	.02	-.04	--			
4. Listening Comp.	-.06	.08	.26	--		
5. Notes	.27	.12	-.05	.19	--	
6. Essay	.11	.17	.18	.43**	.68**	--

Note. VWM = verbal working memory; Listening Comp. = listening comprehension
*$p < .05$ ** $p < .01$ ***$p < .001$

Multiple Regression Analyses

Regression analyses using the enter method were used to evaluate which variables contributed significantly to notes' quality and essay performance. In the first regression analysis, quality of notes was regressed on disability status, attention, transcription fluency, VWM, and listening comprehension. It was hypothesized that disability status, attention, and transcription fluency would all significantly predict quality of notes. The regression model was significant (tolerance and variance inflation factor values were within acceptable limits; $R = .45$, $R^2 = .20$, $R^2_{adjusted} = .14$; $F(5, 66) = 35.73$, $p = .01$). The model accounted for 20% of the variance in the data. The effect size, with R^2 used as an estimate of effect size, was moderate (Cohen, 1992). Contrary to expectations, attention ($\beta = .25$, $p < .05$) and listening comprehension ($\beta = .29$, $p < .05$) were the only significant predictors of quality of notes. See Table 12.

Table 12

Summary of Regression Analysis Predicting Quality of Notes (n = 72)

Variable	*B*	*SE B*	*β*	*Tolerance*	*VIF*
Disability Status	1.33	1.71	.10	.80	1.25
Attention	1.47	.68	.25*	.87	1.15
Transcription Fluency	.06	.03	.20	.81	1.23
VWM	-.40	.26	-.18	.94	1.07
Listening Comp.	.66	.26	.29*	.95	1.05

Note. VWM = verbal working memory; Listening Comp. = listening comprehension; VIF = variance inflation factor

*$p < .05$ ** $p < .01$ *** $p < .001$

In the second regression analysis, essay performance was regressed on disability status, attention, transcription speed, VWM, listening comprehension, and quality of notes. It was hypothesized that disability status and quality of notes would both significantly predict essay performance. The regression model was significant (tolerance and variance inflation factor values were within acceptable limits; $R = .74$, $R^2 = .55$, $R^2_{\text{adjusted}} = .51$; $F(6, 65) = 7.34$, $p < .001$). The model accounted for 55% of the variance in the data. The effect size, with R^2 used as an estimate of effect size, was large (Cohen, 1992). Initial hypotheses were upheld. Consistent with expectations, notes' quality ($\beta = .53$, $p < .001$) was the best predictor of essay quality and disability status also significantly predicted essay quality ($\beta = -.29$, $p < .01$). Contrary to expectations, listening comprehension ($\beta = .19$, $p < .05$) also significantly predicted essay quality. See Table 13.

Table 13
Summary of Regression Analysis Predicting Essay Performance (n = 72)

Variable	*B*	*SE B*	*β*	*Tolerance*	*VIF*
Disability Status	-2.36	.78	-.29**	.80	1.26
Attention	-.17	.32	-.05	.81	1.23
Transcription Fluency	.02	.02	.13	.78	1.28
VWM	.21	.12	.15	.90	1.11
Listening Comp.	.27	.13	.19*	.87	1.15
Notes	.32	.06	.53***	.80	1.25

Note. VWM = verbal working memory; Listening Comp. = listening comprehension; VIF = variance inflation factor
*$p < .05$ ** $p < .01$ *** $p < .001$

Interactions between group (self-reported ADHD or non-ADHD) and each continuous independent and dependent variable were examined in individual regression analyses due to small size and increased likelihood of Type II errors. All continuous variables were centered (means were zero) prior to testing for interactions. No interactions were significant when regressed on either quality of notes or essay performance.

Supplementary Post Hoc Analyses

Outliers. Transcription fluency is one of the independent variables examined in all three research questions of the present study and is a measure of handwriting speed. Due to the small sample size of the current sample, two individuals with diagnoses of writing disability in the sample could present as outliers and skew the results. However, removing these two participants from the sample did not change the results of the multivariate, univariate, or regression analyses. Therefore, the two participants were retained within the total sample.

While the entire sample in the ADHD group self-reported a diagnosis of ADHD, two participants were neither registered with their office of disability services or endorsed elevated symptoms on at least one scale of the *CAARS*. The two remaining students were not excluded from the sample as they endorsed symptoms approaching elevated scores (*T*-score > 61) on at least one scale of the *CAARS*. However, all analyses were conducted after removing these two participants from the sample in order to ensure the self-reported ADHD sample was homogeneous. Results for multivariate tests, univariate tests, and the first regression analysis with notes' quality as the outcome variable all remained the same. Exclusion of the two participants changed the outcome of the second regression analysis with essay quality as the dependent variable in that only quality of notes and disability status remained significant predictors of essay quality. Listening comprehension no longer significantly predicted essay quality at $p = .051$. This slight change in outcomes is more likely a result of decreased statistical power due to diminished sample size rather than differences in the two excluded participants. Therefore, the two participants were retained in all analyses.

Schools. Due to difficulties recruiting a sufficient sample of participants with self-reported ADHD from a single university, even after collecting data for close to two years, the current researcher expanded recruitment efforts to include students from other universities. As a result, the total sample consists of students enrolled in various universities. See Table 14 in Appendix A. Therefore, a one-way MANOVA was conducted to simultaneously compare the means of students from New York University ($n = 37$), Teachers College ($n = 21$), and a group of six other institutions ($n = 14$) on the variables of disability status, attention, transcription fluency, verbal working memory, listening comprehension, notes' quality, and essay performance to test if the sample was still homogenous. Fourteen students from six different universities were grouped into an "Other" category since no more than four students were enrolled in the same institution. The assumption for equality of covariance matrices was met (Box's $M = 73.36$, $F(56, 5418) = 1.07$, $p = .335$). The multivariate test was significant (Wilks' λ

= .63, $F(14, 126) = 2.35$, $p < .01$, partial $\eta^2 = .21$, observed power = .97), indicating differences among schools.

Follow-up univariate analyses applying Tukey's HSD correction revealed differences in means across disability status and essay performance among schools. The other group included more students with ADHD than New York University and Teachers College. There were no differences in disability status between New York University and Teachers College. As additional universities were added in order to specifically recruit students with ADHD, this finding is not surprising. Teachers College students had the highest essay scores, and New York University students had higher essay scores than students in the other group (TC > NYU > Other). These results indicate that graduate students (i.e., all students in the Teachers College group) performed better on a written recall test than undergraduates. See Table 15 for means and standard deviations and Figures 5 and 6 in Appendix A. Given these differences by school, the best practice would be to analyze all data with multilevel models. However, the current sample size is not sufficient to perform these analyses. Future research should consider sampling a large number of participants from multiple schools and examining these data within a nested framework to test whether the relationships among disability status and the other variables measured in this study are similar across academic institutions. However, this is beyond the scope of the current study as a larger sample size would be required to run this analysis.

Gender. In order to assess the impact of gender differences on outcomes, a one-way MANOVA was conducted to simultaneously compare the means of males and females on measures of attention, transcription fluency, VWM, listening comprehension, notes' quality, essay quality, and disability status. The assumption for equality of covariance matrices was met (Box's $M = 43.06$, $F(28, 6941) = 1.34$, $p = .111$). The multivariate test was significant (Wilks' λ

= .71, $F(7, 64) = 3.79$, $p < .01$, partial $\eta^2 = .29$, observed power = .97), indicating differences between males and females. Since post-hoc tests were conducted to make multiple comparisons, a Bonferroni correction was used to avoid Type I errors; therefore, the significance level for all univariate ANOVA tests was set at $p \leq .007$. Assumptions of equal variances were met for all variables except disability status. Follow-up univariate ANOVAs revealed that females took better notes than males ($F(1, 70) = 11.58$, $p = .001$, partial $\eta^2 = .14$) and obtained higher scores on essay quality ($F(1, 70) = 8.92$, $p = .004$, partial $\eta^2 = .11$). See Table 16 in Appendix A.

As a result of differences between males and females on some of the independent variables, gender was entered as a covariate in another MANOVA comparing means of the ADHD self-report and non-ADHD groups on attention, transcription fluency, VWM, listening comprehension, notes' quality, and essay performance. The interaction term (gender by disability status) was tested. The assumption for equality of covariance matrices was met (Box's $M = 29.35$, $F(21, 6453) = 1.23$, $p = .210$). The multivariate test for the interaction term was significant (Wilks' $\lambda = .49$, $F(12, 128) = 4.53$, $p < .001$, partial $\eta^2 = .30$, observed power = 1.00), indicating differences between males and females across disability and control groups. Therefore, main effects for gender and disability status were not further examined. Instead, all participants were placed into four categories: female ADHD, female non-ADHD, male ADHD, and male non-ADHD. This between-subject's variable with four levels was entered into a MANOVA to simultaneously compare the means of all four groups across all previous variables. The assumption for equality of covariance matrices was met (Box's $M = 85.54$, $F(63, 3596) = 1.04$, $p = .384$). The multivariate test was significant (Wilks' $\lambda = .44$, $F(18, 179) = 3.35$, $p < .001$, partial $\eta^2 = .24$, observed power = .99), indicating differences among the four groups.

Follow-up univariate analyses applying Tukey's HSD correction revealed differences among groups on measures of attention and transcription fluency and on notes' quality and essay performance. No differences were observed on measures of VWM or listening comprehension. In terms of attention, female self-reported ADHD students obtained significantly lower scores than male self-reported ADHD students and female controls. There were no differences between female ADHD students and male controls on attention. On transcription fluency, male self-reported ADHD students on average obtained significantly lower scores than female controls. There were no significant differences between any other groups. For notes' quality, female controls obtained significantly higher scores than male controls; however, there were no differences between female controls and either male or female self-reported ADHD students. There were also no significant differences between male controls and either male or female self-reported ADHD students. Finally, in terms of essay performance, female controls obtained significantly higher scores than male controls, female ADHD students, and male ADHD students. Male controls, female ADHD students, and male ADHD students did not differ significantly on essay performance. See Table 17 for means and standard deviations and Figures 7-12 for disability by gender plots on each dependent variable in Appendix A.

Interactions between gender and each of the independent variables (i.e., disability status, attention, transcription fluency, VWM, listening comprehension) were separately regressed on quality of notes. All continuous variables were centered for the analyses. None of the interactions were significant. The analysis was repeated with essay performance as the outcome variable. The interactions between gender x attention ($\beta = -.43$, $p < .05$) and gender x notes ($\beta = -.43$, $p < .05$) were found to be significant. Given the significance of these two interactions, data from this study were analyzed using forced entry hierarchical regression analyses. Essay performance was regressed on gender, disability status, attention, transcription fluency, VWM, listening comprehension, and notes' quality in the first block and two significant interactions (gender x attention and gender x notes' quality) in the second block. The regression equation was significant for Model 1 (tolerance and variance inflation factor values within acceptable limits; $R = .74$, $R^2 = .55$, $R^2_{adjusted} = .50$; $F(7, 64) = 11.21$, $p < .001$) and Model 2 (tolerance and variation inflation factor values were not within acceptable limits; $R = .75$, $R^2 = .57$, $R^2_{adjusted} = .50$; $F(9, 62) = 1.15$, $p < .001$). The R^2 change from Model 1 to Model 2 was significant (R^2 change = .016, $p < .05$). In Model 1, disability status ($\beta = -.27$, $p < .01$), listening comprehension ($\beta = .20$, $p < .05$), and notes' quality ($\beta = .51$, $p < .001$) were the only significant predictors of essay performance, replicating results from the multiple regression analysis without gender. In Model 2, disability status ($\beta = -.22$, $p < .05$) and listening comprehension ($\beta = .13$, $p < .05$) were the only significant predictors. The interactions were not significant. See Table 18 in Appendix A. These results should be interpreted with caution as tolerance and VIF values were outside normal limits and small sample size may have not been adequate enough to detect significant differences.

Undergraduate versus Graduate Students. A one-way MANOVA was conducted to simultaneously compare the means of undergradute ($n = 48$) and graduate ($n = 23$) students on measures of attention, transcription fluency, VWM, listening comprehension, note's quality, essay quality, and disability status. The assumption of equal covariance matrices was met at the .01 alpha level (Box's $M = 54.94$, $F(28, 6941) = 1.70$, $p = .012$). The multivariate test was significant (Wilks' $\lambda = .78$, $F(7, 64) = 2.61$, $p < .05$, partial $\eta^2 = .22$, observed power = .86). Since multiple post-hoc tests were conducted to make multiple comparisons, a Bonferroni correction was used to avoid Type I errors; therefore, the significance level for all univariate

ANOVA tests was set at $p \leq .007$. Assumptions of equal variances were met. Post-hoc univariate analyses revealed that graduate students took better notes than undergraduate students ($F(1, 70) = 7.59$, $p = .007$, partial $\eta^2 = .10$). Additionally, graduate students recalled more information in their essays than undergraduate students ($F(1, 70) = 14.97$, $p < .001$, partial $\eta^2 = .18$). Given the higher level of education attained by graduate students, these results are not surprising. Results are displayed in Table 19 in Appendix A.

Chapter V

Discussion

Taking and reviewing lecture notes is the preferred and most prevalent method of studying in higher education (Armbruster, 2009). Yet few studies have focused on the underlying cognitive variables related to lecture note-taking, especially in the context of a postsecondary disability population. This is the first dissertation to investigate differences in lecture note-taking directly between postsecondary students with and without self-reported diagnoses of ADHD. The primary purpose of this study was to determine if disability differences in lecture note-taking exist, and if they do, to examine the cognitive variables that might explain them. A second purpose was to determine if there might be disability related differences in test performance. The current study is also an extension of previous studies on lecture note-taking (Peverly & Garner, 2010; Peverly et al., 2007; Peverly et al., 2010) to a disability population, specifically students reporting clinically significant symptoms of ADHD.

In the current study, students took notes on a videotaped lecture, reviewed their notes, and took a written free recall test. The independent variables included disability status (i.e., self-reported ADHD and non-ADHD), attention, transcription fluency, verbal working memory, and listening comprehension. The dependent variables were quality of notes and essay performance. A discussion of the relationship between disability status and notes' quality is presented first, followed by a discussion of the relationship between disability status and essay quality. Possible reasons for disability related differences in the independent variables included in this study are also discussed. Finally, a discussion of limitations and of implications for practice and future research is presented.

What variables contribute to differences in quality of lecture notes in a group of postsecondary students with self-reported ADHD and without ADHD?

The role of attention, transcription fluency, verbal working memory, listening comprehension, and current disability status was examined in relation to quality of lecture notes. It was hypothesized that disability status, attention, and transcription fluency would all contribute to quality of notes. Instead, attention and listening comprehension were the only predictors of notes' quality.

Disability status and attention.

Contrary to expectations, disability status did not predict quality of notes. A follow-up ANOVA comparing means of self-reported ADHD and non-ADHD postsecondary students also revealed no differences in quality of lecture notes. Students in the self-reported ADHD group recorded 48.5% of the ideas presented in the lecture, while students in the control group recorded 49.5% of the ideas. While previous research has not measured quality of lecture notes between confirmed or self-reported ADHD postesecondary students and non-ADHD students, accommodations provided to many students with ADHD include copies or audiorecordings of lecture notes. Thus, it was hypothesized that students reporting an ADHD diagnosis would record fewer notes than the control group because of the difficulties they experience in attending (Williams & Eggert, 2002a). The only other study to examine lecture note-taking in students with ADHD found that they recorded 69.8% of the main ideas and 41.1% of the details from a history lecture (Evans et al., 2001). However, the sample in this study consisted of adolescents and no comparison group.

It was also hypothesized that self-reported ADHD students would obtain lower scores than non-ADHD students on a measure of attention as ADHD by definition is a disorder affecting attention. Inconsistent with this hypothesis, no attentional differences were found between the two groups. Unlike the findings from the current study, previous studies have consistently documented deficits in vigilance or sustained attention as measured through higher omission errors compared to controls on continuous performance tests in adults with ADHD (Hervey et al., 2004; Johnson et al., 2001; Murphy et al., 2001; Seidman et al., 1998) and postsecondary students with ADHD (Weyandt & DuPaul, 2006). However, two previous studies also found no attentional differences between confirmed ADHD adults and controls (Holdnack et al., 1995; Rapport et al., 2001). Furthermore, there is some support for the idea that ADHD is not primarily a disorder of attention but a disorder of behavioral inhibition (Barkley, 2006) or more broadly a disorder of executive functions (Cutting & Denckla, 2003). Further studies examining attention in postsecondary students with ADHD are needed to reach any conclusions.

While disability status did not predict quality of notes, attention did contribute to notes' quality. The current study specifically measured sustained attention, or the ability to stay on task for an appreciable amount of time (Mirsky et al., 1999). As most lectures require students to be vigilant for long periods of time, it is not surprising that there was a significant relationship between attention and quality of notes. During the encoding or process phase of lecture note-taking, students must attend to the lecture, which requires orienting to the lecture by listening, inhibiting other distractions not directly related to the lecture, and maintaining attention for the entirety of the lecture. Previous research has noted that unless students' attention is focused on what the instructor is saying, there is little chance that meaningful processing and note-taking will follow (Williams & Eggert, 2002a). Support for the role of attention in quality of notes was also demonstrated by Peverly and Garner (2010), in which the researchers used the same measure of attention as utilized in the present study. Results from this study found that attention significantly correlated to and predicted quality of students' notes (Peverly & Garner, 2010). The results from the present study provide further support to indicate that attention is in fact implicated in lecture note-taking in postsecondary settings.

Possible explanations for the lack of significant differences between groups in attention and the lack of a significant relationship between attention and the quality of notes may be the result of the nature of the sample (i.e., students self-reporting a diagnosis of ADHD versus confirmed diagnoses of ADHD and/or the highly selected population of postsecondary students as compared to adults in the general population), and/or medication use. The current study included postsecondary students who self-reported a diagnosis of ADHD. Therefore, it is likely these students were reporting symptoms of ADHD that did not meet the threshold for full criteria for the disorder and/or were not experiencing impaired educational functioning. These students may be more representative of individuals at the higher end of ADHD symptomatology. Yet the one study comparing psychological functioning between college students with confirmed ADHD and college students with self-reported symptoms of ADHD found significant similarities between the groups and significant differences between both groups when compared to a control group of students without ADHD, suggesting that students who self-report symptoms of ADHD may have the disorder or are experiencing similar symptomatology (Richards et al., 1999).

Additionally, the underlying cognitive variables in lecture note-taking have not previously been studied in a population of postsecondary students with significant symptoms of ADHD. It is possible that students with ADHD who gain admission to postsecondary institutions may not exhibit some of the same cognitive deficits as those in the general ADHD adult population due to higher IQs or more well-developed compensatory.

Finally, the impact of psychostimulant medications in the present study cannot be ruled out as a possible explanation for better outcomes on lecture notes. Sixty-eight percent of the ADHD sample reported taking medication to focus. On the one hand research on adolescents with ADHD has shown an increase in note-taking behavior related to the effect of methylphenidate (Evans et al., 2001), and stimulant medication has been shown to reliably improve sustained attention in adults with ADHD (Advokat, 2010). On the other hand, a review of research in adults with ADHD found that stimulant medications do not equalize academic achievement or improve performance on more complex cognitive tasks (Advokat, 2010). Although the research is equivocal, it may be that the note-taking performance of the ADHD group included in this study was improved by their use of stimulant medications.

However, the explanations mentioned above are not supported in the research literature. A review of the literature suggests that postsecondary students with both significant self-reported and confirmed ADHD symptoms generally obtain lower GPAs, receive more special education services, are more likely to be on academic probation, and are less likely to graduate with a degree when compared to non-ADHD peers (Barkley, 2006; Barkley et al., 2008; Blaise et al., 2009; DuPaul et al., 2009; Heiligenstein et al., 1999; Kaminski et al., 2006; Lewandowski et al., 2008; Murphy et al., 2002; Norwalk et al., 2008; Weyandt & DuPaul, 2006; Wolf, 2001). These outcomes hold true even in the absence of intellectual or other psychological problems. Therefore, it is more likely that taking lecture notes may not be an area of impairment for students with ADHD.

Listening comprehension.

With regard to lecture note-taking, this is the first study to examine the role of listening comprehension to quality of notes. Previous research examining the role of reading comprehension to quality of notes in postsecondary students has shown that reading comprehension significantly predicts notes' quality (Peverly & Sumowski, in press; Peverly et al., 2010). Since there is a high correlation (.90) between listening and reading comprehension at the college level (Gernsbacher, as cited in Perfetti et al., 2005), the current results are consistent with previous research regarding the relationship between comprehension and quality of notes. While some researchers characterize note-taking as a complex process involving both the comprehension and production of written output (Kiewra & Benton, 1988; Piolat et al., 2005), others stipulate that it is possible to hear what an instructor says, even repeat what the instructor said, with minimal understanding of the instructor's comment (Williams & Eggert, 2002a). The findings from the current study suggest that lecture note-taking involves some level of comprehension prior to and/or while transcribing information from a lecture.

Self-reported ADHD and non-ADHD students did not differ on a measure of listening comprehension. Research has not examined listening comprehension in postsecondary students with ADHD symtomatology. Research on reading comprehension, which correlates to listening comprehension, has been more prevalent. Lower reading comprehension abilities in children (Brock & Knapp, 1996; Ghelani et al., 2004; Javorsky, 1996) and incarcerated adults with ADHD (Samuelsson et al., 2004) compared to controls have been observed. Yet one study noted that while students without ADHD had significantly higher reading comprehension scores than students with ADHD, the scores of the latter group were still in the average range (Ghelani et al., 2004). In general, research on differences in reading comprehension among children and adults with and without ADHD has produced inconsistent results. Thus, it may be that postsecondary students with ADHD do not show deficits in this area for some of the reasons cited above; however, further research replicating these results is needed before reaching any conclusions.

Transcription fluency.

Transcription fluency and verbal working memory were the other independent variables examined in this study. Neither of them significantly predicted quality of notes. The finding related to transcription fluency is surprising and in contrast to previous research which has shown transcription fluency to be related to quality of notes (Peverly & Garner, 2010; Peverly et al., 2007; Peverly & Sumowski, in press; Peverly et al., 2010). As in previous studies, transcription fluency did significantly correlate with quality of notes (.25). A possible explanation for this discrepancy is lack of sufficient statistical power to detect a significant result in the current study due to a small sample size.

Verbal working memory.

Verbal working memory also did not significantly predict quality of notes. The role of working memory in predicting quality of notes has been equivocal. Some researchers have documented the role of verbal working memory in taking lecture notes using the reading span task (Hadwin et al., 1999; Piolat, 2007). Yet other studies have failed to show a significant relationship between working memory and quality of notes (Cohn et al., 1995; Peverly & Garner, 2010; Peverly et al., 2007; Peverly & Sumowski, in press; Peverly et al., 2010). A study involving college students in economics' courses found that working memory, as measured by three complex span tasks, was not related to either quality of notes or the number of words recorded in a student's notes (Cohn et al., 1995). Several recent studies measuring auditory verbal working memory through a listening span task indicated that verbal working memory was not significantly related to quality of notes (Peverly & Garner, 2010; Peverly et al., 2007; Peverly & Sumowski, in press; Peverly et al., 2010). However, one of these studies found that working memory was related to test performance on a test of memory-based comprehension questions (Peverly & Sumowski, in press). The findings of the current study support the results from other studies that have used a listening span task to measure verbal working memory.

What variables contribute to differences in essay performance in a group of postsecondary students with self-reported ADHD and without ADHD?

Next, the role of attention, transcription fluency, verbal working memory, listening comprehension, current disability status, and quality of notes was examined in relation to essay performance on a written recall test. It was hypothesized that disability status and quality of notes would significantly contribute to essay performance. Both of these hypotheses were upheld. However, listening comprehension also significantly predicted essay performance.

Disability status.

Disability status predicted essay performance as hypothesized. On average, students in the ADHD group had lower scores on the essay. Students in the self-reported ADHD group only recalled 12.2% of the ideas from the lecture in their essays, while students in the control group recalled 18.7% of the ideas in their essays. This finding is consistent with school problems most commonly recorded by adolescents and young adults with ADHD, which included poor performance on tests and poor writing (Wolraich et al., 2005). Furthermore, this finding is consistent with a previous study by Gregg et al. (2002), which looked at expository writing in college students with ADHD, other disabilities, and a control group. They found that college students with ADHD scored significantly lower on a timed essay than controls and had a lower overall word count. Thus, students with ADHD (self-reporting or confirmed) may fare worse on timed essays. In the present study, time did not seem to play a factor on essay performance, as the majority of students finished the written summary prior to the time limit. Since students in the ADHD and control groups did not differ in terms of the quality of their lecture notes, it is more likely that students in the ADHD group were less adept at reviewing their lecture notes in preparation for the written summary and/or recalling ideas from the lecture and organizing them into a written summary. The research literature has documented poor study skills in students with ADHD (Allsopp, Minskoff, & Bolt, 2005; Crede & Kuncel, 2006; Kaminski et al., 2006; Norwalk et al., 2008; Reaser, Prevatt, Petscher, & Proctor, 2007). Additionally, research has documented poor recall of passages in students with ADHD (Johnson et al., 2001). Thus, future research may need to focus on variables underlying the review process and test-taking in a sample of ADHD postsecondary students to uncover the reasons for these differences.

Quality of notes.

Consistent with hypotheses, quality of notes was the best predictor of essay performance. In line with previous studies examining the underlying variables related to performance on a written recall summary in the context of a postsecondary population (Peverly & Garner, 2010; Peverly et al., 2007; Peverly & Sumowski, in press; Peverly et al., 2010), the current study found that quality of notes was significantly correlated to and predicted essay performance. This finding is consistent with previous research, which has consistently demonstrated the relationship between taking and reviewing notes and higher test performance (Baker & Lombardi, 1985; Barnett, Di Vesta, & Rogozinski, 1981; Fischer & Harris, 1973; Kiewra & Benton, 1988; Kiewra et al., 1991; Norton & Hartley, 1986; Nye, Crooks, Powley & Tripp, 1984; Peverly, Brobst, Graham, & Shaw, 2003; Peverly et al., 2007; Titsworth & Kiewra, 2004; Williams & Eggert, 2002b).

Listening comprehension, transcription fluency, attention and VWM.

Listening comprehension also significantly predicted essay quality. While listening comprehension has not previously been studied in essay performance, previous research has focused on reading comprehension, and as noted previously, listening and reading comprehension are highly correlated. Since listening comprehension and the measures of reading comprehension used in other note-taking research are proxies for verbal ability (Gernsbacher, as cited in Perfetti et al., 2005), these results replicate the findings from other research on the importance of verbal ability to note-taking (Peverly & Sumowski, in press; Peverly et al., 2010).

Contrary to expectations, transcription fluency, despite being significantly correlated with essay performance (.30), did not significantly predict essay quality in a regression analysis. This finding replicates previous research, which found that notes mediated the relationship between transcription speed and test performance (Peverly & Garner, 2010; Peverly et al., 2007; Peverly & Sumowski, in press; Peverly et al., 2010). In other words, transcription fluency has not been found to be related to written recall. However, as with notes' quality, this insignificant result may be due to lack of adequate power due to limited sample size.

Finally, attention and verbal working memory did not significantly predict essay performance, which is consistent with previous research findings (Peverly & Garner, 2010; Peverly et al., 2007; Peverly & Sumowski, in press; Peverly et al., 2010).

Are there significant differences between ADHD self-report and non-ADHD postsecondary students, specifically in terms of attention, transcription fluency, verbal working memory, listening comprehension, quality of notes, and/or essay performance?

The performance of postsecondary students self-reporting a diagnosis of ADHD and those without a diagnosis of ADHD was compared on measures of attention, transcription fluency, verbal working memory, listening comprehension, quality of notes and essay quality.

As reviewed above, the groups did not significantly differ in terms of attention, listening comprehension, or quality of notes. There were, however, significant differences between groups on essay quality and transcription fluency. Postsecondary students self-reporting a diagnosis of ADHD had significantly lower scores on a measure of transcription fluency. There is no previous research on the relationship between individuals with self-reported or confirmed diagnoses of ADHD and transcription fluency; however, research has documented problems with handwriting and slow motor output in children with ADHD (Barkley, 2006; Cutting & Denckla, 2003), and composition writing in adults with ADHD (Gregg et al., 2002; Wolf, 2001). The current study was the first to examine transcription fluency in postsecondary students with self-reported ADHD. Future research to replicate these findings should be conducted in order to confirm an actual deficit in transcription fluency and its academic impact on postsecondary students with ADHD.

Finally, there were no differences between students with self-reported ADHD and non-ADHD in terms of verbal working memory. This finding is in contrast to research studies documenting mild to significant deficits in verbal working memory and short-term memory in adults with ADHD (Barkley, 2006; Buhner et al., 2006; Gallagher & Blader, 2001; Gropper & Tannock, 2009; Hervey et al., 2004; Holdnack et al., 1995; Johnson et al., 2001; Marchetta et al., 2008; Murphy et al., 2001; Nigg, 2006; Quinlan & Brown, 2003). However, one study that matched adults with and without ADHD on age, years of education, gender and IQ found no differences in verbal working memory between the groups (Rapport et al., 2001), and another study noted that differences in verbal working memory between adults with and without ADHD disappeared once controlling for IQ (Murphy et al., 2001). The findings from these studies may provide an explanation for the observed similarities in verbal working memory scores between self-reported and non-ADHD students in the current study. The current study focuses on postsecondary students who presumably have similar IQs and higher levels of functioning in order to gain admission to a postsecondary institution. As observed in other studies, differences in verbal working memory tend to disappear when controlling for differences in IQ. It is also important to note that the current measure of verbal working memory involved a complex span task and was administered in a group format, whereas list learning and digit span tasks administered individually are more typical in research with ADHD individuals and may be another explanation for current differences in findings. Future research with similar measures of VWM in samples of postsecondary students with ADHD are needed to confirm current findings.

Other Variables

The impact of academic settings, higher education level, and gender was examined as these variables interacted with disability status. In terms of school enrollment, Teachers College students had the highest essay scores, and New York University students had higher essay scores than students in the other group (TC > NYU > Other). These results indicate that graduate students (i.e., all students in the Teachers College group) performed better on a written recall test than undergraduates. In general, the current study found that graduate students took better quality notes and performed better on a written recall test. Since admission into graduate schools is more selective and fewer students go on to pursue graduate work, these findings are not unexpected.

In terms of gender, the current study found that females took better notes than males and outperformed males on a written recall test. A closer analysis found an interaction between gender and disability status. The results revealed that females in the non-ADHD group outperformed both males in the control group and males and females in the self-reported ADHD group in terms of essay performance, while male controls performed the poorest on quality of lecture notes. These findings replicate results observed in other studies, showing that female postsecondary students have better notes and achieve higher scores on essay tests (Reddington, 2011; Reddington, Sumowski, Johnson, & Peverly, 2006).

Implications for Practice and Future Research

In spite of variability in individual note-takers, note-taking interventions have focused mainly on lecture variables. Experimental studies have focused on lecturer presentation rate (Peters, 1972; Suritsky & Hughes, 1991), spoken organizational lecture cues (Titsworth & Kiewra, 2004), and the organizational format of notes, such as conventional notes, matrix notes, and outlines (Kiewra et al., 1991; Peverly et al., 2010). However, the interventions used in these studies focused on external factors instead of internal cognitive constructs that may better explain differences in quantity and quality of notes among note-takers. This was the first dissertation to examine underlying cognitive factors in lecture note-taking in postsecondary students reporting clinical symptoms of ADHD.

The findings from the current study indicate that attention and listening comprehension significantly predict quality of lecture notes, and postsecondary students with self-reported ADHD do not significantly differ from their non-ADHD peers in their attention, verbal working memory or listening comprehension abilities, or in the quality of their notes. These findings have significant implications for educational practice. While common accommodations in postsecondary settings include providing students with a copy of lecture notes or granting them permission to audiotape lectures, in light of recent findings these accommodations may not be warranted. Students with ADHD who gain admission to postsecondary institutions may have established compensatory strategies for note-taking and may benefit from actively engaging in lecture note-taking. And given the potential advantages of note-taking, including increased engagement (Carrier & Titus, 1979; Evans et al., 1994) and more generative learning (Stefanou et al., 2008), students may greatly benefit from engaging in lecture note-taking. However, future research should replicate these findings and examine the impact of providing students with a diagnosis of ADHD with complete or partial notes versus taking notes on test performance. Future research on note-taking across various lecture formats and subject areas is also needed to reach any conclusions.

Postsecondary students with self-reported ADHD did significantly differ from non-ADHD peers in terms of essay performance and transcription fluency. This finding from the current study has implications for individuals with ADHD in the area of writing. According to a limited capacity framework, students must be fluent in basic lower level processes, such as transcription fluency, in order to free up resources for the higher level processes of generating, organizing and editing ideas (Berninger & Swanson, 1994; McCutchen, 2000). If students with confirmed or self-reported ADHD experience difficulties with speed of handwriting, they may have fewer resources to devote to the higher level processes necessary for writing essays or taking notes. This may warrant the accommodation of providing students with a laptop for essay exams. However, future research needs to examine whether this accommodation is beneficial in postsecondary students with ADHD and whether poor transcription fluency is related to poor academic outcomes in this population.

The poorer performance of students with self-reported ADHD on a timed essay test than non-ADHD peers also has implications for educational practice and future research. Based on the current findings, it seems postsecondary students with self-reported ADHD do not experience significant difficulties encoding information from lectures, but rather have trouble reviewing information for later recall on tests. Therefore, accommodations in postsecondary settings should focus on improving students study and test-taking skills. Future research should examine the specific individual variables underlying the review process and test-taking.

Finally, future research should examine the present findings in postsecondary students with confirmed ADHD to test for possible differences in outcomes due to confirmed versus self-reported diagnoses.

Limitations

The current study is not without limitations. The biggest limitation is the small sample size. While the primary research attempted to recruit a larger sample of students with ADHD, recruitment efforts were not successful. Therefore, the current results may underestimate differences between students with ADHD and non-ADHD students due to lower statistical power. Secondly, due to the difficulties recruiting a sufficient sample of ADHD postsecondary students, the current sample is not homogeneous. Therefore, differences among students with and without ADHD may exist across academic settings, higher education level (undergraduate versus graduate), and gender. However, these hypotheses could not be adequately tested due to the limited sample. Future research should examine include larger samples to sufficiently examine differences across these constructs.

Thirdly, the present study included students who self-reported diagnoses and symptoms of ADHD as comprehensive evaluations of ADHD were beyond the scope of the study. Therefore, caution should be used when generalizing these results to postsecondary students with confirmed ADHD diagnoses. Finally, the current study did not assess symptoms of other psychiatric disorders and the potential impact of comorbidity on lecture note-taking or the cognitive variables measured. Therefore, it is unclear whether outcomes may be better accounted for by other differences in individuals not measured as it was beyond the scope of the present study.

Conclusion

In summary, taking and reviewing lecture notes is a prevalent activity that is related to higher test performance in higher education. The current study was the first to examine the role of the underlying cognitive variables of attention, transcription fluency, verbal working memory, and listening comprehension in quality of lecture notes and essay performance in a sample of self-reported ADHD and non-ADHD postsecondary students. Attention and listening comprehension were the only predictors of quality of notes, and disability status, quality of notes, and listening comprehension all predicted essay performance. Students with self-reported ADHD obtained lower scores on a written recall test and a measure of transcription fluency compared to non-ADHD peers, but did not differ in terms of quality of notes, attention, verbal working memory, or listening comprehension. Future research should examine the present findings in postsecondary students with confirmed ADHD to test for possible differences in outcomes due to confirmed versus self-reported diagnoses.

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Appendix A

Supplementary Tables and Figures

Table 1

Means, Standard Deviations, and Ranges for the CAARS within the ADHD Group (n = 22)

Scale	*Mean*	*SD*	*Minimum*	*Maximum*
Inattention/Memory Problems	65.82	11.66	44	83
Hyperactivity/Restlessness	60.82	11.34	41	78
Impulsivity/Emotional Lability	54.95	11.46	40	80
Problems with Self-Concept	60.77	9.90	40	76
ADHD Index	63.32	11.75	47	90

Note. Reported scores are *T*-scores with a mean of 50 (*SD* = 10). *T*-scores greater than or equal to 66 are considered elevated.

Table 2

Individual Participant Information Regarding Registration at Office of Disability Services, CAARS Scores, and Medication Use within the ADHD Group (n = 22)

		CAARS Scales					
Part. No.	*ODS Reg.*	*Scale 1*	*Scale 2*	*Scale 3*	*Scale 4*	*Scale 5*	*Medication Use*
101	**No**	**44**	**41**	**45**	**64**	**48**	**Yes**
102	Yes	60	72*	76*	51	74*	Yes
103	No	83*	74*	70*	75*	83*	Yes
104	No	83*	78*	70*	64	78*	Yes
105	No	66*	66*	52	65	63	No
106	Yes	54	49	52	40	47	No
107	No	75*	54	46	62	55	Yes
108	**No**	**57**	**62**	**51**	**52**	**57**	**No**
109	Yes	83*	74*	80*	75*	90*	No
301	Yes	61	44	42	64	63	Yes
302	Yes	57	74*	61	55	68*	Yes
501	Yes	64	74*	61	69*	70*	No
502	Yes	72*	66*	55	62	66*	No
503	Yes	69*	46	49	54	55	Yes
701	No	55	47	52	70*	58	Yes
702	No	75*	60	61	76*	73*	Yes
703	Yes	57	63	49	60	57	Yes
901	Yes	74*	71*	42	55	60	Yes
1101	Yes	47	59	48	44	57	Yes
1102	Yes	66*	54	43	54	50	Yes
1103	Yes	63	51	40	54	48	Yes
1104	Yes	83*	59	64	72*	73*	No
Total	14 (64%)	11 (50%)	9 (41%)	4 (18%)	6 (27%)	9 (41%)	15 (68%)

Note. Part. No. = participant number. ODS Reg. = registered with Office of Disability Services at university. Scale 1 = Inattention/Memory Problems; Scale 2 = Hyperactivity/Restlessness; Scale 3 = Impulsivity/Emotional Lability; Scale 4 = Problems with Self-Concept; Scale 5 = ADHD Index. Medication Use = student endorsed taking medication to focus.

**T*-score > 65 signifying clinically elevated score

Table 3
Results of Univariate ANOVAs Comparing ADHD and Non-ADHD Groups Across Demographic Variables

	ADHD Group		*Non-ADHD Group*		
Variable	*Mean*	*SD*	*Mean*	*SD*	*Sig.*
Gender	.50	.51	.78	.42	.020*
Age	23.63	4.17	22.17	3.43	.126
English First Language	.91	.29	.90	.31	.886
Race/Ethnicity	4.59	1.62	4.47	2.34	.826
Graduate/Undergraduate	.27	.46	.35	.48	.543
Major	1.05	2.61	.51	.51	.169
No. of Psychology Courses	4.91	7.96	7.10	8.27	.300
Reading Disability	.05	.21	.00	.00	.137
Writing Disability	.09	.29	.00	.00	.033*
School	3.05	2.06	2.94	2.37	.856
Referral Source	1.82	.80	2.47	.58	.000***
Fatigue Level	2.59	1.30	2.76	.93	.545

Note.
**p* < .05 ****p* < .001

Table 4
Results of Univariate ANOVAs Comparing ADHD and Non-ADHD Groups Across Variables Related to ADHD Diagnosis

	ADHD Group		*Non-ADHD Group*		
Variable	*Mean*	*SD*	*Mean*	*SD*	*Sig.*
Past ADHD Diagnosis	1.00	.00	.08	.27	.000***
Medication Use	.68	.47	.00	.00	.000***
Registered with ODS	.64	.49	.22	1.28	.146
CAARS: Inattention/Memory Problems	65.82	11.66	50.54	9.01	.000***
CAARS: Hyperactivity/Restlessness	60.82	11.34	47.20	7.88	.000***
CAARS: Impulsivity/Emotional Lability	54.95	11.46	44.74	5.69	.000***
CAARS: Problems with Self-Concept	60.77	9.90	47.42	9.72	.000***
CAARS: ADHD Index	63.32	11.75	45.92	8.54	.000***

Note. Medication Use = takes medication to focus; Registered with ODS = registered with office of disability services. Bonferroni Correction = .006
****p* < .001

Table 5

Eigenvalues and Total Variance Explained from CAARS Principal Components Analysis (n = 66)

Component	*Eigenvalue*	*% of Variance*	*Cumulative %*
1	12.04	46.31	46.31
2	2.20	8.46	54.76
3	1.67	6.44	61.20
4	1.23	4.74	65.94
5	1.08	4.16	70.10

Note. Five components extracted.

Table 6

Rotated Component Matrix from CAARS Principal Component Analysis

	Component				
Item	*1*	*2*	*3*	*4*	*5*
CAARS Item 1	.126	.022	.107	.175	.826
CAARS Item 2	-.014	.115	.130	.805	.292
CAARS Item 3	.744	.280	.157	.060	.020
CAARS Item 4	.430	.118	.360	.678	.061
CAARS Item 5	.536	.348	.340	.052	.057
CAARS Item 6	.556	.068	.505	.262	.108
CAARS Item 7	.203	.206	.822	.094	.073
CAARS Item 8	.261	.288	.744	.124	.183
CAARS Item 9	.447	.635	.323	-.208	.131
CAARS Item 10	.020	.174	.492	.324	.203
CAARS Item 11	.531	.160	.340	.576	-.044
CAARS Item 12	.579	.228	.446	.207	.113
CAARS Item 13	.446	.127	.724	.103	-.010
CAARS Item 14	.573	.133	.161	-.310	.295
CAARS Item 15	.173	.794	.266	.138	.097
CAARS Item 16	.285	.792	.164	.242	-.036
CAARS Item 17	.662	.319	.020	.081	.186
CAARS Item 18	.675	.250	.064	.031	.312
CAARS Item 19	.357	.023	.546	.125	.530
CAARS Item 20	.314	.400	.431	.188	.490
CAARS Item 21	.804	.294	.220	.083	.028
CAARS Item 22	.670	.320	.315	.288	-.013
CAARS Item 23	.708	.028	.325	.138	.113
CAARS Item 24	.653	.270	.415	.283	.059
CAARS Item 25	.288	.842	.017	.001	-.080
CAARS Item 26	.182	.801	.181	.114	.194

Note. Rotation Method: Varimax with Kaiser Normalization

Table 14

Composition of Participants from Three School Groups

School	*Self-Reported ADHD*	*Non-ADHD*	*Total*
New York University	9	28	37
Teachers College	4	17	21
Other	9	5	14

Note. Other = group consisting of six universities. New York University = undergraduates; Teachers College = graduates; Other = 12 undergraduates and 2 graduates.

Table 15

Results of Univariate ANOVAs Comparing Schools Across All Measures (n = 72)

	New York University (n = 37)		*Teachers College (n = 21)*		*Other (n = 14)*		
Source	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Sig.*
Disability Status	.24	.46	.19	.40	.64	.50	a
Attention	8.64	1.13	9.07	.87	8.64	1.36	.423
Transcription Fl.	118.16	22.71	125.29	16.54	111.36	31.18	.136
VWM	9.14	2.86	9.38	2.48	8.71	3.20	.731
Listening Comp.	13.76	3.06	15.14	2.13	13.71	2.59	.221
Notes	21.00	5.68	25.00	6.91	20.79	6.69	.086
Essay	7.11	3.36	10.33	3.64	4.43	2.41	b

Note. Transcription Fl. = transcription fluency; VWM = verbal working memory; Listening Comp. = listening comprehension

[a]NYU/TC sig. = .899; NYU/Other sig. = .014*; TC/Other sig. = .011*

[b]NYU/TC sig. = .002**; NYU/Other sig. = .030*; TC/Other sig. = .000***

**p* < .05, ***p* < .01, ****p* < .001

Table 16
Results of Univariate ANOVAs Comparing Males and Females Across All Measures (n = 72)

	Males (n = 23)		*Females (n = 49)*		
Source	*Mean*	*SD*	*Mean*	*SD*	*Sig.*
Disability Status	.48	.51	.22	.42	.029
Attention	8.76	1.23	8.77	1.07	.988
Transcription Fluency	109.57	18.44	123.31	24.12	.018
VWM	9.96	2.93	8.73	2.67	.083
Listening Comp.	14.09	2.99	14.18	2.68	.891
Notes	18.61	5.15	23.78	6.36	.001**
Essay	5.65	3.38	8.41	3.77	.004*

Note. VWM = verbal working memory; Listening Comp. = listening comprehension; Bonferroni Correction = .007
*$p \leq .007$, **$p \leq .001$

Table 17
Results of Univariate ANOVAs Comparing Disability Status by Gender Interactions Across All Measures (n = 72)

	Female ADHD (n = 11)		*Female Non-ADHD (n = 38)*		*Male ADHD (n = 11)*		*Male Non-ADHD (n = 12)*	
Source	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Attention	7.64	1.34	9.09	.71	8.91	1.07	8.63	1.40
Transcription Fl.	109.18	32.78	127.39	19.69	101.55	15.69	116.92	18.24
VWM	7.55	2.66	9.08	2.60	9.73	1.62	10.17	3.83
Listening Comp.	13.82	3.84	14.29	2.30	14.64	2.94	13.58	3.09
Notes	23.18	6.69	23.95	6.35	20.45	4.06	16.92	5.62
Essay	5.55	3.11	9.24	3.56	5.45	3.73	5.83	3.85

Note. Transcription Fl. = transcription fluency; VWM = verbal working memory; Listening Comp. = listening comprehension
*$p < .05$, **$p < .01$, ***$p < .001$

Table 18

Summary of Hierarchical Regression Analysis Predicting Essay Performance with Interaction Terms of Attention and Quality of Notes (n = 72)

Variable	*B*	*SE B*	*β*	*Tolerance*	*VIF*
Model 1					
Disability Status	-2.20	.81	-.27**	.74	1.36
Attention	-.12	.33	-.03	.78	1.28
Transcription Fl.	.02	.02	.12	.76	1.31
VWM	.23	.12	.16	.87	1.15
Listening Comp.	.27	.13	.20*	.87	1.15
Notes' Quality	.30	.06	.50***	.69	1.45
Gender				.71	1.40
Model 2					
Disability Status	-1.80	.86	-.22*	.65	1.53
Attention	-.36	.51	-.10	.32	3.12
Transcription Fl.	.02	.02	.10	.73	1.37
VWM	.20	.13	.15	.84	1.19
Listening Comp.	.26	.13	.19*	.85	1.17
Notes' Quality	.18	.12	.31	.16	6.19
Gender	1.11	.91	.14	.57	1.75
Gender x Attention	-.56	.68	-.13	.30	3.39
Gender x Notes' Quality	-.15	.14	-.20	.19	5.23

Note. Transcription Fl. = transcription fluency; VWM = verbal working memory; Listening Comp. = listening comprehension; VIF = variance inflation factor

*$p < .05$ ** $p < .01$ *** $p < .001$

Table 19

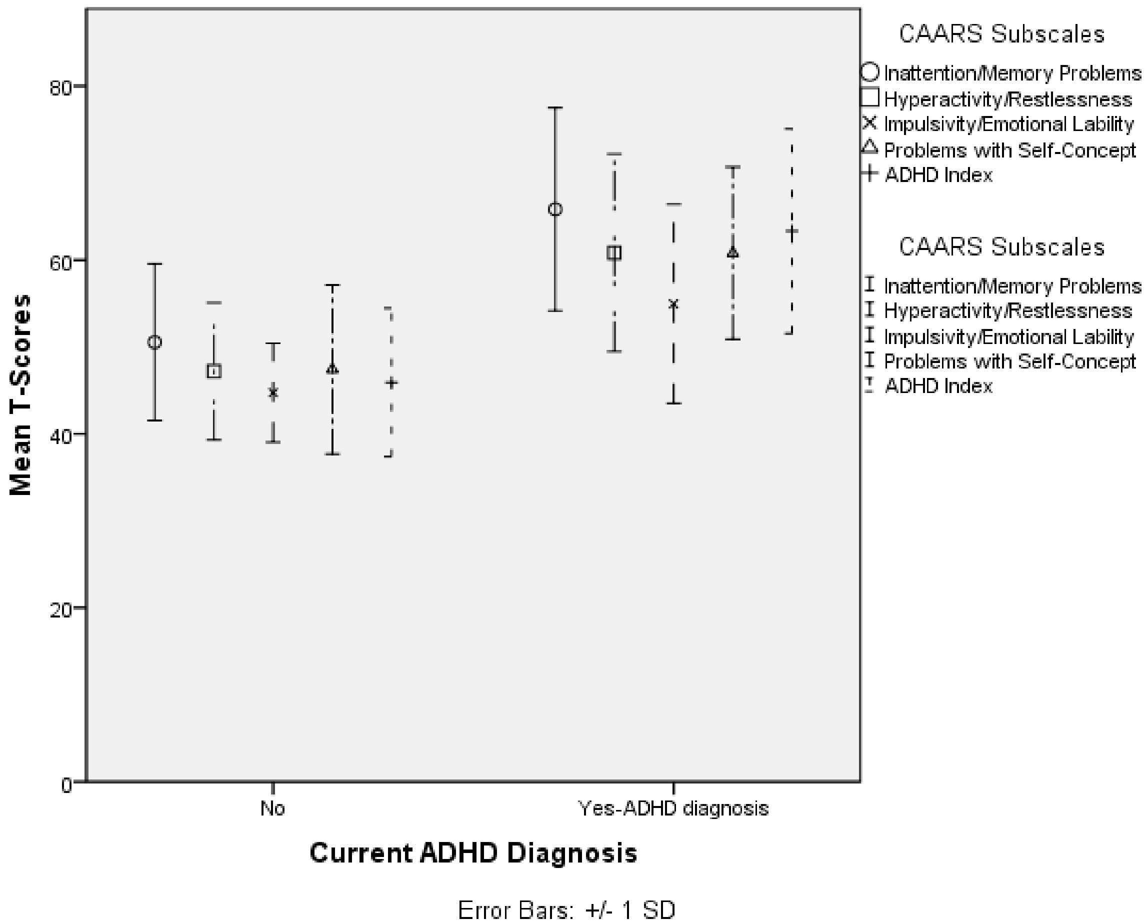
Results of Univariate ANOVAs Comparing Undergraduate and Graduate Students Across All Measures (n = 72)

	Undergraduate Students (n = 49)		*Graduate Students (n = 23)*		
Source	*Mean*	*SD*	*Mean*	*SD*	*Sig.*
Disability Status	.33	.47	.26	.45	.579
Attention	8.62	1.20	9.07	.84	.116
Transcription Fluency	117.35	24.99	122.26	19.06	.407
VWM	9.00	2.99	9.39	2.37	.583
Listening Comp.	13.61	2.89	15.30	2.12	.014
Notes	20.76	5.91	25.04	6.67	.007*
Essay	6.43	3.36	9.87	3.85	.000**

Note. VWM = verbal working memory; Listening Comp. = listening comprehension; Bonferroni Correction = .007

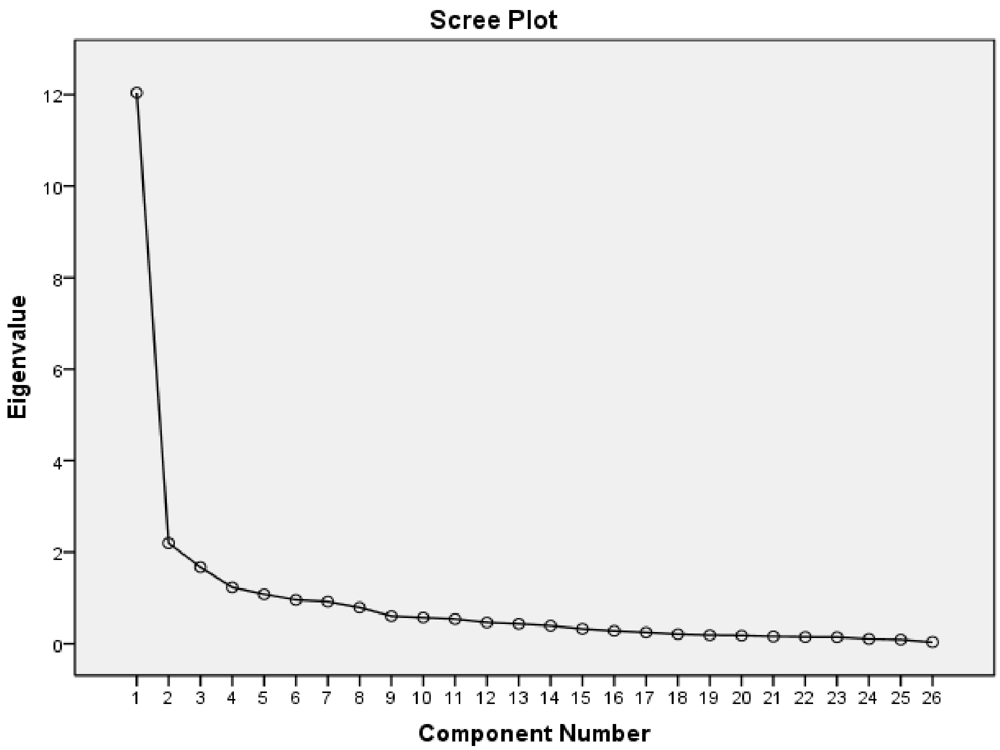
*$p \leq .007$, **$p \leq .001$

Figure 1
Graph of Means of CAARS Scales by Group



Note. ○ = Inattention/Memory Problems; □ = Hyperactivity/Restlessness; x = Impulsivity/Emotional Lability; Δ = Problems with Self-Concept; + = ADHD Index.

Figure 2
Scree Plot of CAARS Principal Components Analysis



Note. Based on 26 items.

Figure 3
Histogram of Lottery Task Scores

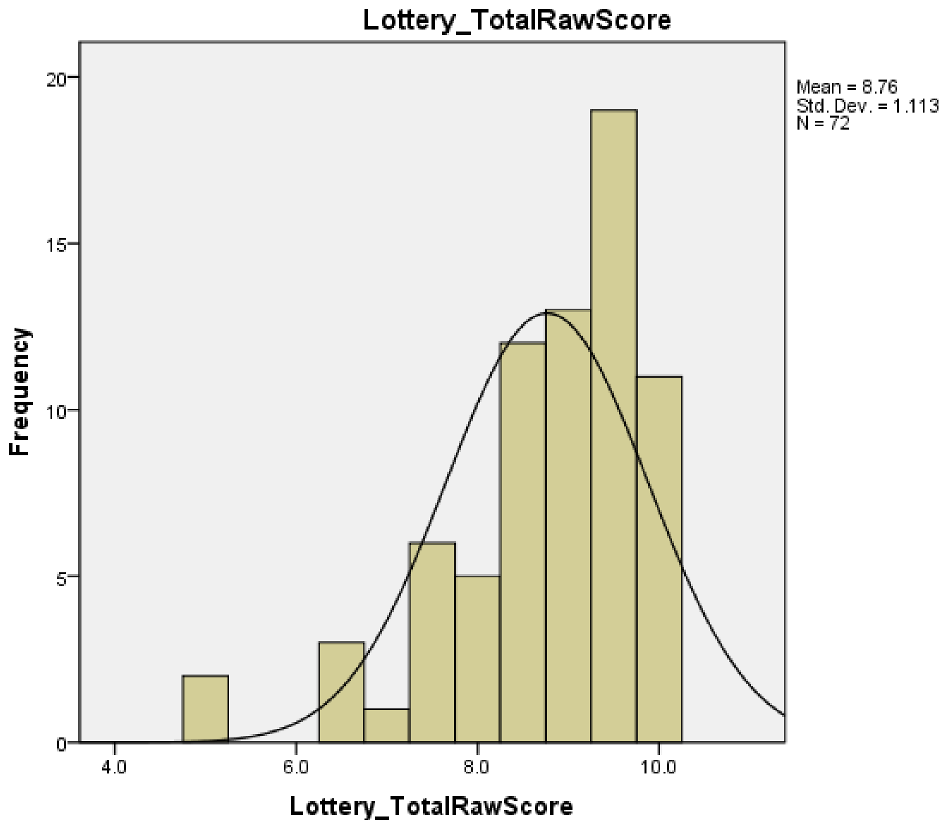


Figure 4
Histogram of Listening Comprehension Scores

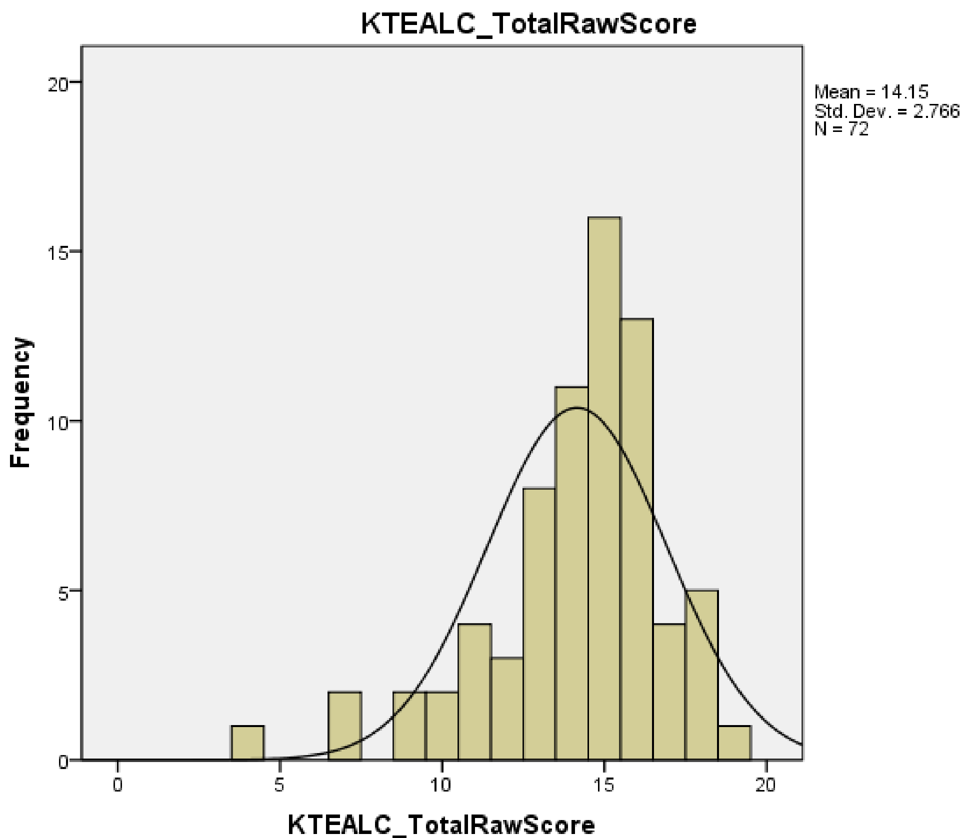
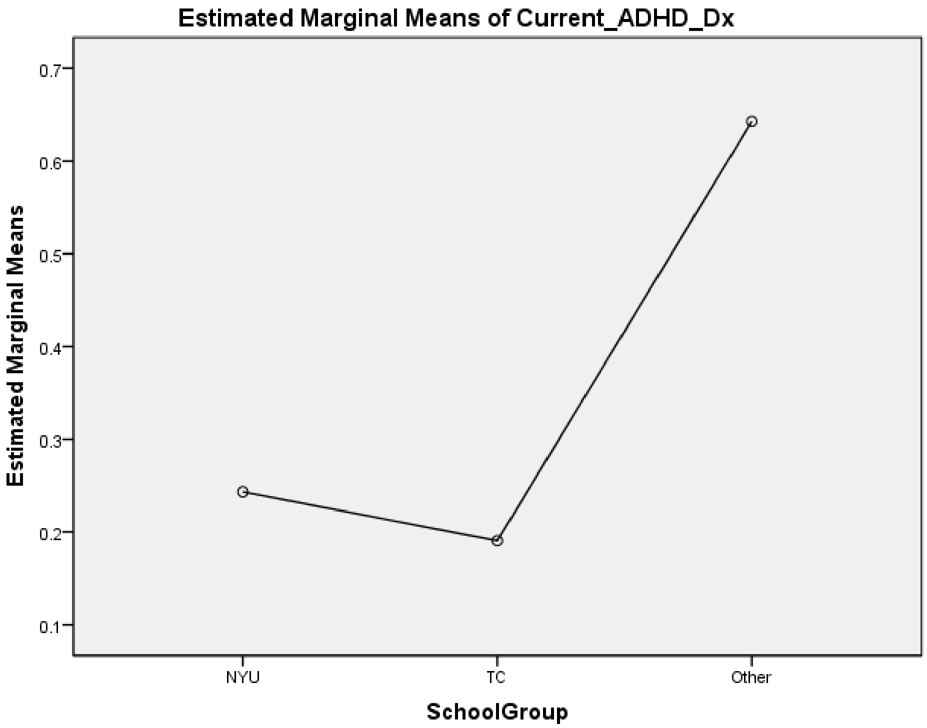
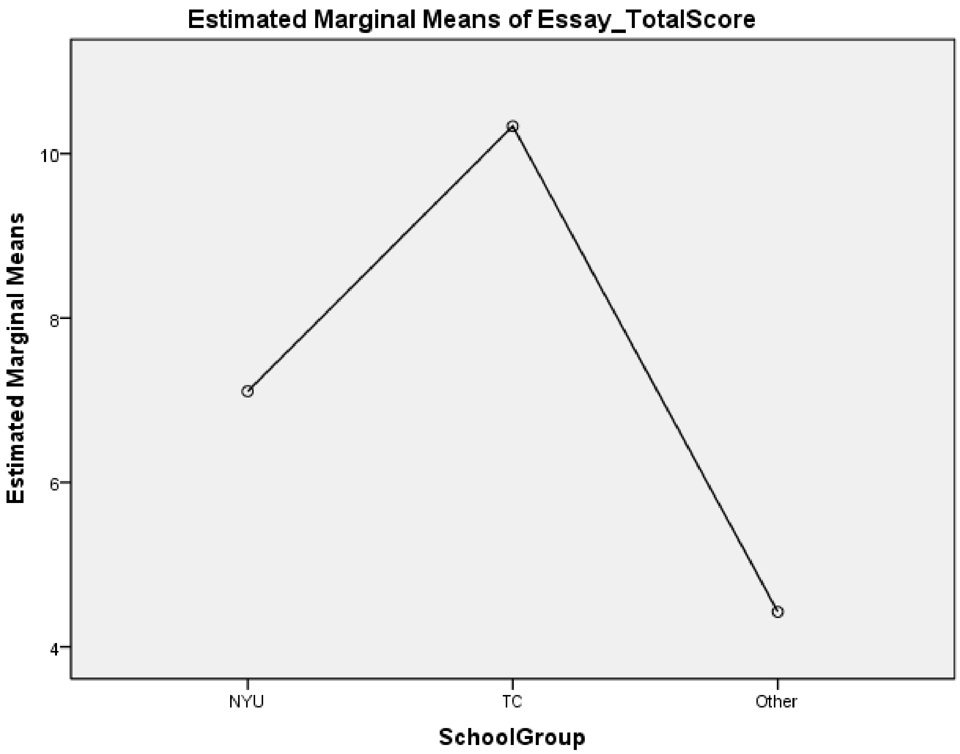


Figure 5
Graph of Disability Status Across Schools



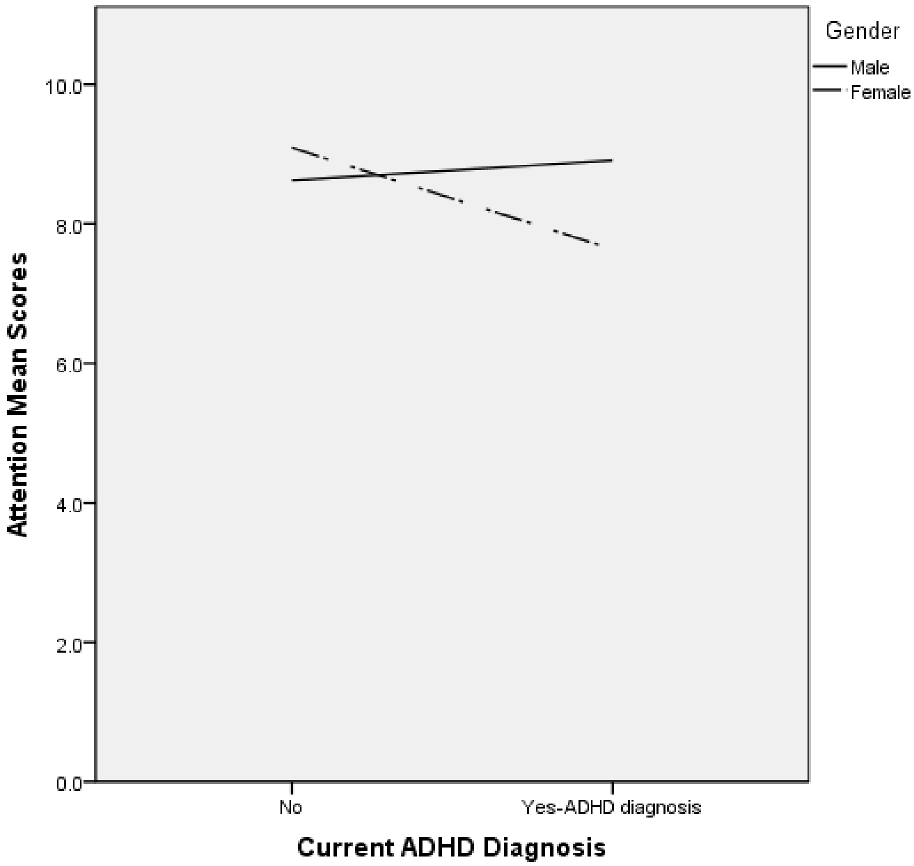
Note. NYU/TC sig. = .899; NYU/Other sig. = .014*; TC/Other sig. = .011*
*$p < .05$

Figure 6
Graph of Essay Performance Across Schools



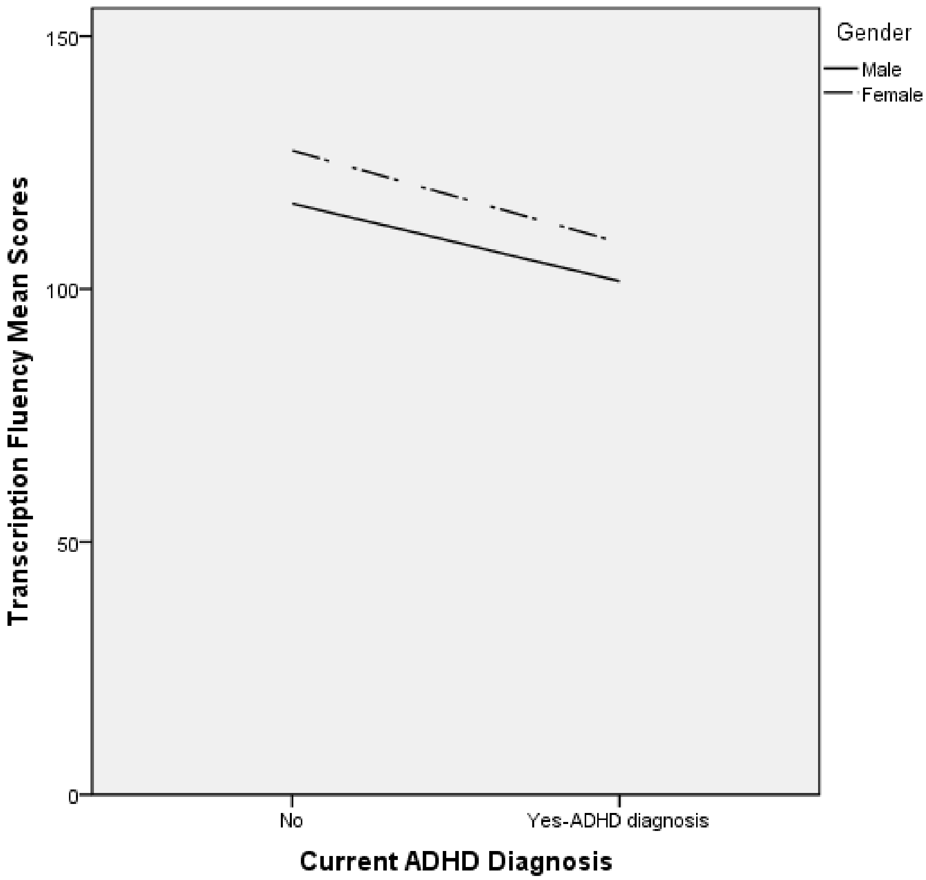
Note. NYU/TC sig. = .002**; NYU/Other sig. = .030*; TC/Other sig. = .000***
*$p < .05$, **$p < .01$, ***$p < .001$

Figure 7
Disability Status by Gender on Attention



Note. Male = solid black line; Female = broken black line.

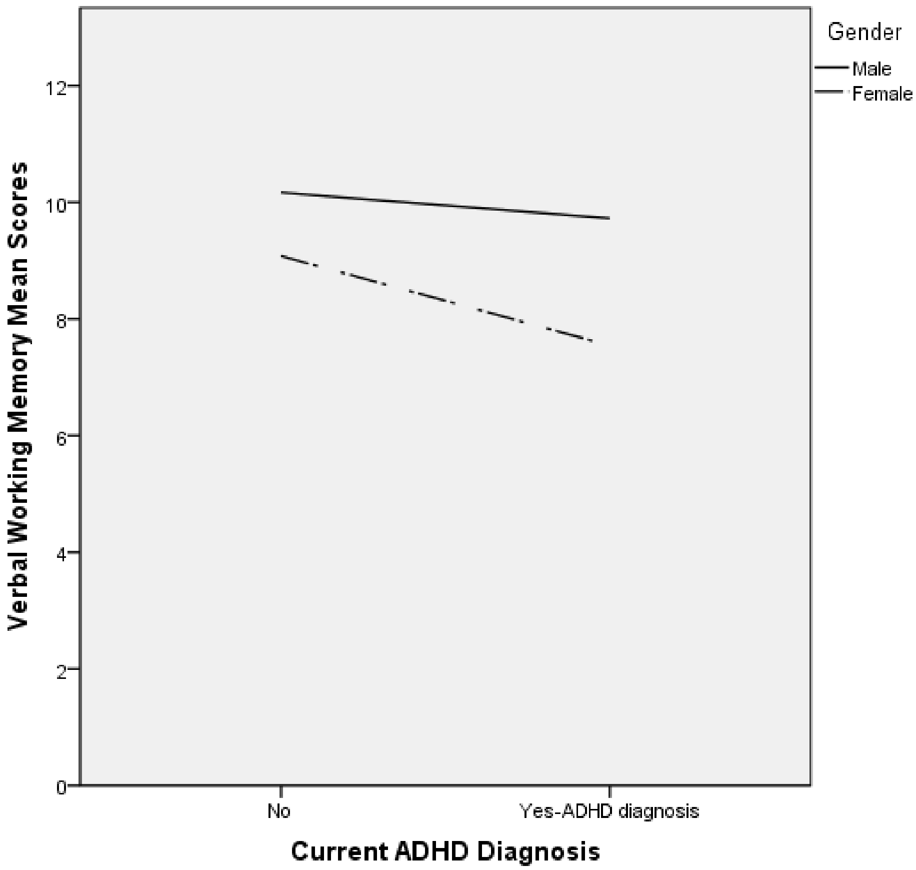
Figure 8
Disability Status by Gender on Transcription Fluency



Note. Male = solid black line; Female = broken black line.

Figure 9

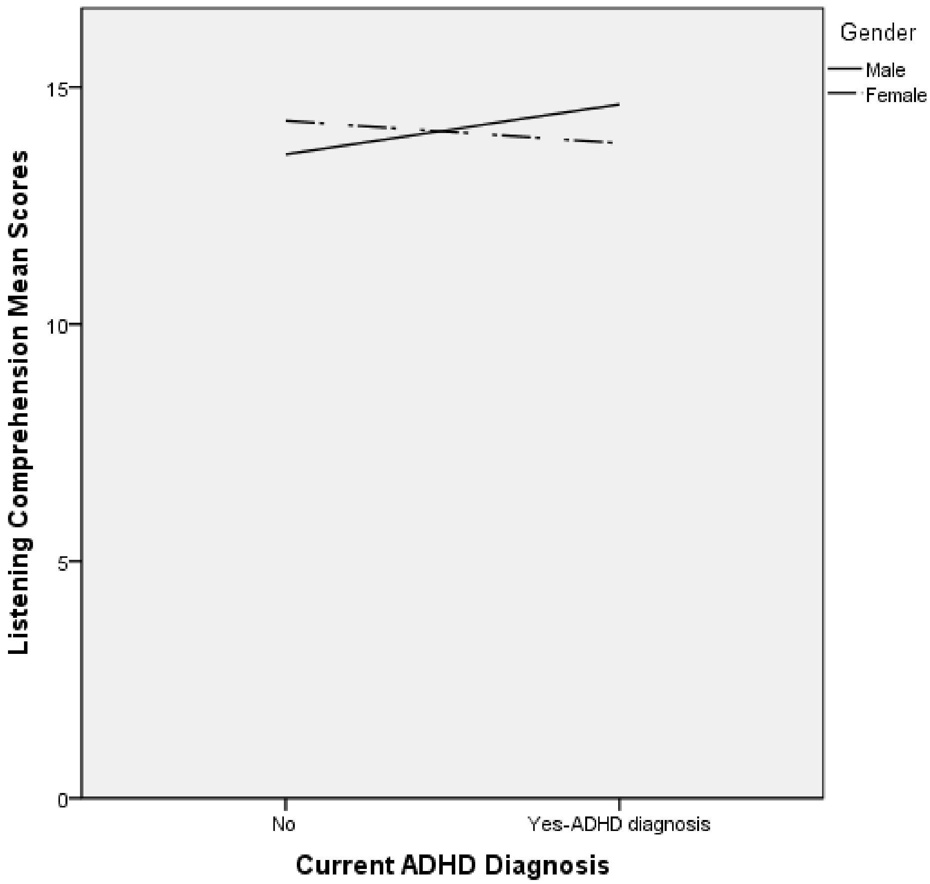
Disability Status by Gender on Verbal Working Memory



Note. Male = solid black line; Female = broken black line.

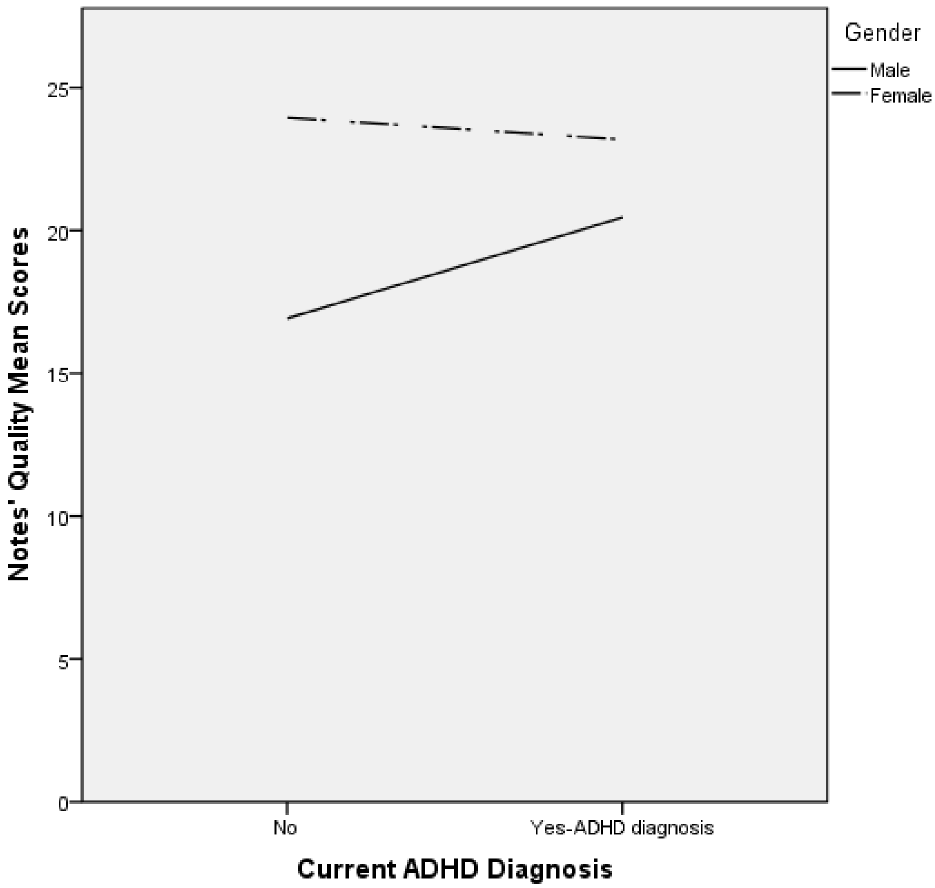
Figure 10

Disability Status by Gender on Listening Comprehension



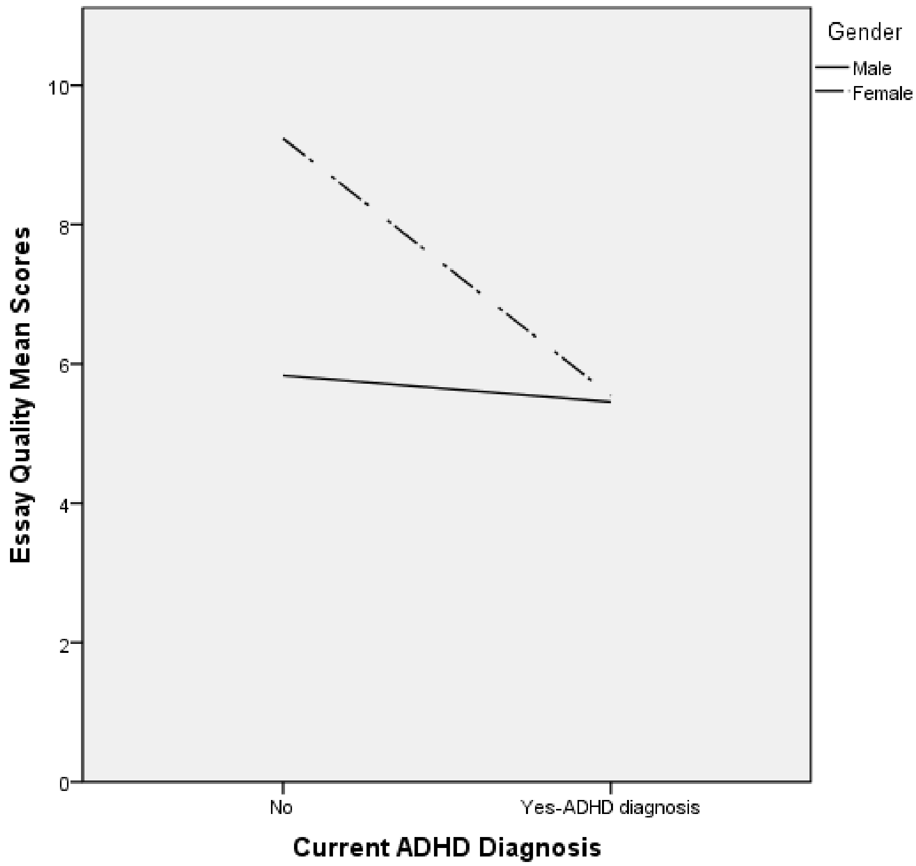
Note. Male = solid black line; Female = broken black line.

Figure 11
Disability Status by Gender on Notes' Quality



Note. Male = solid black line; Female = broken black line.

Figure 12
Disability Status by Gender on Essay Performance



Note. Male = solid black line; Female = broken black line.

Appendix B

The Structure and Content of the Lecture

I. Functions of problem solving in education

a. Problem solving is a cognitive activity important to educational theory and classroom practice.
b. Problem solving is considered part of learning subject matter. It serves a testing and teaching function.

II. Definition of a problem

a. A problem is said to exist when an individual has a particular goal but is unable to obtain that goal.
b. It is frequently assumed that there is some type of obstacle or barrier that prevents the solver from reaching the goal.
c. These obstacles must, of necessity, be broadly defined and include such factors as failure to remember and lack of information.

III. Information processing approach

a. Concepts
    1. Problem representation
    2. Goal states
    3. Constraints
    4. Problem states
    5. Operators
    6. Ill-structured problems
b. Example-Tower of Hanoi

IV. Research findings: Problem solving in particular domains

a. Chess
b. Physics

V. Factors involved in problem solving

a. Understanding the problem representation
b. Effective problem solving is related to abstract knowledge structures

VI. Instructability of general problem solving