An Investigation of the Lecture Note-Taking Skills of Adolescents with and without Attention Deficit/Hyperactivity Disorder: An Extension of Previous Research

Jessica Gleason

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ABSTRACT

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Jessica D. Gleason

Note-taking is an effective and prevalent study strategy that has been widely examined in post-secondary settings. However, little is known about the underlying cognitive variables associated with note-taking. The current study set out to investigate the note-taking skills of high school students with and without Attention Deficit-Hyperactivity Disorder (ADHD), in order to extend previous studies on lecture note-taking (Peverly, Garner, & Vekaria, 2011; Peverly et al., 2007; Peverly et al, 2010) to this younger population and disability group. It additionally set out to investigate the utility of providing an outline as an intervention to improve the note-quality of these populations.

Participants included 40 high school students with ADHD and 40 high school students without ADHD. Participants took notes on a videotaped lecture, and half were provided with an outline on which to take their notes. One week later, participants reviewed their notes and took a multiple choice test. The independent variables included ADHD status, outline status (yes/no), attention, transcription fluency, verbal working memory, and listening comprehension. The dependent variables were quality of notes and test performance. All measures were group administered.

Results of this investigation indicated that ADHD status, attention, transcription speed, and listening comprehension all emerged as significant predictors of note-taking skill. Note-quality and listening comprehension were the only predictors of test performance. Students with
ADHD produced lower quality notes when compared to non-ADHD peers. They additionally obtained lower scores on a multiple choice test as well a measure of listening comprehension, but did not significantly differ in terms of attention, verbal working memory, or transcription speed. The provision of an outline did not significantly impact the note quality of students with or without ADHD in the current study. Future research aimed at replicating these findings and expanding the results to include wider samples with more rigorously confirmed diagnoses is recommended.
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Chapter I

Introduction

As children progress through middle school and into high school, lectures become the primary mode of teaching information (Bretzing, Kulhavy, & Caterino, 1987; Ornstein, 1994). In fact, educators have expressed that they are increasingly relying on lecturing, because they feel it is an efficient way to introduce the content that they need to cover in order to prepare their students for state-mandated testing (Queen, 2008). Students are expected to absorb relevant lecture material and exhibit their knowledge on tests. Therefore, the student’s capacity to learn relies heavily on his or her ability to grasp lecture content, and effective independent study skills are of great importance. The most popular strategy that students employ in order to facilitate learning through a lecture is taking lecture notes (Armbruster, 2000). The research on note-taking indicates that it is an effective study strategy, and both taking notes and reviewing notes are associated with increased academic performance outcomes (e.g. Armbruster, 2000; Fischer & Harris, 1973; Kiewra, 1985; Kobayashi, 2006; Peverly, Brobst, Graham, & Shaw, 2003; Peverly et al., 2007).

Despite the value of note-taking, little is known about the cognitive variables associated with it. The act of taking notes is complex and demanding. In order to take notes, one must attend to a lecture and temporarily hold the information in one’s mind, while selecting the important information and quickly writing it down before it is forgotten (Piolat, Olive, & Kellogg, 2005; Peverly et al., 2007). The limited literature that does explore the cognitive variables that underlie lecture note-taking indicates that transcription speed (handwriting fluency), verbal working memory (one’s ability to temporarily store and manipulate verbal information), listening comprehension, and attending skills are all important variables.
(Armbruster, 2009; Peverly et al., 2007; Piolat, Olive, & Kellogg, 2005). It is likely that a breakdown in any of these areas could result in note-taking difficulties. However, little is known about the note-taking skills of struggling learners. Additionally, despite the increased expectations for students to learn from lectures as they progress beyond middle school, most of the research on note-taking has been done with normally achieving college-aged populations.

Attention Deficit Hyperactivity Disorder (ADHD) is a prevalent psychiatric disorder characterized by patterns of inattention and hyperactivity/impulsivity that begins in childhood. It is inextricably associated with academic underachievement (Barkley, 2006; Cantwell & Satterfield, 1978; DuPaul, McGoey, Eckert & VanBrakle, 2001; Fischer, Barkley, Edelbrock, & Smallish, 1990; Frick et al., 1991; Hinshaw, 1992) and is the focus of this dissertation. The most prevalent interventions for treating ADHD include psychopharmacological treatments and behavioral interventions (Barkley, 2006). While researchers have found that these interventions improve many areas of functioning, they have not clearly been shown to alleviate the academic difficulties faced by ADHD students in the long run (Carlson & Bunner, 1993; Pelham et al. 1998; Raggi & Chronis, 2006). Therefore, academically targeted interventions are needed to help this population to succeed in school. Additionally, when compared to non-ADHD populations, ADHD students are at increased risk for dropping out of high school (Barkley, 1990), and intervening before this critical point is of utmost importance.

One factor that may contribute to ADHD students’ academic difficulties is their deficient study skills (DuPaul & Stoner, 1994), and perhaps specifically, their ability to take notes. Little is known about the note-taking skills of ADHD students of any age, but there is
anecdotal evidence that they have difficulty with this important skill. Moreover, students with ADHD seem to have difficulty with the specific cognitive variables that seem to be associated with note-taking. For example, research suggests that transcription speed is highly correlated with lecture note quality (Peverly et al. 2007; Peverly, Garner, & Vekaria, 2011), and there is anecdotal evidence that ADHD individuals have deficient handwriting skills and increased risks for movement and coordination disorders (Barkley, 2006; Harvey & Reid, 2003; Racine Majnemer, Shevell, & Snider, 2008). Therefore, it is possible that transcription speed is also problematic for ADHD individuals. As mentioned above, note-taking research also suggests that lecture note-taking additionally requires adequate listening comprehension skills, verbal working memory capacity and sustained attention, which are all areas of difficulty for ADHD students (Barkley, 2006; Frazier, Demaree, & Youngstrom, 2004; Ghelani, Sidhu, Jain, & Tannock, 2004; Kuntsi, Oosterlaan & Stevenson, 2001; Lorch, Milich & Sanchez, 1998; McInnes, Humphries, Hogg-Johnson, & Tannock, 2003). Therefore it seems important to study these variables in ADHD populations.

Given the connection between note-taking and achievement in regular education populations, improving the quality of notes taken by ADHD students would likely have a positive impact on their academic performance. One intervention that has shown promise in improving the notes of normally achieving populations is providing students with lecture handouts that contain an outline of the lecture topics and provide space for taking notes (Armbruster, 2009; Collingwood & Hughes, 1978; Hartley, 1976; Kiewra et al., 1989; Kiewra, Benton, Kim, Risch, & Christensen, 1995; Klemm, 1976). Whereas there is no research that investigates the use of such outlines in ADHD populations, it is expected that in their use with ADHD students, outlines would serve to 1) help them to follow the sequence of
the lecture 2) focus their attention to what lecture information is important and 3) provide them with topic headings so they don’t need to organize the information on their own. Therefore, the current investigation will seek to validate these assumptions by testing the effectiveness of providing outlines to improve the quality of notes of ADHD students.

In summary, there are several important purposes of this dissertation. First, it seeks to compare the quality of notes as well as the individual differences in the cognitive variables associated with lecture note-taking among high school students with and without ADHD. Second, it aims to replicate the results of past research by demonstrating the relationship between note quality and academic learning outcomes, and to further this area of research by delineating the contribution of ADHD status in adolescents. Additionally, it seeks to explore the utility of providing skeletal outlines as a means of improving the quality of ADHD students’ notes.

The following chapter will review the literature associated with the aforementioned variables. First, it will describe Attention Deficit Hyperactivity Disorder, including information about what is known about its presentation, etiology, course and related outcomes. Next, it will review the relevant research on note-taking and its connection with academic performance outcomes. Subsequently, each cognitive variable that is thought to be related to note-taking skill will be introduced and expanded upon to outline the possible related difficulties that are associated with ADHD. Finally, the research on utilizing skeletal outlines as a note-taking intervention will be discussed.
Chapter II

Attention-Deficit/Hyperactivity Disorder (ADHD)

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most prevalent childhood psychiatric disorders in the United States and has been estimated to affect three to seven percent of the general school-aged population (American Psychiatric Association, 2000). Around 44% of children receiving special education services are identified as having ADHD (Bussing et al., 1998). The essential feature of ADHD is a continuous pattern of inattention and/or hyperactivity-impulsivity that is more severe than is typical for that child’s developmental level (American Psychiatric Association, 2000). Some inattentive or hyperactive-impulsive symptoms must have been present before the age of seven years, and some level of impairment with regards to developmentally appropriate social, academic, or occupational functioning must be evident in more than one setting (e.g. at home and at school). Additionally, the disturbance may not be better accounted for by another mental disorder (American Psychiatric Association, 2000).

Depending on the expression of their symptoms, children with an ADHD diagnosis fall under the predominantly inattentive subtype, the predominantly hyperactive-impulsive subtype, or the combined subtype. Hyperactive symptoms are often first observed by parents when the children are toddlers. However, because their symptoms do not tend to cause behavioral concerns, those of the predominantly inattentive subtype may not come to the attention of clinicians until later in childhood (American Psychological Association, 2000).

**Primary Clinical Presentation.** Inattentive, hyperactive and impulsive symptoms can manifest themselves in a number of ways. Individuals with inattentive symptoms of ADHD experience difficulties sustaining attention or persisting with tasks that require effort. This is especially true for tasks that are considered boring or tedious for the individual. They need and
prefer stimulation and experience an attentional bias to novelty. As a result, they seem to lack
the impetus to complete things that are short on individual appeal, even when these tasks are
necessary or important. Easily distracted, they lose concentration while completing tasks, and
thus they often have difficulty completing assignments without supervision or redirection to the
task at hand. Children with ADHD often dislike and/or avoid homework and long assignments
due to the sustained mental effort that is required to complete them. When they do attempt
assignments, they frequently fail to attend to details, resulting in careless mistakes (American
Psychological Association, 2000; Barkley & Murphy, 1998).

Hyperactive symptoms of ADHD include excessive activity that is not appropriate or
relevant for the situation. For example, individuals with ADHD are often extremely fidgety and
restless: wiggling their legs, tapping things, and shifting positions while seated. Children with
ADHD generally engage in excessive gross motor activities, such as running around and
climbing on things, and in classrooms they often get out of their seats at inappropriate times.
Additionally, they tend to have difficulty playing or participating in leisure activities quietly. For
older adolescents and adults, hyperactive symptoms can also be experienced subjectively as
feelings of extreme restlessness and an inability to sit still (American Psychological Association,
2000; Barkley & Murphy, 1998).

Symptoms of impulsivity associated with ADHD are thought to stem from impaired
control over behavioral or emotional responses, which results in poor impulse control or an
inability to delay gratification (Barkley & Murphy, 1998). Common manifestations of impaired
response inhibition include an inability to consider consequences before acting, difficulties
taking turns in games or conversations, difficulties continuing to work when faced with
distractions, and an inability to control one’s immediate reaction to an event. Individuals with
ADHD often chose smaller, more immediate rewards rather than working towards larger, longer term rewards. They seem to be lacking in the development of self-imposed rewards when environmental reinforcement is not immediate, and so others may see them as lazy or unmotivated to complete tasks that have no immediate pay-off for them (Barkley & Murphy, 1998).

**Etiology.** ADHD appears to be multiply determined, with evidence of genetic and environmental causes; the most widely researched and accepted etiology points to genetic factors (Zentall, 2006). First degree biological relatives of children with ADHD are more likely than the general population to have ADHD (American Psychological Association, 2000), and some evidence suggests that a specific gene associated with dopamine sensitivity may be associated with ADHD (Cook et al., 1995; Zentall, 2006). Moreover, twin studies have found consistently larger monozygotic concordance rates than dizygotic concordance rates of ADHD, indicating that ADHD has a genetic component (Sherman, McGue, & Iacono, 1997).

In addition to genetic factors, the expression of ADHD can be influenced by responses learned within the social, family, and classroom contexts (Zentall, 2006). For example, the difficult behaviors of ADHD children often result in increased controlling responses by caregivers and/or peers. Often these controlling responses meet with little success and lead to frustration, fatigue, and sometimes avoidance of interaction with the ADHD child. Thus, child management efforts become inconsistent and unpredictable at best, and coercive or absent at worst, resulting in unchecked development of even more problem behaviors (Barkley, 1990).

**Adaptive Functioning.** The expression of symptoms in children with ADHD is associated with delays in the development of adaptive functioning. In other words, they are behind in acquiring the day-to-day responsibilities for caring for themselves, socializing and
conversing with others, and those skills necessary for succeeding in becoming an independent member of communities. Stein et al. (1995) found that despite having average intellectual potential, children with ADHD displayed impairments in adaptive functioning that were “similar or even more pronounced” than those observed in children with pervasive developmental disorder or mild mental retardation (pp 668). Similarly, Roizen et al. (1994) found that children with ADHD had standard scores in the borderline to low-average range (mean of 73 +/- 14) on the Vineland adaptive behaviors scales (a measure of the personal care and social skills needed for everyday living), despite displaying average full-scale IQ scores (mean score = 101). Additionally, they found that the discrepancy between the Vineland standard scores and the full-scale IQ scores increased with increasing age and IQ.

**Social Corollaries.** Social problems are common in ADHD children. It is estimated that over 50% of ADHD children have significant problems in their peer relationships. The ADHD child’s immature, disruptive, and provoking behaviors often result in misunderstandings and negative responses by other children. Moreover, children with ADHD have difficulties sharing, responding appropriately, keeping promises, and cooperating with others. Taken together, their behaviors make it very difficult for them to form and keep friendships (Barkley, 2000). Bagwell et al. (2001) established that poor peer relations associated with ADHD extend into adolescence. Specifically, they found that adolescents (13 to 18 years old) with ADHD were reported to have fewer friends and to be involved in fewer common social activities than adolescents without ADHD.

**Academic Corollaries.** One area of enormous difficulty for ADHD children is academic performance. In the classroom, students with ADHD are typically more inattentive and display higher rates of off-task behaviors than their non-ADHD peers. This is especially true during
passive classroom activities, such as listening to the teacher or reading silently. They have difficulty remaining seated, following directions and classroom rules, working independently, and paying attention (DuPaul, 2007). Importantly, they exhibit deficient study skills and poor test performance (DuPaul & Stoner, 1994). Their off-task behaviors are often disruptive and interrupt the lessons going on in their classroom. These disruptive behaviors interfere with their learning and the learning of their classmates (DuPaul, 2007). Additionally, they frequently have great difficulty keeping track of their books, papers, homework assignments, and other academic materials due to poor organizational skills. Their academic problems range from failing to complete their work and poor grades to more serious academic underachievement, grade retentions, suspensions, and higher probabilities of dropping out of school. Additionally, their behaviors are typically difficult to manage, and teachers often become frustrated over time. This often results in negative student-teacher interactions, possibly exacerbating the academic difficulties already faced by these children (Piffner & Barkley, 1990).

There have been numerous studies looking at academic underachievement in ADHD children. Early on, Cantwell and Satterfield (1978) found that 39% of a clinical sample of hyperactive children (vs. 9% of controls) were at least two grades behind their predicted level in reading by using an IQ-achievement discrepancy formula for determining achievement deficits. In a study looking at the prevalence of academic underachievement in children with ADHD and Conduct Disorder (CD), Frick et al. (1991) controlled for both regression and age effects in their use of a discrepancy formula between intelligence and academic achievement. When studied separately, both ADHD and CD were associated with academic underachievement. However, once sophisticated model analyses were performed, the apparent relation between underachievement and CD was found to be due to its comorbidity with ADHD.
Academic difficulties in ADHD children begin early in life and persist into adolescence and young adulthood. Preschool children with symptoms of ADHD are more likely to be behind in basic academic readiness skills, meaning that they enter school at a significant disadvantage relative to their classmates (DuPaul, McGoe, Eckert & VanBrakle, 2001). In an 8 year prospective study following hyperactive children and normal controls, the hyperactive children scored from 0.5 to 1 standard deviation lower than the control children on measures of reading, spelling, and arithmetic, representing significantly poorer academic skills (Fischer, Barkley, Edelbrock, & Smallish, 1990). Hinshaw (1992) concluded that the nature of early attentional problems seems to predispose them toward academic failure. Moreover, ADHD children are more likely than the general population to be diagnosed with a specific learning disorder (American Psychological Association, 2000), and 40% or more of children with ADHD may at some point be placed within formal special educational programs for learning disabled or behaviorally disordered children (Barkley, 2006).

**Treatment Interventions.** Not surprisingly, there have been many intervention studies attempting to improve the off-task behaviors displayed by ADHD children. The most prevalent area of research dealing with interventions for ADHD symptoms is the study of the effects of stimulant medications (the most common of which is methylphenidate, marketed as Ritalin). In their report for the American Medical Association, Goldman and his colleagues (1998) reported that there have been over 170 studies involving school-aged children using stimulant medication, and they concluded that stimulant “medications have been unequivocally shown (i.e., by double-blind, placebo-controlled studies) to reduce core symptoms of hyperactivity, impulsivity, and inattentiveness” (pg 1103). In addition, these medications have been shown to improve academically related tasks in the short term. For example, studies assessing the effects of
stimulant medication have found that compared to ADHD students that have not received medication, those that have recently ingested the medication (from 1 to 3 hours) have shown significantly faster letter matching and sentence verification (Ballinger et al. 1984), higher percentages of complete and accurate language arts and mathematics seatwork (Rapport et al. 1985), improvements in the number of arithmetic problems attempted and percentage correct (Pelham et al. 1985), and a higher number of attempted reading comprehension problems with no decline in accuracy (Balthazor, Wagner, & Pelham 1991).

Though stimulant medications have been shown to have immediate positive results on academic-type tasks, there has been much debate over the effects that such treatments have in the long-term. There have been several studies that have examined the effects of extended medical treatments on academic achievement, which have produced mixed results. It has been suggested that the effect of stimulants on behavior and cognition may be much greater than the effects on academic achievement (Carlson & Bunner, 1993). Only a limited number of studies have utilized a broad range of academic outcome measures including grades, comprehension, achievement scores etc. Of the studies that have used such measures, most have found much smaller effect sizes than for behavioral variables (Raggi & Chronis, 2006). Moreover, about 20-30% of children are considered “non-responders” to stimulant medication (Rapport et al., 1994), and many parents are hesitant or opposed to the use of medication in the treatment of their ADHD children (Smith et al., 2000). Therefore, although stimulant medications seem to offer short-term benefits in attention and off-task behaviors, their ability to improve long-term academic functioning is still unclear. Additionally, they do nothing to teach long-term skills or habits like organization or study skills that may be instrumental in helping ADHD children achieve academically in the long run (Raggi & Chronis, 2006). Pfiffner and Barkley (1990)
suggest that on-task behavior alone, which has been improved by the use of medication, may be “necessary but not sufficient for promoting academic progress in ADHD children” (pp 499).

Psychosocial treatments for ADHD, including behavioral interventions have also been widely researched. Within the school, behavioral interventions typically focus on the manipulation of variables within the environment, including behavioral antecedents and consequences. Antecedents include factors like location (e.g. sitting close to the teacher) or setting (e.g. smaller classrooms), and the consequences can be both positive (e.g. reward systems, praise, token economies), and negative (e.g. time outs, loss of privilege, response-cost procedures). Behavioral interventions have been found to be effective in many respects, some of which include the reduction of teacher-reported ADHD symptoms on behavior rating scales (Pelham, Wheeler, & Chronis, 1998), increased levels of on-task behavior (DuPaul, Guevremont, & Barkley, 1992), and increased levels of seatwork productivity (Rapport, Murphy, & Bailey, 1982).

However, there are some limitations to the research and the interventions themselves that merit noting. First, much like the research on stimulant medication, most of the studies focus on behavioral outcome variables such as time on task, or number of disruptive behaviors, rather than looking at academic outcome measures (Raggi & Chronis, 2006). Additionally, these interventions are typically quite complicated and very time consuming, and the practicality of implementing them within real world classrooms is uncertain (Raggi & Chronis, 2006). Moreover, evidence that behavioral management programs result in behavioral gains that last beyond the direct implementation of the intervention is lacking (Pelham et al. 1998). Therefore, much like pharmacological interventions, while there does seem to be beneficial effects with
regards to improving classroom behaviors, their effectiveness in producing gains in academic achievement is unclear (Raggi & Chronis, 2006).

**Study Skills.** One significant contributor to students’ academic success is their knowledge of and utilization of study skills. Even capable students in all grade levels may experience academic difficulties because they do not possess good study skills (Gettinger & Seibert, 2002). Study skills involve the knowledge and utilization of various study strategies, which are applied during the learning process and support a student’s ability to absorb the information to be learned (Meneghetti, De Beni, & Cornoldi, 2007). They generally involve activities that are necessary to organize and complete academic tasks and to prepare for and take tests. Such activities include time management, utilizing information resources, note-taking, preparing for tests, and successfully communicating with educators (Robins et al., 2004).

Research suggests that study skills are directly related to high school course grades (Noble, Davenport, Schiel, & Pommerich, 1999 as cited in Robins et al., 2004), and several studies have established a link between study skills and cumulative GPA in college students (e.g. Crede & Kuncel, 2006; Gadzella & Williamson, 1984; Kern, Fagley, & Miller, 1998; Ruban, McCoach, McGuire, & Reis, 2003; Robbins et al., 2004).

There is some evidence that students with ADHD have difficulties with study skills, which likely impacts their ability to achieve academically. For example, Reardon and Nagliery (1992) found that young students with ADHD reported having difficulty with inhibiting impulsive responses when they were asked to plan and implement learning strategies. Further, many of the skills that are necessary to implement successful study strategies are deficient in ADHD students, including planning, attention, cognitive processing, and self control (DuPaul & Stoner, 1994; Frazer, Belzner, & Conte, 1992; Reardon & Nagliery, 1992).
Just as poor study skills are likely related to academic difficulties, good study skills have been shown to predict academic success in college students with attention disorders (Kaminski, Turnock, Rosen & Laster, 2006). It would seem that improving the study skills of high school students with ADHD might also positively impact their ability to achieve academically. With this important goal in mind, this dissertation focuses specifically on the ubiquitous study skill of lecture note-taking.

**Lecture Note-taking**

Note-taking, or the abridged written recording of information gathered while simultaneously listening to a lecture or reading a text, is a widely accepted strategy for improving academic performance. As children reach the sixth or seventh grade and beyond, the primary method of relaying information in school becomes teacher lectures (Bretzing et al, 1987; Ornstein, 1994). Students are expected to learn the information gathered in lectures and are then tested on this information. Note-taking is perhaps the most popular technique for facilitating the process of learning through lectures (Bretzing et al., 1987; Hartley & Davis, 1978). By the time students reach college, 99% report taking notes during lectures (Palmatier & Bennett, 1974).

Note-taking is thought to achieve two functions, an encoding function and an external memory function (Anderson & Armbruster, 1986). In the note-taking literature, encoding refers to the learning that occurs as a function of actually taking notes (Kobayashi, 2005). The external memory function consists of the availability of the written notes for further review once they have been taken (Piolat et al., 2005). In other words, taking notes helps one learn in at least two ways: by helping one to encode information while taking notes, and by providing a source for the review of information later on. Each of these functions has been studied for their ability to
improve test-taking performance. Such research has been conducted on note-taking from both lectures and text, but the current review will focus primarily on the research on lecture note-taking.

The encoding/process function of note-taking has been studied by research that investigates whether students who take lecture notes without the opportunity to review them achieve more than those who listen without taking notes during a lecture. The reported results of such studies have been mixed, but a majority of studies have found significant effects for the encoding function of notes. For example, when compared to non-notetakers, notetakers have been found to accomplish significantly greater recall of lecture content (DiVesta & Gray, 1972; Fisher & Harris, 1973; Shrager & Mayer, 1989), significantly better scores on tests of subjects’ immediate recall of details (Titsworth & Kiewra, 2004) and significantly higher scores on tests of subjects’ ability to transfer their knowledge (Shrager & Mayer, 1989). Kiewra (1985a) reviewed 56 studies that investigated the generative effects of note-taking, and 33 studies found significant effects, 21 found no effect, and two studies found detrimental effects. Kobayashi (2005) conducted a metaanalysis of generative note-taking studies and found that the mean weighted effect size across 131 independent samples was 0.22, indicating a small to medium effect for note-taking over no note-taking (according to Cohen’s 1988 criteria). Overall, it seems that a greater proportion of studies have reported positive effects, though the magnitude of those effects appears to be relatively small.

Additional support for the utility of the process of taking notes has been reported through studies that investigate the relationship between the content of subjects’ notes and their recall of lecture information or their performance on tests of lecture content. Studies on lecture note-taking have found that the number of ideas recorded in subjects’ notes correlates with their
performance on tests (Crawford, 1925; Fisher & Harris, 1973; Kiewra & Fletcher, 1984; Peverly et al., 2007), and additionally that specific ideas that were recorded in subjects’ notes had a higher chance of being recalled on a free recall exam than those ideas that were not recorded (47% vs 12% respectively) (Aiken, Thomas, & Shennum, 1975).

Reviewing one’s notes is an exceptionally popular study strategy, and the external storage/product function of notes has also been widely investigated. In response to a survey by Hartley and Davies (1978) 98% of American students polled reported taking notes in order to have the information available for later review. The product function of notes has been studied by looking at subjects who either take notes or do not take notes (listen only) during a lecture and subsequently comparing the achievement of subjects who either review their own notes, review no notes (mental review) or review a set of provided notes before taking a test. Overall, results from such studies are overwhelming in their support for the value of reviewing notes. In the review mentioned above, Kiewra (1985a) analyzed 22 studies that investigated the storage function of notes. He found that 17 of the studies reported a clinically significant advantage for subjects who reviewed notes, 5 of the studies found no significant effects, and none of the studies found detrimental effects. In 2006, Kobayashi conducted a metaanalysis of studies that investigated the outcomes of note-taking plus review versus control groups (21 independent samples), and the outcomes of note-taking plus review versus mental review groups (34 independent samples). He found mean weighted effect sizes of 0.75 and 0.77 respectively, indicating medium to large effects for reviewing notes (according to Cohen’s (1988) criteria).

We know that ADHD students have significant academic difficulties and that research on current psychopharmacological and behavioral treatments has fallen short of showing improvement in academic achievement over the long term. We also know that note-taking is an
important academic skill that correlates well with academic performance. In fact, there is some evidence (though limited) that skill in lecture note-taking may actually predict test scores better than verbal ability (Peverly et al., 2007). However, we do not know very much about the cognitive processes that underlie note-taking, and we know even less about the impact that having ADHD has on these processes. Research on note-taking suggests that it is a cognitively demanding skill. Students are required to attend to the lecture, hold information in working memory while simultaneously selecting important information and transcribing this information into written form before it is forgotten (Piolat et al., 2005; Peverly et al., 2007). Students need to accomplish all this while continuing to follow along with the lecture content.

Transcription speed, working memory, and listening comprehension have each been identified as variables of probable importance to note-taking skills (Armbruster, 2009; Peverly et al., 2007; Piolat et al., 2005), and there is some evidence that individuals with ADHD may have difficulty with these skills. Additionally, students with ADHD present with a primary deficit in their ability to pay attention, and attending to lecture content is assumed to be an important component to lecture note-taking ability (Peverly, Garner, & Vekaria, 2011). Therefore, it seems that it is important to study this population in order to analyze differences in lecture note-taking skills in General education and ADHD populations.

**Transcription Speed**

The term transcription refers to the process of transforming spoken language or thought into written output. Proficient transcription skills are believed to be important to writing development, because writing letters and words can take up significant attentional resources when these skills are not fluent and efficient (Graham & Harris, 2000). Support for this assertion
comes out of several areas of research. Jones and Christensen (1999) found that first grade students’ speed and accuracy in writing letters accounted for greater than 50% of the variance in the quality of their story writing when reading ability was held constant. In other words, skilled writers exhibited better transcription abilities than unskilled writers. Dunsmuir and Blatchford (2004) found that handwriting skills at school entry predicted writing ability at age 7 years. In addition, improvement in handwriting skills has been found to improve quality of writing for students in elementary grades (Berninger et al., 1997; Graham et al., 2000; Jones & Christensen, 1999) as well as middle and high school grades (Christensen, 2005). Finally, transcription skill was found to be the best variable to distinguish good and poor writers among intellectually talented students in elementary grades (Yates, Berninger, & Abbott, 1994).

As normally developing writers get older and the mechanical aspects of handwriting becomes more fluent, research suggests that the amount of variance that is accounted for by handwriting decreases (Berninger, 1999; Connelly & Hurst, 2001). However, Connelly, Dockrell, and Barnett (2005) found that even in college student populations, where transcription skills are assumed to be fluent, writing speed was significantly correlated with timed essay exam scores. Transcription ability certainly seems to be an important component of writing skills, and this association continues within the domain of note-taking. Notably, in their study examining the cognitive variables associated with note-taking, Peverly et al. (2007) looked at the relative contributions of transcription fluency, verbal working memory capacity, and main idea identification skills. They found that transcription speed was the single greatest predictor of the quality and quantity of subjects’ notes.
Transcription and ADHD populations. In order to achieve automaticity of transcription skills, one must hold accurate representations of letter forms in memory, have the ability to fluently retrieve those representations, and additionally hold the planning and motor skills necessary to convert their knowledge to written output (Berninger et al., 1997). Although there is no empirical research that directly examines transcription speed in individuals with ADHD, there is some information about a number of the component skills.

Poor handwriting has long been anecdotally noted to be associated with ADHD children (Barkley, 2006; Selikowitz, 2004; Wender, 2000). Racine, Majnemer, Shevell, and Snider (2008) reported that many studies on individuals with ADHD have described the presence of handwriting difficulties, but they additionally noted that these studies have failed to compare the prevalence of handwriting problems to control groups or normative data. For example, Doyle, Wallen, and Whitmont, (1995) found that parents of children with ADHD subjectively rated their children’s handwriting to be of inferior quality to their normal peers, but these findings were based on parental perception alone. Similarly, Whalen, Henker, and Fink (1981) reported that teachers of children with ADHD reported that their handwriting was “messy and illegible” (pg 421). Overall, although there does seem to be some evidence that the handwriting performance of ADHD children is often inferior to their normal peers, the research is limited and the nature and extent of the difficulties are still unknown. Additionally, even less is known about the handwriting of individuals with ADHD beyond elementary school.

Further indication of possible transcription difficulties is evidenced in research showing that children with ADHD have various motor difficulties, including fine motor problems that could interfere with their transcription skills. For example, ADHD children have shown deficiencies in tests of fine motor control, especially when specific motor sequences are required
In their review of research on movement skill in ADHD children, Harvey and Reid (2003) found that children with ADHD are at greater risk for movement skill difficulties than their non-ADHD peers, and that they are also at greater risk for developing Developmental Coordination Disorder than their peers. Also of note, Marcotte and Stern (1997) found that children with ADHD exhibited impaired planning and graphomotor skills on the Repeated Patterns Test (RPT) when compared with non-ADHD peers. In sum, it seems that there is preliminary evidence to suggest that individuals with ADHD present with difficulties that could adversely impact their transcription speed.

**Working Memory**

Another individual difference variable that has been studied for its impact on note-taking is working memory. Working memory refers to the system that enables and controls the temporary storage and manipulation of information (Baddeley, 1998; 2003). One’s working memory is believed to have finite capacity and limited resources, such that it both facilitates and places constraints on the performance of complex tasks (Baddeley, 2003). Thus individual differences in working memory are believed to influence a wide range of cognitive skills and abilities, especially those that require coordinating multiple processes (Baddeley, 1986).

Empirical studies have shown that working memory plays a large role in language development (Adams & Gathercole, 1996; 2000) and is associated with a wide range of verbal abilities including verbal fluency (Daneman, 1991), reading comprehension (e.g. Cain, Oakhill & Bryant, 2004, Daneman & Carpenter, 1980; Engle, Cantor & Carullo, 1992), and writing skills (e.g. Kellogg, 2001, Swanson & Berninger, 1996). For example, Daneman and Carpenter (1980)
found that individual differences in working memory capacity as measured by a reading span task were significantly positively correlated with reading comprehension performance.

Note-taking is certainly a complex cognitive skill that involves the simultaneous comprehension of lecture information, the selection of important information and the production of written output. It is therefore assumed that taking notes is very taxing of working memory resources (Piolat et al., 2005), especially during a lecture where note-takers must make up for the difference between the rate of speech and their writing speed (Piolat, Barbier & Roussey, 2008). However, the small amount of research that studied the relationship between verbal working memory and the quantity and quality of notes has produced inconsistent results. This inconsistency may be due to the disparate measures used to evaluate working memory among the studies. For example, Kiewra and Benton (1988) measured subjects’ working memory by asking them to unscramble a set of randomly ordered words in order to form sentences under timed pressure. Using this measure, they found that working memory was significantly related to the quantity and quality of subjects’ notes. Similar results were found by McIntyre (1992), who used a related measure where subjects were asked to look at a series of randomly ordered sentences and produce a coherent paragraph. These measures are seemingly related to the nature of the type of processing required while taking notes (Kiewra & Benton, 1988). However, they are not representative of the measures typically used to assess verbal working memory, as they do not involve the overall capacity of the working memory system, which includes both storage and processing components (Daneman & Carpenter, 1980).

Daneman and Carpenter’s reading span test, which is widely used in verbal working memory research, requires subjects to read a set of sentences one at a time (each sentence is removed from sight once read) and to recall the last word of each sentence once the final
sentence is removed from sight. Cohn, Cohn, and Bradley (1995) used similar reading span tasks to test the association between working memory and the quality and quantity of subjects’ notes and found no significant relationship. Peverly et al. (2007) used a span task modeled after Daneman and Carpenter’s (1980) span tests. Because lecture note-taking is a listening task, subjects were asked to listen to a set of sentences instead of reading them, to judge whether each sentence made sense (based on Turner and Engle’s (1989) sentence-word task), and finally to recall the last word from each sentence from the set. Using this method, Peverly et al. (2007) found no significant relationship between working memory and the quality and quantity of subjects’ notes. Of note, however, the authors suggested that verbal working memory was correlated with their measure of transcription speed (the only significant predictor of subjects’ quality of notes), and it failed to contribute a significant amount of additional variance.

**Working Memory and ADHD Populations.** As indicated above, working memory involves the temporary storage and manipulation of information, and it additionally includes a system of executive control that manages the allocation of resources within the system (Baddeley, 2003). One way that these executive control functions have been conceptualized is as a domain-free representation of one’s ability to control attention (Engle, 2002; Kane & Engle, 2003). Indeed, individuals with ADHD tend to have great difficulty with executive control functions, including modulating and allocating attentional resources (Barkley, 2006). Therefore, there has been much research dedicated to determining if individuals with ADHD have working memory deficits.

Empirical results have been inconsistent, and the method of measuring subjects’ working memory varies widely between studies within this domain. Tasks have varied in modality, such
as verbal or spatial modes, and differences in the type of processing required, including the storage and/or manipulation of information (Martinussen, Hayden, Hogg-Johnson & Tannock, 2005). Moreover, some studies control for potentially confounding variables such as comorbid learning disorders or IQ, while others do not.

Since note-taking is thought to be influenced specifically by verbal working memory, the current discussion will focus on results from studies using verbal working memory measures. Within the verbal working memory modality, the tasks can involve numerical digits or non-numerical information like words or sentences. In studies using numerical information, such as digit span tasks (Barkley, Murphy, & Kwansik, 1996; Frazier, Demaree & Youngstrom, 2004; Mariani & Barkley, 1997; McInnes, Humphries, Hogg-Johnson, & Tannock, 2003) or mental arithmetic computation (Golden, 1996; van der Meere, Gunning & Stemerding, 1996) researchers have consistently found significant deficits in working memory in children and adolescents with ADHD when compared with non ADHD controls. Of note, most of these studies failed to control for comorbid learning disabilities or language impairments, which could be contributing factors to the results (Barkley, 2006; Cohen et al., 2000).

Studies using semantic information have been more inconsistent. Siegal and Ryan (1989) developed a task that was modeled after Daneman and Carpenter’s (1980) reading span task with the exception that the final word from each sentence was missing. The child was asked to mentally supply the missing word from each sentence in the set and produce all of the missing words after each sentence set had been administered. They found that 7 and 8 year old children with ADHD performed worse than normal controls, but they found no significant difference for any of their older age groups. One later study that used this modified reading span task found that hyperactive children (exhibiting a T score of 64 or higher on the hyperactivity dimension of
the Conners Teacher Rating Scale) performed significantly worse than normal controls, but only when they did not control for IQ (Kuntsi, Oosterlaan & Stevenson, 2001). Other studies using this version of the sentence span task found no significant deficit in verbal working memory for ADHD children when compared with normal controls (Kerns, McInerney & Wilde, 2001; Ruckridge & Tannock, 2002; Willcutt et al., 2001). Each of these studies looked at the contribution of Reading Disability (RD), and found that RD subjects did show significant deficits in the sentence span task. It is important to consider that each of these studies required the subjects to read the target sentences, which may have contributed to the findings. Moreover, since note-taking during a lecture is a listening task, it is assumed that a listening span version of this working memory measure (like that employed in Peverly et al., 2007) would better capture the working memory processes of interest. It is unclear how ADHD individuals would perform on a listening span task of this kind, because no such studies exist.

**Listening Comprehension**

When students take notes from lectures, it is generally assumed that they must comprehend the information they hear in order to select the important information and record it by writing it down (Fahmy & Bilton, 1990, Piolat et al., 2005). Heaton (1977) outlined a set of sub-skills involved in note-taking, the first of which is “the ability to listen and understand uninterrupted and spontaneous speech.” Listening takes place in real-time and information must be perceived as it is spoken. Therefore, the listener is forced to comprehend while new information is being presented (Flowerdew, 1994). Lecturers aid in the learner’s comprehension by presenting information in a planned and structured way so that the learner can follow the logic of the discourse (Hansen & Jensen, 1994). While taking notes, students look for cues provided
by the lecturer to aid in their comprehension such as oral cues or changes in voice tone (Piolat et al. 2005). It seems intuitive that one’s listening comprehension ability would influence the quality of the notes that one records, but this has not been directly researched in the note-taking literature.

Kiewra, Benton, and Lewis (1987) and Kiewra and Benton (1988) examined the relationship between lecture note quality and measures of general verbal ability including the American College Test (ACT) Comprehension and English scores and grade point average (GPA), the latter of which correlates strongly with listening comprehension ability (Conaway, 1982), and found no significant relationship. However, anecdotal evidence of the importance of listening comprehension in note-taking is brought forth in research involving note-taking with second language learners. Dunkel and Davy (1989) found that non-native American college students reported feeling dissatisfied with their note-taking skills and felt as though they were having difficulty understanding and writing down information conveyed by their English speaking instructors. Specifically, the students reported having inadequate time to listen and simultaneously note important lecture points. Similar findings were reported by Piolat et al. (2008), where college survey respondents rated note-taking as more difficult in a second language due to comprehension difficulties.

**Listening Comprehension in ADHD Populations.** Current conceptualizations of language comprehension theory suggest that listening comprehension involves maintaining both explicit and implicit information in working memory while one’s mental representation of the information is modified and processed as new information is perceived (Kintsch, 1998). It is a cognitively demanding process that requires sustained concentration and effort. In addition to
adequate language skills and the ability to process linguistic elements (Westby, 1991), successful lecture comprehension requires the ability to concentrate on and understand a long stretch of talk, often without the opportunity to engage in active discourse (e.g. asking for repetition or clarification) (Flowerdew, 1994). Finally, comprehension ability is influenced by one’s ability to consciously reflect on the information that is being presented in order to monitor one’s own understanding metacognitively (Dollaghan, 1987).

Individuals with ADHD have difficulty with sustained attention, self-regulation and executive control (for a review see Barkley, 2006). Research on the language abilities of children with ADHD has focused largely on their expressive abilities and has cited weaknesses in the area of verbal production, specifically with sentence-formation (Oram, Fine, Okamoto, & Tannock, 1999) and with the organization and coherence of retold stories (Purvis & Tannock, 1997; Tannock, Purvis, & Schachar, 1993). The limited research on receptive language abilities in ADHD children suggests that ADHD children may be able to comprehend simple factual details as well as their normal peers, but that they may have significant difficulties with tasks that require more complicated processing, vigilance, and effort. For example Lorch, Milich and Sanchez (1998) found that ADHD children were able to answer questions about factual details of a story presented on a television, but that they showed difficulty answering questions that required a causal connection.

McInnes et al. (2003) examined the listening comprehension abilities in 9-12 year old boys with ADHD, Language Impairment (LI), ADHD and LI, and normal controls. They found that the ADHD group performed as well as the normal control group in their comprehension of factual information from both narrative and expository passages. However, the ADHD children performed significantly worse than normal controls on measures that required them to make
inferences from expository information or to monitor their comprehension of instructions, despite adequate word decoding and sentence formulation abilities. Their findings support previous suppositions that ADHD children seem to have difficulty with more complicated or subtle aspects of listening comprehension. Though little is known about the listening comprehension of adolescents with ADHD, they have been found to exhibit poorer scores than normal controls on measures of reading comprehension (e.g. Ghelani, Sidhu, Jain, & Tannock, 2004), which strongly correlates with listening comprehension ability (Hoover & Gough, 1990).

Since lectures are typically much longer than the listening passages involved in listening comprehension measures, it is possible that the listening comprehension difficulties exhibited by ADHD children could prove more severe when they are asked to sustain their attention even longer, especially when the additional demands of note-taking are required of them. Therefore, it seems that ADHD students display inferior listening comprehension skills, which likely has a negative impact on their note-taking skills.

**Attention and Note-taking**

In order to discuss the relationship between note-taking and attention, it is helpful to have a framework of attention from which to work. There are many theories of attention, but the current discussion shall focus on an influential theory proposed by Mirsky and his colleagues (Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Mirsky, 1996) that is based on cognitive and neuropsychological research. Like other models of attention (Posner & Peterson, 1990; Pribram & McGuinness, 1975), Mirsky and his colleagues conceptualize human attention as a complex system with multiple components involving distinct brain regions. Based on their
research, their model subdivides the attention process into five “factors:” focus/execute, sustain, stabilize, shift and encode.

Focusing refers to the ability to screen out distracting stimuli in order to concentrate attentional resources on a specific task (Mirsky, 1996). The focus/execute factor includes the term “execute,” because tests of focus include some element of rapid task execution, which the authors found impossible to isolate from the focus function. The sustain factor describes the ability to maintain a vigilant state through staying on task for some time. The shift factor refers to the capability to shift one’s attentional focus from one target or aspect of the target to another in a “flexible, efficient” way (Mirsky, 1996 p77). Their research has also identified a factor that they call the encoding factor, which is closely tied to traditional definitions of working memory and describes one’s ability to hold information briefly in the mind while performing some action or manipulation upon it. The most recent addition to the model is the stability factor, which refers to the stability, or reliability, of one’s efforts while sustaining attention over time (Tatman, Fantie, & Mirsky, 1995 as cited in Mirsky, 1996).

It seems to make intuitive sense that note-taking requires each of these aspects of the attentional system. For example, in order to take effective notes, one must first listen to and take in the information that the lecturer is saying. Since humans are unable to effectively attend to everything in the environment at once (Ward, 2004), this requires the student to direct his or her attention (focus factor) to the instructor. Also, while taking notes, the note-taker needs to delegate some attentional resources to the act of writing and continuously shift focus between listening and writing (shift factor). In order to take complete notes, focus must be maintained consistently throughout the entire lecture so that the note-taker does not miss anything of importance (sustain and stability factors). The “encode” factor in Mirsky’s model has largely
been addressed above in the section on note-taking and working memory, but including it here emphasizes the attentional demands that are required for one’s working memory to function well.

The connection between attention and note-taking has been widely assumed in the literature on note-taking or effective study skills. In her guide for becoming an effective student, Donaldson (2005) suggested that attending and note-taking during lectures go hand-in-hand, saying “note-taking and paying attention are entwined.” Peper and Mayer (1978) suggested that the generative effect of note-taking may in part be due to the increased concentration that is required to take notes. In their review of studies dealing with student attending behaviors during lectures, Wilson and Korn (2007) concluded that most studies did not account for individual differences in attention, but they suggested that lecturers should take note of the attending behaviors of their students while making sure that they are taking down relevant lecture content in their notes. Finally, Peck and Hannafin (1983) investigated the effects of training in note-taking, and the first step of their training taught subjects how to pay close attention to the speaker. They emphasized the fact that information that is not heard cannot be recorded, and they reminded subjects to listen carefully. Additionally, they taught subjects how to pay particular attention to words that are likely to signal the importance of the lecture information, including “remember,” “important,” or “always.”

The connection between attention and note-taking has also been studied in regard to a proposed intervention for students with attention deficits. Evans, Pelham, and Grudberg (1995) set out to study the efficacy of a note-taking intervention for adolescents diagnosed with Attention Deficit Disorder. Their study design was unusual, but it is included here because this is the only study of its kind and it points to the positive outcomes associated with note-taking in ADHD students. They were interested in the behavioral and learning outcomes associated with
taking notes and studying notes. After training all subjects to take notes using a direct instruction procedure, they compared the on and off-task behaviors of the subjects taking notes versus those not taking notes during daily lectures. They also measured subjects’ performance on next-day quizzes after either allowing them to study their own notes or provided notes or taking away access to all notes during post lecture study hall. Finally, they gave all subjects assignments during study hall that tested their comprehension of the information given during the lecture that day.

They found that taking notes versus not taking notes had no significant effect in reducing disruptive behaviors, but they suggested that this may have been due to a floor effect. They also found that note-taking versus not did not predict next-day quiz scores. They did find, however, that note-taking increased subjects’ on-task behaviors during the lectures. Additionally, they found that allowing access to notes in study hall improved subjects’ performance on study hall assignments (comprehension questions), with quality of notes significantly predicting assignment score. The quality of subject notes also predicted decreased disruptive behaviors during the lecture. The authors concluded that taking notes and having notes while completing assignments improved both the comprehension and on-task behaviors of ADHD adolescents.

Information pertaining to individual differences in attention and its direct impact on note-taking has never been published. However, Peverly, Garner, & Vekaria (2011) recently included sustained attention among the cognitive variables that were studied in relation to their impact on the quantity and quality of notes in college students. They found that individual differences in sustained attention significantly predicted quality of notes.
Attention in ADHD populations. By definition, individuals with ADHD have deficits in their ability to pay attention when compared to non-ADHD peers. Specific inattentive symptoms as outlined in the DSM IV were described above and ADHD diagnoses generally rely heavily on parent and teacher reports of these inattentive symptoms (Barkley, 2006). Moreover, studies using the direct observation of on and off-task behaviors have consistently found that ADHD individuals display significantly more off-task and non-attending behaviors than non-ADHD individuals (Barkley, DuPaul, & McMurray, 1990; Borger & van der Meere, 2000; Sawyer, Taylor, & Chadwick, 2001). Whereas ADHD individuals have not been found to have significant difficulties with orienting (focus factor) (Huang-Pollock, & Nigg, 2003; Mirsky, Pascualvaca, Duncan, & French, 1999), they have displayed significant difficulties with sustained attention and persistence (sustain and stability factors), especially during dull or boring and repetitive tasks (Barkley, DuPaul, & McMurray, 1990; Newcorn, et al., 2001; Mirsky, 1999). Additionally, Mirsky (1999) found that ADHD children were impaired in their ability to shift their attention in a flexible manner when compared to non-ADHD controls based on their performance on the Wisconsin Card Sorting task. It seems clear that ADHD individuals have difficulties with the very attending skills that are central to taking notes during a lecture.

Subtypes. As briefly introduced above, a diagnosis of ADHD is associated with one of three specific subtypes of the disorder. The DSM-IV-TR outlines the symptoms associated with the Predominantly Inattentive (PI), Predominantly Hyperactive-Impulsive (PH), and Combined (C) subtypes. Some researchers argue that those with the PI subtype may actually have a distinct, independent disorder. They agree that children with the PI subtype are impaired, but argue that the constellation of their symptoms differ from the C and PH subtypes in prevalence, gender ratio, and co-occurring problems (Carlson, Shin, & Booth, 1999). The PI subgroup is
generally described as having “sluggish” cognitive processing and do not show the same behavioral inhibition deficits that are so central to the other subtypes (Barkley, 2006).

The Predominantly Hyperactive/Impulsive (PH) subtype is the least prevalent (Baeyens, Roeyers, & Walle, 2006), the most recently established (Barkley, 2006) and the least studied subtype. Moreover, there has also been much debate over the proposition that the PH subtype represents a subset of young, often preschool aged children who tend to qualify for the Combined subtype as they age. Therefore, the PH subtype is often argued to be simply an early developmental stage of the ADHD Combined subtype (Barkley, 2006, Baeyens et al, 2006). For these reasons, most comparison studies focus on the PI and C subtypes.

Individuals with ADHD-C subtype reportedly exhibit more externalizing problems than those with the PI subtype (Baeyens et al., 2006). Faraone, et al. (1998) found that the C group had significantly higher incidences of comorbid Conduct Disorder and Oppositional Defiance Disorder than the PI group. The incidence of internalizing disorders (specifically Anxiety and Depression) is similar between the two groups (Baeyens et al., 2006; Murphy, Barkley, & Bush, 2002), but the PI group does receive higher scores on measures of Withdrawn or Somatic Behaviors (Baeyens et al., 2006). Individuals with the Combined subtype have also been found to exhibit higher rates of bipolar disorder and substance use disorders than those with the PI subtype (McGough et al., 2005; Millstein, Wilens, Biederman, & Spencer, 1997). Notably, however, academic functioning appears to be impacted in all individuals with ADHD regardless of subtype classification and/or presence or absence of co-morbid disorders (Faraone et al., 2000; Loe et al., 2007; Murphy et al., 2002). Since this study’s main focus involves academic functioning, it does not differentiate between subtypes of ADHD.
Note-taking Intervention

It is clear that ADHD is associated with academic underachievement, and the current psychopharmacological and therapeutic treatments have not proven to be successful in improving the academic performance of ADHD individuals in the long term. It seems that there is a real need for ADHD interventions that target poor academic achievement. Within schools, students with ADHD often seek special education services or accommodations in order to aid in their school success. Gordon and Murphy (2000) reported that suggesting accommodations for ADHD students is difficult, because empirical evidence for best-practice interventions is not available, but they do suggest that students with ADHD must acquire good study skills, organizational skills, and test-taking skills.

As outlined above, taking notes is certainly an important component of good study skills, and one’s quality of notes is a significant predictor of test performance. Given the difficulties that ADHD individuals seem to have with the individual difference variables associated with note-taking skills, it is probable that ADHD students have more difficulty with note-taking than non-ADHD students. In fact, Minskoff and Allsopp (2003) suggested that note-taking is a particularly difficult task for ADHD individuals. DuPaul and Stoner (1994) recommended that ADHD students should be allowed to tape-record lectures in order to supplement their notes due to their attentional and organizational difficulties. Additionally, it has been suggested that one effective accommodation for college students with ADHD is to provide them with note-takers (National Resource Center on ADHD, 2003). Whereas providing ADHD students with skilled note-takers or access to audio recordings of lectures is likely to result in their having more complete information from which to study, reliance on this type of accommodation negates the encoding function that is thought to stimulate student attention and to facilitate the transfer of
information into long-term memory (Ruhl & Suritsky, 1995). Therefore, the current investigation seeks to investigate the need for an intervention that serves to improve the quality of ADHD individuals’ notes while allowing them to take their own notes.

There is strong empirical evidence that the completeness of one’s notes is positively related to achievement (for a review see Armbruster, 2009), and Kiewra et al. (1989) suggested that one way to improve the quality of an individual’s notes is to help them to take more complete notes. One method for improving the completeness of subjects’ notes that has shown success for non-ADHD students is providing them with an outline (also called skeletal or linear) framework on which to take their notes (Armbruster, 2009). The skeletal outline generally consists of a handout containing main lecture points as well as space for students to take notes. In a set of naturalistic experiments, Hartley (1976) found that students who were provided with skeletal outlines recalled more lecture information than subjects who took their own notes or those who were provided with a complete set of instructor notes prior to lectures. Similarly, Collingwood and Hughes (1978) and Klemm (1976) found that students who took notes on skeletal outlines during lectures performed better on classroom examinations than those who took conventional notes with no outlines.

Other lecture handout formats have also been studied in the literature, the most popular of which is the “matrix” framework. Handouts using the matrix framework contain a grid (matrix) with a set of topics along the horizontal axis and a set of sub-topics along the vertical axis. Students are expected to take notes within the cells of the grid by recording information that links the intersecting topic and sub-topic at each cell. Kiewra and colleagues (1989, 1991, and 1995) compared the test performance and completeness of subject notes using skeletal outline frameworks, matrix frameworks, and conventional notes. In Kiewra, DuBois, Christensen, Kim,
and Lindberg (1989), the researchers found that students taking notes on a skeletal outline framework recorded more idea units than those using the matrix framework and significantly more idea units than those taking notes with no outline framework. In Kiewra, DuBois, Christian, McShane, Meyerhoffer, and Roskelly (1991), they found that subjects who took notes on matrix (47%) and outline (46%) frameworks recorded significantly more lecture ideas in their notes than those taking their own conventional notes (32%). Finally, in study 1 of Kiewra, Benton, Kim, Risch, and Christensen (1995), they found that subjects taking notes on a skeletal outline took more complete notes than those recording notes conventionally or using a matrix framework.

In terms of performance outcomes, Kiewra et al. (1989) failed to find that providing lecture handout frameworks (skeletal or matrix vs. none) significantly affected learning outcomes. However, Kiewra et al. (1991) found that subjects taking notes using a matrix framework outperformed those taking conventional notes on a cued recall test of lecture content. No significant results were found involving the skeletal outline framework. Conversely, study one from Kiewra et al. (1995) found that students provided with skeletal outline frameworks performed significantly better than those with no outline or matrix frameworks on measures of relational learning and delayed recall. The authors suggested that their disparate findings may have resulted from modifications they made to the skeletal outline framework. In their 1991 study, Kiewra et al. used a “fixed” format, where the main ideas presented on the handout did not necessarily follow the order the ideas were presented in the lecture. Kiewra et al. (1995) changed this to a flexible format in study one, where the main ideas in the outline followed the presentation order of the lecture. They suggested that this modification reduced the need for subjects to search for the appropriate space to record their notes while also providing a cue to
upcoming lecture topics. Kiewra et al. (1995) bolstered these findings in study two, where they found that students taking notes using a flexible outline framework recorded more notes than those using other note-taking frameworks, including a fixed outline framework and matrix frameworks.

As a note-taking intervention, skeletal outlines seem to produce promising results in non-ADHD populations. Kiewra et al. (1985b) speculated that skeletal outlines provide note-takers with an organizational framework that aids in learner understanding of lecture structure and content. Additionally, they suggested that the outline provides guidance regarding which information is important and warrants their attention. Finally, referencing Thompson and Tulving (1970), Kiewra et al. (1985b) suggested that skeletal outlines also provide note-takers with helpful review materials through their capability to supply effective cues for the retrieval of note content.

It seems that the format of lecture handouts makes an important impact on their efficacy for improving subject note-taking. Early insight into the most effective outline format for note-takers was provided by Hartley (1976), who found that subjects given skeletal notes containing less information and more space took more notes than subjects given full notes or more information and less space for note-taking. These findings were replicated by Morgan, Lilley, and Boreham (1988), who found an inverse relationship between the amount of information provided within a lecture handout and the amount of notes that students recorded. Morgan et al. (1988) additionally found that students who were provided with headings only (compared with full lecture text and headings plus key details) performed best on cued recall tests given two days and two weeks following the lecture.
Despite the promising results with non-ADHD populations and the difficulties that ADHD individuals seem to have with conventional note-taking, no studies currently exist that investigate the use of skeletal outlines with ADHD individuals. In fact, there is little information pertaining to the use of outlines with populations who have learning difficulties in general. One study, by Ruhl and Suritsky (1995), investigated the use of skeletal outlines and a “pause-procedure” on measures of note completeness and recall of lecture content for Learning Disabled (LD) college students. They found that the pause procedure (including strategically placed pauses throughout the lecture) was more effective on both outcomes than providing an outline. However, the outline they used was “fixed” format, and they suggested that the LD students had a difficult time following the outline and keeping up with the lecture. Armbruster (2009) suggested that a flexible format, like that used in Kiewra et al. (1995) may be easier for LD students to use.

Additional gaps in this literature include studies involving note-takers that are younger than college-aged. By the time students reach high school, the primary mode of instruction is lecturing, and good note-taking skills are increasingly important (Minskoff & Allsopp, 2003). Notably, in a prospective, longitudinal study of ADHD outcomes, Barkley, Fisher and colleagues (1990) found that nearly a third of ADHD subjects had dropped out of high-school and only 5 percent (compared with 40% non-ADHD controls) had completed a university degree program. These findings indicate that interventions that promote academic success are needed before students drop out or fail to attempt or complete college. Moreover, Kobayashi (2006) found that note-taking interventions in general were more successful for junior high and high school students than for college students, perhaps because students who make it to college have often successfully acquired adequate note-taking skills on their own.
Summary and Hypotheses

In summary, the current investigation aims to study the efficacy of providing flexible skeletal outlines to high school students with ADHD. Specifically, it aims to investigate the role of ADHD status (ADHD versus not) and note-taking format (skeletal outline versus conventional notes) in subjects’ quality of notes and test performance. Additionally, information pertaining to the role of attention, verbal working memory, transcription fluency, and listening comprehension will be gathered and compared across groups. The proposed study purports the following hypotheses and/or raises the following research questions:

Independent Variables

Hypothesis: High school students with ADHD will perform more poorly on measures of attention, working memory, transcription fluency, and listening comprehension than high school students without ADHD.

Notes

Hypothesis 1: Transcription speed and attention will be significantly related to notes quality.

Hypothesis 2: High school students with ADHD will produce lower quality lecture notes than high school students without ADHD.

Hypothesis 3: High school students with and without ADHD who are provided with a skeletal lecture outline will produce higher quality notes than high school students who are not provided with a lecture outline.

Research Question 1: Will the variables of verbal working memory and listening comprehension be related to test performance? Will these relationships differ for students with and without ADHD?

Test Performance

Hypothesis 1: Quality of lecture notes will significantly predict overall test performance as well as performance on items testing memory for details. However, lecture notes are not expected to predict performance on inferential learning items.
Hypothesis 2: ADHD status will predict performance on learning items and overall test performance. or Students without ADHD will perform better than ADHD students on a test of lecture content.

Hypothesis 3: High school students who are provided with a skeletal lecture outline will perform better on a multiple choice test than high school students who are not provided with a lecture outline.

Research Question 1: Will the variables of attention, verbal working memory, transcription fluency, and listening comprehension be related to test performance? Will these relationships differ for students with and without ADHD?
Chapter III

Method

Participants

Participants were high school students ($N = 83$) from two Massachusetts high schools. One was a large high school in a suburban school district in the Boston Metropolitan Area ($n = 63$), and the other was a relatively smaller high school in a more rural area in western Massachusetts ($n = 20$). Three participants were excluded from analyses for reasons to be described later. The resulting sample ($N = 80$) had a mean age of 16.7 years ($SD = 1.33$) and consisted of 66% males. Participants were 83% White, 13% Hispanic, 1% African American, and 3% “Other.” Of note, 6% chose not to report their ethnicity. Table 1 contains demographic information by school. Based on a report by the US Census Bureau in 2008 (Davis & Bauman), the average student population in the United States is composed of 58% White, 14% African American, 14% Latino/a, 3% Asian, and 7% other foreign born students.

<table>
<thead>
<tr>
<th></th>
<th>Eastern MA ($n=60$)</th>
<th>Western MA ($n=20$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Age ($SD$)</td>
<td>16.71 (1.41)</td>
<td>16.68 (1.04)</td>
</tr>
<tr>
<td>Male</td>
<td>72%</td>
<td>50%</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>75%</td>
<td>90%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>14%</td>
<td>0%</td>
</tr>
<tr>
<td>African American</td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>Asian</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Native American</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>Not reported</td>
<td>8%</td>
<td>0%</td>
</tr>
</tbody>
</table>

ADHD Group. Participants were non-clinic referred individuals with a diagnosis of ADHD ($n = 40$) recruited through the high schools’ special education departments. In order to
receive accommodations or services at school, students must have either an Individualized Education Plan (IEP) or a Section 504 Accommodation Plan. Each of these plans includes information pertaining to disability diagnoses, including ADHD. In order for their plan to include an ADHD diagnosis, students must have been assessed by a qualified evaluator within the last three years. Each student receiving special education services also receives annual reviews and triennial evaluations by the School Psychologist. Students with ADHD diagnoses were identified, and a master list was compiled by school personnel. No information was provided pertaining to which plan (i.e. IEP or 504) or special education classification the students had. A letter prepared by the researcher was sent home to the parents of each student on the list in order to introduce the study and to obtain parental consent for participation (see Appendix B).

Parents were also asked to complete a modified version of the Disruptive Behavior Rating Scale (Barkley & Murphy, 2006). This scale is a narrow and symptom specific rating scale, and was modified so that parents provided ratings for DSM-IV-TR symptoms of ADHD only in order to confirm their school-based diagnoses. As such, questions pertaining to other disorders were eliminated. Notably, only 45% of parents from the total sample and 33% of parents from the ADHD group returned the behavior rating scale. Of those who did return the scale in the ADHD group, 87% (14 out of 16) met full criteria for ADHD based on their parent’s ratings, and the two individuals who did not meet criteria were each one symptom below diagnostic threshold. No individuals from the non-ADHD group met criteria for ADHD based on the rating forms. Information confirming ADHD subtype was not available for this study. However, examination of the parent rating forms indicates that of the ADHD sample who returned parent rating forms, 71% met DSM-IV-TR criteria for the Combined subtype, 14% met
criteria for the Predominantly Inattentive subtype, and 14% met criteria for the Predominantly Hyperactive subtype. Notably, of the participants within the ADHD group, 47% self reported taking medication to address symptoms of inattention.

**Non-ADHD Group.** For each ADHD participant who returned a consent form, a non-ADHD participant from the same English class was selected to participate. Both schools tracked their students. A member of school staff selected the first non-ADHD student of the same gender as the ADHD participant that was listed on the class roster. If a parent did not give consent for the student to participate, then the next same-gendered student on the roster was selected, and so on, until there were equal numbers of students in each group. In this way, students were selected of the same gender, grade, and English class track level. The ADHD group did not differ significantly from the non-ADHD group in age, gender distribution, or native language. However, the groups did differ significantly by ethnicity. Of the participants who reported being Latino, African American, or “other,” 77% were from the non-ADHD group.

**Co-morbidity.** Participants were also asked to report if they had ever been diagnosed with a reading or writing disability. Importantly, 27% of the ADHD group reported also having a reading or writing disability, or both. In contrast, only 7.5% of the non-ADHD group reported having a learning disability. Therefore, a significantly larger proportion of the ADHD group identified that they had a learning disability ($\chi^2 = 6.08, p < .05$). These results should be interpreted with caution, because learning disability status was determined solely on the basis of self report, which is likely not an accurate method. Nevertheless, this speaks to the co-morbidity of learning disabilities and ADHD and was not unexpected. Table 2 contains demographic information by ADHD group.
Individual assent for participation was obtained at the start of experimental sessions. Students who returned a consent form were given an ID number for use in the remainder of the study in order to protect confidentiality. Student participants were compensated for their time by receiving a movie pass and by being entered into a drawing for one of two $50 dollar Visa gift cards.

Table 2

<table>
<thead>
<tr>
<th>Demographic Information by ADHD Status</th>
<th>ADHD (n=40)</th>
<th>Non-ADHD (n=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Age (SD)</td>
<td>16.48 (1.23)</td>
<td>16.93 (1.39)</td>
</tr>
<tr>
<td>Male</td>
<td>68%</td>
<td>65%</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>90%</td>
<td>65%</td>
</tr>
<tr>
<td>Latino/a</td>
<td>5%</td>
<td>20%</td>
</tr>
<tr>
<td>African American</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td>Asian</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Native American</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td>Not reported</td>
<td>3%</td>
<td>10%</td>
</tr>
<tr>
<td>Eng. First Lang.</td>
<td>95%</td>
<td>83%</td>
</tr>
<tr>
<td>Comorbid LD</td>
<td>27%</td>
<td>7.5%</td>
</tr>
</tbody>
</table>

Note. Eng. First Lang. = English as a first language, LD = Learning disability

Materials

The materials consisted of a lecture video, a flexible style skeletal outline of lecture topics, a multiple choice test of lecture content, a measure of sustained attention (the Lottery subtest of the Test of Everyday Attention; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994), a measure of transcription fluency (the alphabet task), a measure of listening comprehension (the Listening Comprehension subtest of the Kaufman Test of Educational Achievement-Second Edition; Kaufman & Kaufman, 2004), a measure of verbal working memory (a listening span task), and a demographics questionnaire. All measures were group administered. An mp3 player using a dock speaker system was used to present the auditory based measures. Inter-rater
agreement in scoring was established for all measures by randomly selecting 25% of the protocols to be scored by an independent rater, who is a PhD level graduate from the same doctoral program as the examiner. Disagreements were be settled by consensus.

**Lecture.** The videotaped lecture was read from a prepared text by a woman who has experience reading for radio commercials. The lecture was 15 minutes long and covered the history of a 19th century American mercantile ship called The General Harrison. The content was adapted from a book by a maritime archeologist named James P. Delgado (2004), titled *Adventures of a Sea Hunter: In Search of Famous Shipwrecks.* The topic was chosen, because the content is not covered in traditional public school curricula. The prepared lecture text had a Flesch-Kincaid Reading Level of 9.6 (Flesch, 1951), and consisted of 1,802 words. For a pilot study, the lecture (1970 words) was read at approximately 131 words per minute. This rate of presentation is in the midrange of rates used in previous note-taking studies: 100 WPM (DiVesta & Gray, 1972); 110 WPM (Boyle & Weishaar); 120 WPM (Frank, 1984); and 150 WPM (Peck & Hannafin, 1983). However, based on feedback during the pilot study, the lecture was revised and re-recorded so that it could be read at a slower pace of approximately 120 WPM. The lecture text is included in Appendix C.

**Note-taking outline.** Approximately half of the participants received a flexible style skeletal outline on which to take their notes (n= 43). The outline consisted of five sheets of unlined 8 by 11- inch paper containing the main lecture points/headings as well as space for participants to take notes. This outline format was chosen based on empirical studies of note-taking outlines. Within the note-taking outline literature, the term *flexible* describes an outline where the lecture topics that are provided on the outline follow the presentation order of the lecture. The use of a flexible outline for this study was based on research by Kiewra et. al.
(1995), who found that students taking notes using a flexible outline recorded more notes than those using fixed formats. Additionally the outline used for the current study contained three to four lecture topics/headers on each page with plenty of space (6-7cm, or about 2.5 inches) for taking notes between each topic. This is based on the research by Hartley (1976) and Morgan et al. (1988), who found that subjects given skeletal notes containing less information and more space took more notes than subjects given full notes or more information and less space for note-taking. Morgan et al. (1988) additionally found that students who were provided with headings only (compared with full lecture text and headings plus key details) performed best on cued recall tests given two days and two weeks following the lecture. The outline used for this study can be found in Appendix D. The other half of participants (n= 40) received 4 pages of plain, unlined 8 by 11 inch paper on which to take their notes.

**Scoring notes.** All participants’ notes were scored for quality, including scores for main ideas, details, and total note quality. One participant was removed from analyses, because he or she did not take any notes. Note quality is defined in this study as the proportion of lecture points recorded within participant notes divided by the total possible lecture points delivered. Therefore, this measure of note quality could also be considered a measure of note completeness. This type of proportion (points recorded/total possible presented) has been widely used in the lecture note-taking literature as a measure of note quality (e.g. Crawford, 1925; Kiewra & Frank, 1988; Kiewra et al., 1995). In order to score participant notes, main ideas and details for each paragraph of the lecture text were identified and listed onto a scoring rubric. Interrater agreement of information unit categorization (detail vs. main idea) was 0.93, and disagreement was settled through consensus.
Participants received 1 point for each main idea information unit that they recorded in their notes (main ideas range from 2 to 8 information units). Participants also received 1 point for each detail they recorded in their notes. For example, the main idea of one lecture topic was: The General Harrison was converted into a warehouse (worth 2 points: The GH was converted + into a warehouse). The details presented about that topic included: the GH was hauled onto the mud (1 pt), it was housed over (1 pt), a door was cut into the hull (1 pt), it was located at the corner of Clay and Battery Streets (1 pt), and so on. Participants received 1 point for the main idea if they recorded that the General Harrison was converted, but they needed to record that it was converted into a warehouse in order to receive the full two points. Separate proportions were calculated for the main ideas, details, and total lecture points recorded (main ideas + details). Since some units of information were provided on the outlines, the total possible information units (the denominator in each proportion) differed slightly for the outline group, and participants were not awarded points for information that was provided on the outline.

Twenty-five percent of the notes were randomly selected and scored by an additional trained scorer who is a Ph.D. level graduate of the same doctoral program as the researcher. Inter-rater agreement was good (intra-class correlation coefficient = .94).

**Multiple-Choice Exam.** The multiple-choice (MC) test used in this study is based on the ones developed by Brown (2005) and Sumowski (2007), which consisted of 18-20 questions with four possible answers for each question. Brown and Sumowski each based the development of their test questions on Kintsch’s (1998) model of text comprehension. Kintsh proposed that there is a difference between tasks that assess *memory*, which includes items that test one’s ability to recall information stated explicitly within text, and those that assess one’s ability to generate *inferences* beyond what is stated in the text. Within the note-taking research literature,
some have found that note quality predicts inference performance (Peper & Mayer, 1986; Peverly et al., 2003), and others have found that note quality is a better predictor of memory items than inferential items (Kiewra, 1989; Sumowski, 2007).

The development of both memory and inferential items in the MC test used in this study was also based on the research on listening comprehension in children with ADHD by McInnes et al. (2003). They found that a group of boys with ADHD performed as well as the normal control group in their comprehension of factual information from both narrative and expository passages; however, the ADHD group performed significantly worse than normal controls on measures that required them to make inferences from expository information. Therefore, the MC test used in this study consists of 20 questions, each with four answer choices. Half of the items asked questions with answers that were stated directly in the lecture (memory), and half of the items asked questions that require some degree of inferential reasoning to choose the correct answer (inferential). Interrater agreement of question categorization (memory vs. inferential) was 0.95, and disagreement was settled through consensus (raters were the author and one advanced graduate student independent rater). Total test scores were calculated by dividing the number of correct answers by the total number of questions, yielding a total percentage correct. The proportion of correct memory and inferential items were also calculated separately. Possible scores for the total score, memory items, and inferential items ranged from 0-100%. The questions are presented in Appendix E, with the correct answers printed in italics. Results produced a Cronbach Alpha of 0.86 for the complete test, showing good reliability. The Cronbach Alpha for memory items was 0.72 and for inferential items was 0.77.

**Sustained Attention.** The Lottery subtest of the Test of Everyday Attention (Robertson et al., 1994; TEA) was used to measure participants’ sustained attention, or the ability to
maintain attention to a relatively unchanging task that may be boring at times. The TEA was used instead of the Test of Everyday Attention for Children (TEA-Ch), because neither age range (TEA-Ch: 6-16, TEA: 18-80) encompasses the age range expected in this study (14-19 years), and ceiling effects have been reported (Strauss, Sherman, & Spreen, 2006). Therefore, under the assumption that the adult version of the test is harder, the TEA was used in order to maximize variability.

During the Lottery subtest of the TEA, participants are told that they found a lottery ticket ending in the number “55” (Version A). They are told to listen for their winning number (55), and then immediately orally recall the two letters preceding that number. To do this, participants are required to listen to a 10-minute series of letters and numbers of the form “AB123, CD255” presented by a male voice on a compact disc. In this study, the participants were administered the Lottery subtest in a group format. Therefore, while listening to the numbers, participants were required to write down the two letters preceding all numbers ending in “55” rather than orally recalling them to an examiner. There are 10 incidents on the recording were the number ends in “55.” The scoring instructions in the test manual states that participants should receive one point every time they write down at least one of the two preceding letters in the correct place (e.g., participant writes KB instead of KC) for a maximum of 10 points.

Based on the results from a pilot study, the current study was scored using two different scoring criteria. In one method of scoring, participants received a point when they recorded either of the two preceding letters in the correct place as suggested by the test manual. In the other method, participants received half of a point for each correctly placed letter in an attempt to increase variability. The former method produced skewed results (-.680, SE = .264) with 20 percent of participants receiving a perfect score, suggesting a ceiling effect. The latter method
resulted in a more acceptable skewness statistic (-.486, SE = .264), with only one percent of participants receiving a perfect score. Therefore, the latter score (raw scores) was used for all statistical analysis. Interrater agreement was 1.0.

According to the manual, the TEA’s non-clinical normative sample consisted of 154 volunteers from England, who ranged in age from 18 to 80. The sample was stratified into four age bands, with 39 individuals falling within the 18-34 age bracket. It was also stratified according to educational level, which was assessed using the *National Adult Reading Test (NART)* (Nelson, 1982), splitting each age band into those who scored above and below 100. The clinical sample consisted of 80 unilateral stroke patients seen two months post-stroke. Information is reported for 74 members of the clinical sample. No information was reported regarding the demographics of the samples (Robertson et al., 1994).

No internal reliability information is provided in the manual, and due to ceiling effects, no test-retest reliability information is provided for the lottery subtest for the normative sample. Alternate form test-retest reliability was reported for the clinical sample, and was adequate (0.77). The lottery subtest appears to have strong construct validity. The TEA is one of the few clinical measures of attention that is theoretically grounded (Bate, Mathias, & Crawford, 2001), and is increasingly used in research on attention. The authors carried out a principal components analysis, which yielded four factors that accounted for 62.4% of the total variance in the normative sample. The lottery subtest loaded heavily into the Sustained Attention factor (.70), and evidenced low loadings on the other three factors (-.10, .18, and .25). The manual also reported that the correlation between the lottery subtest and a measure of estimated verbal intelligence is very low (0.05) when age is partialled out, suggesting discriminant validity. Additionally, the lottery subtest adequately differentiates between attention and hearing deficits;
it was not highly correlated to a measure of hearing impairment. Further, validity studies conducted by the authors and others have shown that the Lottery subtest significantly discriminates between clinical and control groups (Bate et al., 2001; Robertson et al., 1994).

**Transcription Speed.** The alphabet task, based on the one used by Berninger and Alsdorf (1989), was used to measure participants’ ability to write quickly. Participants were provided with lined paper and asked to write the alphabet horizontally in capital or lowercase letters, starting with the letter “A.” Once finished, they were instructed to begin the alphabet again and continue to write all the letters of the alphabet until the 30 second time limit was reached. One point was awarded for each recognizable letter, and the points were summated to calculate participants’ total scores. Interrater agreement was 1.0.

**Verbal Working Memory.** A modified version of the Listening Span task, first used by Daneman and Carpenter (1980, Experiment 2) was used in order to assess individual differences in auditory verbal working memory. This task is based on Baddeley and Hitch’s (1974) model of working memory, which stresses the importance of both a storage function and simultaneous ongoing mental activity. The task involves orally presenting 60 unrelated sentences in five groups of three sets of sentences each. In the original version, each group consisted of three sets of sentences that ranged from two to six sentences each. Therefore, the first group consisted of three sets of two sentences, the second consisted of three sets of three sentences and so on until the last group, which included three sets of six sentences. Subjects were asked to recall the last word of each sentence in the set, and in order to include an additional processing component, participants are required to make a judgment about whether or not each sentence makes sense. In order to cut down on participant fatigue, the current study modified the presentation of this task, such that each group of sentences was comprised of two sets of sentences instead of three.
Conway et al. (2005) consider span tasks to be adequate in length as long as there are a minimum of two elements per set (i.e. two sets of two sentences each, two sets of three sentences each, etc). Therefore, participants listened to 40 sentences in five difficulty groups with two sets of sentences in each group via mp3 player. The sets ranged from two to six sentences. Participants were given two seconds following the presentation of each sentence to circle “yes” or “no” on their response sheets to indicate whether or not the sentences made sense. Once all of the sentences in a set were presented, a tone sounded on the recording, which indicated to participants that they should recall and write down the last word from each sentence in the set. After 20 seconds, a second tone sounded, indicating the start of the next set of sentences. Participants were given two practice items at the two- and three-sentence level before the test began, and were told to expect the number of sentences to increase during the course of the task.

In the original study by Daneman and Carpenter (1980, experiment 2) they questioned subjects upon completion of the task and found that subjects believed the yes/no decision component to be an important part of the task. In order to add a quantifiable check that subjects did in fact engage in the processing of the sentences rather than simply focusing on the final words, Turner and Engle (1989) calculated a processing score. The current study also calculated a processing score based on the method used by Turner and Engle (1989), such that the processing score equaled the percentage of sentences that participants accurately identified as making sense or not making sense. According to Conway et al., as long as subjects receive a processing score of 85% or above, the score can be disregarded, since it generally correlates positively with performance on the storage component and accuracy is generally close to ceiling. Therefore, for the current study, it was proposed that participants’ processing scores would be checked to make sure they were at least 85%. If the processing score fell below 85%, it was to
be assumed that the subject was not engaged in the processing component of the task, and the participant’s working memory score was to be disregarded. However, upon scoring the results, over 40 percent of participants scored below 85% on the processing portion of the task. The recording did contain white noise in the background, and it is possible that this made it somewhat difficult for participants to understand in a group format. Therefore, a less stringent 80% cutoff was used with this sample, yielding two disregarded scores.

A listening span score was calculated based on the procedures outlined in Daneman and Carpenter (1980). Participants’ span scores were calculated according to the level at which they correctly recalled the last word of both sets of sentences. Levels correspond to the number of sentences in the set, ranging from two to six. That is, if participants correctly recalled the last word of both sets of sentences at level four (four sentences per set) but not for level five, then their span score was scored as four. If participants correctly recalled the last word of one set of sentences but not the other set, then their span score was equal to the highest level where they accurately recalled the last word from both sentence sets, plus 0.5. Therefore, if a participant correctly recalled the last word of both sets at level four, but only one set at level five, then their span score equaled 4.5. Participants were not be penalized for not recalling the words in the correct sequential order; however, they were not given credit for responses beginning with the last word of any set. This was clearly stated to participants during the instructions to this task. Possible scores on this measure had a range of 0.5 – 6.0, and interrater agreement in scoring was 1.0.

Span tasks of this nature are not standardized; however, working memory span tasks have been used in literally hundreds of independent studies. In terms of reliability, internal consistency estimates obtained from these studies are adequate, generally resulting in coefficient
alpha correlations ranging from 0.70-0.90 for span scores (Conway et al., 2005). Additionally, test-retest reliability was high (0.70-0.80) for reading span tasks over weeks, months, and even a year (Conway et al.). Since reading span scores correlate highly with listening span scores (0.75), these findings can be inferred to correspond with this listening span task (Daneman & Carpenter, 1980).

In terms of validity, working memory span tasks have demonstrated substantial construct validity, since they have been found to predict performance on tasks that are assumed to rely heavily on the working memory components of attention and executive control (Conway et al., 2005). Additionally, working memory span tasks correlate extremely well with each other as well as other complex tasks that depend on working memory, and they do not predict performance on tasks that are thought to manifest relatively automatic processing, indicating convergent and discriminant validity (Conway et al.). Therefore, complex span tasks, like the one in this study, have been established as reliable and valid measures of working memory.

**Listening Comprehension.** The Listening Comprehension subtest of the Kaufman Test of Educational Achievement - Second Edition (Kaufman & Kaufman, 2004) was used to assess participants’ ability to understand relatively formal speech. Typically, this subtest is administered individually, where the examinee is required to listen to a passage via compact disk and then orally answer questions about it that are presented the examiner. Administration was altered slightly in order to allow for group administration. Participants listened to six passages using a digital mp3 player (Form A), consisting of the item set designated for administration to grades 8 and above. After the presentation of each passage, the experimenter presented the corresponding questions one at a time via PowerPoint. In this way, participants did not have access to the questions while the passage was being presented, and they were unable to go back
to earlier questions. Participants wrote down their answers to the questions in their response packets. Items consisted of multiple choice and short answer questions, and each item was presented for 30 seconds. Total administration of the Listening Comprehension subtest was approximately 17 minutes.

Scoring of the Listening Comprehension subtest followed the procedures outlined in the KTEA-II manual. Participants were awarded zero or one point for each of their responses, according to their similarity with the answers provided in the KTEA-II test manual. Raw scores (with possible range of 0-19) were used in statistical analyses, and interrater agreement in scoring was 1.0.

The KTEA-II was normed and standardized according to the March 2001 Current Population Survey, and according to the manual, there were 2,400 participants in the grade normative sample, and 3000 in the age norm sample. There was overlap between samples. Grade and age groups were matched to the U.S. population for gender, geographic region, mother’s education level, ethnicity, and parental education within each ethnic group. The sample for ages 18-25 was further controlled for educational status of the examinee. Administration procedures and subtest content were adjusted following item analysis during the standardization process (Kaufman & Kaufman, 2004).

According to the test manual, administration via compact disc yielded higher reliabilities than oral presentation by the examiner. Internal consistency estimates for the Listening Comprehension subtest were high (0.83-0.88) across the 14-25 year old age groups, and Standard Error of Measurement estimates ranged from 5.27 to 6.21. Interrater reliability for the Listening Comprehension subtest was excellent (0.97). Validity was established through administering one or more other tests of achievement or cognitive abilities along with the KTEA-II to select
samples during standardization. Scores on the KTEA-II Listening Comprehension measure correlated strongly with scores from the WIAT-II Listening Comprehension (0.72 for grades 6-11) and the WJ-III Achievement Oral Language Composite (0.71 for grades 6-11). Additionally, the KTEA-II Listening Comp measure also showed modest correlation with the OWLS Listening Comprehension subtest (0.45) and cognitive measures of verbal intelligence (0.66-.75). Overall, the manual provides strong evidence that the KTEA-II Listening Comprehension subtest provides a reliable and valid measure of listening comprehension ability. Of note, the test authors administered the Comprehensive Form of the KTEA-II to a sample of 51 students (age 5-18) who had previously been diagnosed with ADHD. This sample scored an average of 6.9 points lower than the nonclinical reference group on the Listening Comprehension subtest, controlling for sex, ethnicity, and parent education (Kaufman & Kaufman, 2004).

Demographics. Participants were asked to provide information pertaining to their gender, age, and ethnicity. They were also asked to indicate whether or not they had ever been diagnosed with a reading or writing disability, and whether or not they were currently taking medication to address attention difficulties.

Design and Procedure

Students were recruited for participation in this study through the help of school personnel from the special education department. First, the school compiled a master list of all students in the school who were identified in their records as having ADHD, organized according to grade and class level. A group of non-ADHD students matched for gender, grade, and class level were then selected from the remainder of the student population. Once selected for participation, students were provided with a packet that contained a letter explaining the
study as well as a parental consent form, a short parent rating form, and an empty envelope (see Appendix B). The students were asked to bring the packet home and to return the parental letter of consent and the rating form (placed within the envelope provided) to identified school personnel. The envelopes remained unopened until given to the experimenter. All participants were then randomly assigned by ADHD status to outline/no outline groups yielding four groups (ADHD/outline; ADHD/no outline; non-ADHD/outline; non-ADHD/no outline) with 20 participants per group. Individual assent was obtained at the start of experimental sessions.

Participants of the study completed all measures in a group format over the course of two forty-five minute sessions (1 class period each). There were 15 to 20 participants per group. The intersession interval was seven days for all participants. At the start of the first session, the students were provided with a packet that contained all of the materials needed for the study. The first pages included a description of the study, information pertaining to their rights as participants, and an informed assent form for them to sign. Participants were given the opportunity to ask questions at the beginning of each task. During the rest of the first session, participants were asked to (a) fill out a demographics questionnaire (5 minutes), (b) watch/listen to and take notes on a 15-minute videotaped lecture about a historical American ship (15 minutes), (c) complete the KTEA-II Listening Comprehension Subtest (17 minutes), and (d) complete a measure of transcription fluency (the alphabet task) (30 seconds). During the note-taking task of this session, half of the participants’ packets contained the note-taking outline described above, and half contained blank paper on which to take their notes. Participants were informed that they were taking notes in preparation for a multiple choice test to occur during the second session. They were also informed that, because they would only have their notes for studying, it was important to take the best possible notes. Following the completion of the first
session, participants were placed in a drawing for one of two 50 dollar Visa gift cards. During the second session, participants’ packets from session one were returned to them. Subsequently, they (a) completed the Working Memory Listening Span task (15 minutes) (b) reviewed their notes from session one for 10 minutes, (c) completed a measure of attention (Lottery subtest of the TEA) (10 minutes), and (e) completed a multiple choice test based on the lecture content (10 minutes). At the end of this session, participants were thanked for their participation and given one Loews Theater Gold Ticket movie pass.
Figure 1
Overall hypothesized model:

ADHD Status

Transcription Speed

Listening Comprehension

Attention

Working Memory

Note Quality

Exam Score

Outline Intervention?
Yes/no
Chapter IV

Results

This dissertation utilized a quasi-experimental design to investigate the lecture note-taking skills of adolescents with and without ADHD. Specifically, it sought to determine whether ADHD status impacts lecture note-quality and subsequent test performance. In addition, it set out to examine the cognitive variables underlying note-taking skill in adolescents with and without ADHD. Finally, it sought to investigate the utility of providing an outline as an intervention for improving note quality in this population. The primary dependent variables were: lecture note quality and multiple choice test performance. Lecture note quality was additionally broken down into a total score, a main ideas score, and a details score; multiple choice test performance was broken down into total performance, memory item performance, and inferential item performance scores. There were two between subjects variables, including ADHD status (ADHD/non-ADHD) and outline (yes/no). Other independent variables included: attention, verbal working memory, transcription fluency, and listening comprehension. One participant did not take any notes, and was consequently dropped from analyses. Additionally, as mentioned above, two participants scored below threshold for inclusion on the verbal working memory span task. Therefore the valid data set for all analyses included 40 ADHD and 40 non-ADHD participants. Within each ADHD group, 20 participants received an outline and 20 did not.

Table 3 contains the means, standard deviations, and range of scores in the total sample, as well as information pertaining to the distribution for each of these variables. The variables of attention, transcription fluency, verbal working memory, listening comprehension, and note quality scores met all assumptions of normality. For measures of exam performance, there was
evidence of slight negative kurtosis, indicating that a higher than expected proportion of participants scored within the very low and very high ranges. However it was decided that no transformation was needed due to the slight nature of the kurtosis. See figures 2 through 4 in Appendix A for distribution charts of these variables.

**Intercorrelations**

All intercorrelations were tested using an adjusted alpha of .001 in order to avoid Type I errors. Intercorrelations among the independent and dependent variables for the total sample are contained in table 4. Additional demographic variables that were explored include gender, age, ethnicity, native English speaker status, reading disability status, writing disability status, and ADHD medication status. Due to low frequencies, reading disability status and writing disability status were combined to form a learning disability variable. Intercorrelations among the demographic variables within the entire sample with each of the independent and dependent variables are contained in table 5. Total note quality was significantly correlated with ADHD status, transcription speed, attention, verbal working memory, and listening comprehension; it was additionally correlated with gender, age, and learning disability status. Exam score was significantly correlated with note quality, ADHD status, transcription speed, attention, verbal working memory, and listening comprehension; it was additionally correlated with gender, English as a first language, and learning disability status.

Separate intercorrelation tables for all of the variables were also calculated for the ADHD group and the non-ADHD group. Intercorrelations among the independent and dependent variables for the ADHD and non-ADHD group are in table 6. Intercorrelations among the demographic variables with the independent and dependent variables within the ADHD and non-ADHD groups are presented in Tables 7 and 8 respectively.
Table 3
Means, Standard Deviations, Ranges, Skew, and Kurtosis for Predictor and Outcome Variables of the Total Sample (n = 80)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
<th>Skew</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>6.17</td>
<td>2.31</td>
<td>1.0-10.0</td>
<td>-0.49(0.26)</td>
<td>-0.89(0.52)</td>
</tr>
<tr>
<td>Transcription Fluency</td>
<td>50.39</td>
<td>11.57</td>
<td>20.0-72.0</td>
<td>-0.51(0.27)</td>
<td>-0.35(0.53)</td>
</tr>
<tr>
<td>Verbal Working Memory</td>
<td>2.43</td>
<td>1.09</td>
<td>0.5-5.0</td>
<td>0.12(0.26)</td>
<td>-0.85(0.52)</td>
</tr>
<tr>
<td>Listening Comp.</td>
<td>7.22</td>
<td>4.41</td>
<td>0.0-16.0</td>
<td>0.43(0.26)</td>
<td>-0.90(0.52)</td>
</tr>
<tr>
<td>Notes Total</td>
<td>19.73</td>
<td>12.30</td>
<td>1.0-47.0</td>
<td>0.41(0.26)</td>
<td>-0.89(0.52)</td>
</tr>
<tr>
<td>Notes Main Ideas</td>
<td>17.92</td>
<td>12.13</td>
<td>1.0-45.0</td>
<td>0.38(0.26)</td>
<td>-0.83(0.52)</td>
</tr>
<tr>
<td>Notes Details</td>
<td>21.30</td>
<td>13.40</td>
<td>1.0-56.0</td>
<td>0.43(0.26)</td>
<td>-0.86(0.52)</td>
</tr>
<tr>
<td>Multiple Choice Exam</td>
<td>48.40</td>
<td>24.82</td>
<td>5.0-95.0</td>
<td>0.14(0.27)</td>
<td>-1.28(0.53)</td>
</tr>
<tr>
<td>MC Exam Memory Items</td>
<td>52.35</td>
<td>25.70</td>
<td>10.0-100.0</td>
<td>0.19(0.27)</td>
<td>-1.11(0.53)</td>
</tr>
<tr>
<td>MC Exam Learning Items</td>
<td>44.44</td>
<td>26.79</td>
<td>0.0-90.0</td>
<td>0.08(0.27)</td>
<td>-1.30(0.53)</td>
</tr>
</tbody>
</table>

Note. Listening Comp. = listening comprehension; MC = Multiple Choice

Table 4
Intercorrelations Among the Independent and Dependent Variables for Entire Sample (n = 80)

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
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<tbody>
<tr>
<td>Note Total</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2. Note MI</td>
<td>.95*</td>
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</tr>
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<td>3. Note D</td>
<td>.97*</td>
<td>.84*</td>
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<td></td>
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</tr>
<tr>
<td>4. MC Exam</td>
<td>.66*</td>
<td>.69*</td>
<td>.63*</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. MC Exam M</td>
<td>.71*</td>
<td>.70*</td>
<td>.67*</td>
<td>.94*</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. MC Exam L</td>
<td>.56*</td>
<td>.62*</td>
<td>.52*</td>
<td>.95*</td>
<td>.79*</td>
<td>--</td>
<td></td>
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<tr>
<td>7. ADHD status</td>
<td>-.54*</td>
<td>-.46*</td>
<td>-.53*</td>
<td>-.35</td>
<td>-.37</td>
<td>-.29</td>
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<tr>
<td>8. Outline</td>
<td>.07</td>
<td>.10</td>
<td>.04</td>
<td>.03</td>
<td>.04</td>
<td>.01</td>
<td>-.02</td>
<td>--</td>
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<tr>
<td>9. Trans Speed</td>
<td>.54*</td>
<td>.48*</td>
<td>.55*</td>
<td>.48*</td>
<td>.51*</td>
<td>.41*</td>
<td>-.24</td>
<td>-.04</td>
<td>--</td>
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<tr>
<td>10. Attention</td>
<td>.48*</td>
<td>.47*</td>
<td>.52*</td>
<td>.42*</td>
<td>.36</td>
<td>.43*</td>
<td>-.20</td>
<td>.09</td>
<td>.24</td>
<td>--</td>
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</tr>
<tr>
<td>11. VW Mem</td>
<td>.43*</td>
<td>.39*</td>
<td>.43*</td>
<td>.39*</td>
<td>.38*</td>
<td>.36</td>
<td>-.11</td>
<td>-.02</td>
<td>.27</td>
<td>.51*</td>
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<tr>
<td>12. List. Comp.</td>
<td>.67*</td>
<td>.67*</td>
<td>.61*</td>
<td>.69*</td>
<td>.67*</td>
<td>.64*</td>
<td>-.32</td>
<td>.01</td>
<td>.43*</td>
<td>.41*</td>
<td>.45*</td>
<td>--</td>
</tr>
</tbody>
</table>

Note. MI = main idea; D = detail; MC = multiple choice; M = memory; L = learning; Trans Speed = transcription speed; VW Mem. = verbal working memory; List. Comp. = listening comprehension.

*p < .001
Table 5
Intercorrelations Among the Independent and Dependent Variables for ADHD and Non-ADHD Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADHD Group (n=40)</th>
<th>Non-ADHD Group (n=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
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<tr>
<td>1. Note Total</td>
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<td>2. Note MI</td>
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<td>3. Note D</td>
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<td>4. MC Exam</td>
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<td>.59*</td>
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<td>5. MC Exam M</td>
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<td>.63*</td>
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<td>6. MC Exam L</td>
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<td>7. Outline</td>
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<td>.13</td>
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<tr>
<td>8. Trans Speed</td>
<td>.35</td>
<td>.33</td>
</tr>
<tr>
<td>9. Attention</td>
<td>.36</td>
<td>.32</td>
</tr>
<tr>
<td>10. VW Mem</td>
<td>.25</td>
<td>.19</td>
</tr>
<tr>
<td>11. List. Comp.</td>
<td>.61*</td>
<td>.65*</td>
</tr>
</tbody>
</table>

Note. MI = main idea; D = detail; MC = multiple choice; M = memory; L = learning; Trans Speed = transcription speed; VW Mem. = verbal working memory; List. Comp. = listening comprehension.
*p < .001
### Table 6
Intercorrelations Among Demographic Variables with the Independent and Dependent Variables for Entire Sample (n = 80)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Gender</th>
<th>Age</th>
<th>Ethnicity</th>
<th>Nat. Eng.</th>
<th>LD</th>
<th>ADHD M</th>
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<td>1. Gender</td>
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<td>3. Ethnicity</td>
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<td>4. Native Eng. Speaker</td>
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<td>5. Learning Disability (LD)</td>
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<td>-.07</td>
<td>.05</td>
<td>.22</td>
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<td>6. ADHD Medication (M)</td>
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<td>-.27</td>
<td>-.11</td>
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<td>.32</td>
<td>.66*</td>
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<td>8. Outline (yes/no)</td>
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<td>.00</td>
<td>-.04</td>
<td>.11</td>
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<td>9. Note Total</td>
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<td>-.22</td>
<td>-.25</td>
<td>-.33</td>
<td>-.18</td>
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<td>13. MC Exam Mem.</td>
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<td>-.22</td>
<td>-.23</td>
<td>-.32</td>
<td>-.19</td>
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<td>14. MC Exam Learn.</td>
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<td>.04</td>
<td>-.19</td>
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<td>15. Attention</td>
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<td>-.09</td>
<td>-.20</td>
<td>-.24</td>
<td>-.28</td>
<td>.01</td>
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<td>16. Verbal Working Mem.</td>
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<td>-.32</td>
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<tr>
<td>17. Listen Comp.</td>
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<td>.18</td>
<td>-.12</td>
<td>-.15</td>
<td>-.34</td>
<td>-.15</td>
</tr>
<tr>
<td>18. Trans Speed</td>
<td>-.24</td>
<td>.17</td>
<td>-.14</td>
<td>-.13</td>
<td>-.16</td>
<td>-.13</td>
</tr>
</tbody>
</table>

*Note. Native Eng. Speaker = native English speaker; MC = multiple choice; Mem. = memory; Learn. = learning; Listen Comp. = listening comprehension

*p < .001
Table 7
Intercorrelations Among Demographic Variables with the Independent and Dependent Variables for the ADHD Group (n = 40)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Gender</th>
<th>Age</th>
<th>Ethnicity</th>
<th>Nat. Eng.</th>
<th>LD</th>
<th>ADHD M</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gender</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Age</td>
<td>-.18</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Ethnicity</td>
<td>.14</td>
<td>.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Native Eng. Speaker</td>
<td>.13</td>
<td>.20</td>
<td>.47</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Learning Disability</td>
<td>-.05</td>
<td>-.05</td>
<td>.08</td>
<td>.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. ADHD Medication (M)</td>
<td>-.16</td>
<td>-.27</td>
<td>-.28</td>
<td>-.04</td>
<td>.13</td>
<td>-</td>
</tr>
<tr>
<td>7. Outline (yes/no)</td>
<td>-.19</td>
<td>-.19</td>
<td>.00</td>
<td>-.21</td>
<td>.27</td>
<td>.00</td>
</tr>
<tr>
<td>8. Note Total</td>
<td>-.37</td>
<td>.06</td>
<td>-.24</td>
<td>-.06</td>
<td>-.23</td>
<td>.21</td>
</tr>
<tr>
<td>9. Note Main Ideas</td>
<td>-.44</td>
<td>.05</td>
<td>-.11</td>
<td>-.02</td>
<td>-.11</td>
<td>.22</td>
</tr>
<tr>
<td>10. Note Details</td>
<td>-.28</td>
<td>.05</td>
<td>-.25</td>
<td>-.09</td>
<td>-.31</td>
<td>.20</td>
</tr>
<tr>
<td>11. MC Exam</td>
<td>-.16</td>
<td>-.22</td>
<td>-.19</td>
<td>-.23</td>
<td>-.30</td>
<td>.07</td>
</tr>
<tr>
<td>12. MC Exam Mem.</td>
<td>-.22</td>
<td>-.24</td>
<td>-.32</td>
<td>-.25</td>
<td>-.26</td>
<td>.10</td>
</tr>
<tr>
<td>13. MC Exam Learn.</td>
<td>-.09</td>
<td>-.19</td>
<td>-.07</td>
<td>-.20</td>
<td>-.29</td>
<td>.04</td>
</tr>
<tr>
<td>14. Attention</td>
<td>-.09</td>
<td>-.18</td>
<td>-.36</td>
<td>-.22</td>
<td>-.16</td>
<td>.28</td>
</tr>
<tr>
<td>15. Verbal Working Mem.</td>
<td>.21</td>
<td>-.26</td>
<td>-.28</td>
<td>-.23</td>
<td>-.31</td>
<td>.05</td>
</tr>
<tr>
<td>16. Listen Comp.</td>
<td>-.19</td>
<td>-.06</td>
<td>-.22</td>
<td>-.10</td>
<td>-.23</td>
<td>.12</td>
</tr>
<tr>
<td>17. Trans Speed</td>
<td>-.09</td>
<td>.18</td>
<td>-.04</td>
<td>.24</td>
<td>.04</td>
<td>.04</td>
</tr>
</tbody>
</table>

Note. Native Eng. Speaker = native English speaker; LD = Learning Disability; ADHD M = ADHD Medication; MC = multiple choice; Mem. = memory; Learn. = learning; Listen Comp. = listening comprehension
*p < .001
Table 8
*Intercorrelations Among Demographic Variables with the Independent and Dependent Variables for the Non-ADHD Group (n = 40)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Gender</th>
<th>Age</th>
<th>Ethnicity</th>
<th>Nat. Eng.</th>
<th>LD</th>
<th>ADHD M</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Age</td>
<td>-.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Ethnicity</td>
<td>.21</td>
<td>.03</td>
<td></td>
<td>.66*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Native Eng. Speaker</td>
<td>.17</td>
<td>.25</td>
<td>.03</td>
<td>.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Learning Disability</td>
<td>.09</td>
<td>.09</td>
<td>.15</td>
<td>.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Outline (yes/no)</td>
<td>-.15</td>
<td>.03</td>
<td>-.03</td>
<td>.06</td>
<td>.29</td>
<td></td>
</tr>
<tr>
<td>7. Note Total</td>
<td>-.45</td>
<td>.28</td>
<td>-.37</td>
<td>-.39</td>
<td>-.13</td>
<td></td>
</tr>
<tr>
<td>8. Note Main Ideas</td>
<td>-.38</td>
<td>.17</td>
<td>-.34</td>
<td>-.36</td>
<td>.02</td>
<td></td>
</tr>
<tr>
<td>9. Note Details</td>
<td>-.46</td>
<td>.35</td>
<td>-.37</td>
<td>-.38</td>
<td>-.21</td>
<td></td>
</tr>
<tr>
<td>10. MC Exam</td>
<td>-.20</td>
<td>.25</td>
<td>-.53</td>
<td>-.42</td>
<td>-.04</td>
<td></td>
</tr>
<tr>
<td>11. MC Exam Mem.</td>
<td>-.28</td>
<td>.31</td>
<td>-.46</td>
<td>-.37</td>
<td>-.11</td>
<td></td>
</tr>
<tr>
<td>12. MC Exam Learn.</td>
<td>-.08</td>
<td>.15</td>
<td>-.51</td>
<td>-.39</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>13. Attention</td>
<td>-.13</td>
<td>-.10</td>
<td>-.26</td>
<td>-.36</td>
<td>-.29</td>
<td></td>
</tr>
<tr>
<td>14. Verbal Working Mem.</td>
<td>-.43</td>
<td>.12</td>
<td>-.50</td>
<td>-.27</td>
<td>-.36</td>
<td></td>
</tr>
<tr>
<td>15. Listen Comp.</td>
<td>-.31</td>
<td>.31</td>
<td>-.28</td>
<td>-.31</td>
<td>-.22</td>
<td></td>
</tr>
<tr>
<td>16. Trans Speed</td>
<td>-.33</td>
<td>.09</td>
<td>-.35</td>
<td>-.46</td>
<td>-.26</td>
<td></td>
</tr>
</tbody>
</table>

*Note. Native Eng. Speaker = native English speaker; LD = Learning Disability; ADHD M = ADHD medication; MC = multiple choice; Mem. = memory; Learn. = learning; Listen Comp. = listening comprehension

*p < .001*
Multivariate and Univariate Tests

Two two-way MANOVAs were conducted to investigate the effects of ADHD status and outline group on the outcome variables. The first two-way MANOVA was conducted to compare the means between the ADHD, non-ADHD, outline, and no-outline groups across measures of transcription speed, attention, verbal working memory, listening comprehension, total note quality, and multiple choice test performance. It was hypothesized that ADHD status would affect each of the aforementioned variables, and that outline group would affect total note quality and test performance.

The assumption of equal covariance matrices was met (Box’s $M = 77.86$, $F(63, 13534) = 1.06$, $p = .353$). All assumptions of equal variances were met except for the variable of total note quality; $F(3, 76) = 3.39$, $p < .05$. Therefore, the variable note quality was log-transformed, and the MANOVA was run again. Subsequently, the assumption of equal covariance matrices was met (Box’s $M = 84.36$, $F(63, 13534) = 1.15$, $p = .201$), and all assumptions of equal variances were met. The multivariate test for the ADHD by outline group interaction effect was not significant. The multivariate test for the main effect of ADHD status was significant (Wilks’ $\lambda = .82$, $F(6, 71) = 2.68$, $p = .021$, partial $\eta^2 = .18$, observed power = .84). Contrary to hypotheses, the main effect of outline group was not significant.

Given the significance of the multivariate main effect for ADHD in the overall test, post hoc tests were conducted in order to make univariate comparisons. A Bonferroni correction was used to avoid Type I errors. Thus, the significance level for all univariate tests was set at $p < .008$. 
Table 9

Results of Univariate ANOVAs Comparing ADHD and non-ADHD Groups Across Outcome Measures
(n= 80)

<table>
<thead>
<tr>
<th>Source</th>
<th>ADHD Group n=40</th>
<th>Non-ADHD Group n=40</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transcription Speed</td>
<td>47.70</td>
<td>53.18</td>
<td>.037</td>
</tr>
<tr>
<td>Attention</td>
<td>5.65</td>
<td>6.64</td>
<td>.066</td>
</tr>
<tr>
<td>Verbal Working Memory</td>
<td>2.33</td>
<td>2.58</td>
<td>.305</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>5.93</td>
<td>8.65</td>
<td>.006*</td>
</tr>
<tr>
<td>(Notes Total)</td>
<td>(13.64)</td>
<td>(26.30)</td>
<td>-</td>
</tr>
<tr>
<td>Log Notes Total</td>
<td>1.03</td>
<td>1.33</td>
<td>.000**</td>
</tr>
<tr>
<td>Exam Total</td>
<td>40.00</td>
<td>57.13</td>
<td>.002*</td>
</tr>
</tbody>
</table>

Note. Log Notes Total = log-transformed total note quality scores, Bonferroni Correction = .008
*p < .008, **p < .001

In order to further explore the contributions of ADHD status and outline group to note quality and test performance, an additional two-way MANOVA was conducted to simultaneously compare the means between the ADHD, non-ADHD, outline, and no-outline groups across measures of the component note quality scores (main ideas and details) and the component multiple choice test scores (memory and learning items). It was hypothesized that ADHD status and outline group would both affect each of the aforementioned variables.

The assumption of equal covariance matrices was met (Box’s M = 15.78, F(10, 29086) = 1.491, p = .136). Assumptions of equal variances were met for both exam variables, but assumptions of equal variances were not met for the variables of main idea note quality (F(1,78) = 7.96, p < .05) or details note quality (F(1,78) = 10.81, p < .05). Therefore, the note quality variables were log-transformed, and the MANOVA was run again. Subsequently all assumptions of equal variances were met, but the assumption of equal covariance matrices was not met (Box’s M = 50.16, F(30, 15880) = 1.51, p = .036). However, since multivariate tests are
robust to violations of this assumption when cells are equal, results were interpreted anyway. The multivariate test for the ADHD by outline group interaction effect was not significant. In line with expectations, the main effect of ADHD status was significant (Wilks’ $\lambda = .78$, $F(4,73) = 5.20$, $p = .001$, partial $\eta^2 = .22$, observed power = .96). Contrary to hypotheses, the main effect of outline group was not significant.

Given the significance of the multivariate main effect for ADHD in the overall test, post hoc tests were conducted in order to make univariate comparisons. A Bonferroni correction was used to avoid Type I errors. Thus, the significance level for all univariate tests was set at $p < .0125$. Post hoc ANOVAs revealed that on average, students in the non-ADHD group took more complete notes regarding the main ideas of the lecture ($F(1,76) = 9.49$, $p = .003$) and regarding the details of the lecture ($F(1,76) = 19.03$, $p = .000$) than the ADHD group. In addition, the non-ADHD group achieved higher scores than the ADHD group on both the memory items ($F(1,76) = 12.28$, $p = .001$) and the inferential items ($F(1,76) = 6.77$, $p = .011$) of the multiple choice exam. Specifically, on average, students without ADHD recorded 23.6% of the main idea information units and 28.7% of the detail information units presented within the lecture; whereas students with ADHD recorded 12.6% of the main ideas and 14.1% of the details presented. One week later and after studying their notes, on average, students without ADHD scored 19 percentage points higher than students with ADHD on memory items in the multiple choice test (62% versus 43% respectively). Additionally, students without ADHD scored 15.25 percentage points higher than students with ADHD on inferential learning items in the multiple choice test (52.25% versus 37% respectively). Table 10 contains the results of the univariate tests.
Table 10
Results of Univariate ANOVAs Comparing ADHD and non-ADHD Groups Across Outcome Component Measures (n = 80)

<table>
<thead>
<tr>
<th>Source</th>
<th>ADHD Group (n=40) Mean</th>
<th>ADHD Group (n=40) SD</th>
<th>Non-ADHD Group (n=40) Mean</th>
<th>Non-ADHD Group (n=40) SD</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(MI Notes)</td>
<td>(12.55)</td>
<td>(1.75)</td>
<td>(23.63)</td>
<td>(1.75)</td>
<td>-</td>
</tr>
<tr>
<td>Log MI Notes</td>
<td>0.94</td>
<td>0.44</td>
<td>1.24</td>
<td>0.43</td>
<td>.003*</td>
</tr>
<tr>
<td>(D Notes)</td>
<td>(14.10)</td>
<td>(1.82)</td>
<td>(28.73)</td>
<td>(1.82)</td>
<td>-</td>
</tr>
<tr>
<td>Log D Notes</td>
<td>1.04</td>
<td>0.34</td>
<td>1.38</td>
<td>0.33</td>
<td>.000**</td>
</tr>
<tr>
<td>Memory Exam</td>
<td>43.00</td>
<td>21.39</td>
<td>62.00</td>
<td>26.62</td>
<td>.001*</td>
</tr>
<tr>
<td>Learning Exam</td>
<td>37.00</td>
<td>25.94</td>
<td>52.25</td>
<td>25.97</td>
<td>.010*</td>
</tr>
</tbody>
</table>

Note. MI Notes = Main Idea Notes, D Notes = Detail Notes, Bonferroni Correction = .0125
*p < .0125, **p < .001

Multiple Regression Analyses

Multiple regression analyses using the enter method were used to evaluate which variables predicted overall note quality and test performance. Since outline group did not have any effects in the multivariate analyses, the ADHD by outline group interaction was not evaluated in regressions. The first regression analysis focused on the predictors of note quality. The total notes score was regressed on ADHD status, outline group, transcription speed, attention, verbal working memory, and listening comprehension. It was hypothesized that ADHD status, outline group, transcription speed, and attention would all significantly predict quality of notes. The regression model was significant (tolerance and variance inflation factor values were within acceptable limits; R= .810, R² = .656, R² adjusted = .628; F (6,74) = 23.491, p <.001). The model accounted for over 65% of the variance in the data. The effect size, with R² used as an estimate of effect size, was large (Cohen, 1992). ADHD status (β = -0.29, p <.001), transcription speed (β = 0.26, p = .001), attention (β = 0.18, p = .035), and listening comprehension (β = .37, p < .001) all significantly predicted quality of notes; however, contrary to expectations, outline group and verbal working memory scores were not significant predictors.
See Table 11. Interactions between ADHD status and each of the cognitive variables were separately regressed on total note quality. All continuous variables were centered for the purpose of these analyses. No interactions were found to be significant. The component note quality measures were also analyzed using the same predictors as above, and the pattern of prediction was essentially the same as those for overall note quality, except that the variable of attention did not contribute to the model predicting detail note quality.

Table 11
Summary of Regression Analysis Predicting Total Quality of Notes (n = 80)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>Tolerance</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADHD Status</td>
<td>-7.25</td>
<td>4.62</td>
<td>-0.29***</td>
<td>0.87</td>
<td>1.14</td>
</tr>
<tr>
<td>Outline Group</td>
<td>1.18</td>
<td>1.70</td>
<td>0.05</td>
<td>0.98</td>
<td>1.02</td>
</tr>
<tr>
<td>Transcription Speed</td>
<td>0.28</td>
<td>0.08</td>
<td>0.26**</td>
<td>0.79</td>
<td>1.26</td>
</tr>
<tr>
<td>Attention</td>
<td>0.95</td>
<td>0.44</td>
<td>0.18*</td>
<td>0.68</td>
<td>1.47</td>
</tr>
<tr>
<td>Verbal Working Memory</td>
<td>0.65</td>
<td>0.97</td>
<td>0.06</td>
<td>0.65</td>
<td>1.53</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>1.02</td>
<td>0.24</td>
<td>0.37***</td>
<td>0.63</td>
<td>1.59</td>
</tr>
</tbody>
</table>

Note. VIF = variance inflation factor
*p < .05, **p < .01, ***p < .001

The second set of regression analyses explored predictors for test performance. In the first regression analysis, total multiple choices exam score was regressed on total note quality, ADHD status, outline group, transcription speed, attention, verbal working memory, and listening comprehension. It was hypothesized that total note quality, ADHD status, and outline group would significantly predict quality of notes. The regression model was significant (tolerance and variance inflation factor values were within acceptable limits; R = .765, R² = .586, R² adjusted = .545; F (7, 72) = 14.53, p < .001). The model accounted for over 58% of the variance in the data. The effect size, with R² used as an estimate of effect size, was large (Cohen, 1992). In line with initial hypotheses, total note quality (β = 0.29, p = .032) significantly predicted test performance; however, contrary to expectations ADHD status and outline group were not significant predictors. Also unexpected, listening comprehension (β = .40, p < .001) was the best
predictor of overall test performance. See Table 12. Interactions between ADHD status and each of the cognitive variables were separately regressed on total test performance. All continuous variables were centered for the purpose of these analyses. No interactions were found to be significant.

Table 12  
Summary of Regression Analysis Predicting Total Multiple Choice Exam Performance (n = 80)  

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>Tolerance</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Note Quality</td>
<td>0.57</td>
<td>0.26</td>
<td>.29*</td>
<td>.34</td>
<td>2.95</td>
</tr>
<tr>
<td>ADHD Status</td>
<td>-1.22</td>
<td>4.45</td>
<td>-.03</td>
<td>.87</td>
<td>1.40</td>
</tr>
<tr>
<td>Outline Group</td>
<td>0.34</td>
<td>3.82</td>
<td>.01</td>
<td>.97</td>
<td>1.03</td>
</tr>
<tr>
<td>Transcription Speed</td>
<td>0.29</td>
<td>0.20</td>
<td>.14</td>
<td>.69</td>
<td>1.45</td>
</tr>
<tr>
<td>Attention</td>
<td>0.29</td>
<td>1.01</td>
<td>.08</td>
<td>.64</td>
<td>1.55</td>
</tr>
<tr>
<td>Verbal Working Memory</td>
<td>0.13</td>
<td>2.19</td>
<td>.01</td>
<td>.65</td>
<td>1.53</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>2.26</td>
<td>0.60</td>
<td>.40***</td>
<td>.51</td>
<td>1.97</td>
</tr>
</tbody>
</table>

Note. VIF = variance inflation factor  
*p < .05, **p < .01, ***p < .001

Next, memory and inferential item scores were separately regressed on total note quality, ADHD status, outline group, transcription speed, attention, verbal working memory, and listening comprehension in order to explore the contribution of the predictor variables to these component measures. It was hypothesized that total note quality would predict performance on memory items and ADHD status would predict performance on inferential items. It was also hypothesized that outline group would predict performance on both memory and inference items.

The regression model predicting memory item performance was significant (tolerance and variance inflation factor values were within acceptable limits; R= .769, R² = .592, R² adjusted = .552; F (7,72) = 14.895, p < .001). The model accounted for over 59% of the variance in the data. The effect size, with R² used as an estimate of effect size, was large (Cohen, 1992).

Upholding initial hypotheses, overall note quality (β = 0.38, p = .004) significantly predicted memory item exam performance. However, contrary to expectations, listening comprehension (β
= 0.33, \( p = .002 \) was also a significant predictor and outline group did not predict memory item performance.

The regression model predicting inferential item performance was also significant (tolerance and variance inflation factor values were within acceptable limits; \( R = .694, R^2 = .481, R^2_{\text{adjusted}} = .431; F(7,72) = 9.541, p < .001 \). The model accounted for 48% of the variance in the data. The effect size, with \( R^2 \) used as an estimate of effect size, was large (Cohen, 1992).

Upholding initial hypotheses, overall note quality did not significantly predict inferential item exam performance. However, contrary to expectations, ADHD status and outline group were not significant predictors. Importantly, listening comprehension (\( \beta = 0.43, p = .001 \)) was the only significant predictor of inference item performance. See Tables 13 and 14.

<table>
<thead>
<tr>
<th>Table 13</th>
<th>Summary of Regression Analysis Predicting MC Test Performance: Memory Items (n = 80)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>( B )</td>
</tr>
<tr>
<td>Total Note Quality</td>
<td>0.79</td>
</tr>
<tr>
<td>ADHD Status</td>
<td>-1.72</td>
</tr>
<tr>
<td>Outline Group</td>
<td>1.42</td>
</tr>
<tr>
<td>Transcription Speed</td>
<td>0.33</td>
</tr>
<tr>
<td>Attention</td>
<td>-0.16</td>
</tr>
<tr>
<td>Verbal Working Memory</td>
<td>0.67</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>1.93</td>
</tr>
</tbody>
</table>

*Note. MC = Multiple Choice, VIF = variance inflation factor*

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

<table>
<thead>
<tr>
<th>Table 14</th>
<th>Summary of Regression Analysis Predicting MC Test Performance: Inference Items (n = 80)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>( B )</td>
</tr>
<tr>
<td>Total Note Quality</td>
<td>0.34</td>
</tr>
<tr>
<td>ADHD Status</td>
<td>-0.72</td>
</tr>
<tr>
<td>Outline Group</td>
<td>-0.74</td>
</tr>
<tr>
<td>Transcription Speed</td>
<td>0.25</td>
</tr>
<tr>
<td>Attention</td>
<td>1.91</td>
</tr>
<tr>
<td>Verbal Working Memory</td>
<td>-0.44</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>2.58</td>
</tr>
</tbody>
</table>

*Note. MC = Multiple Choice, VIF = variance inflation factor*

\(*p < .05, **p < .01, ***p < .001*
Supplementary Analyses

Gender and Learning Disability. Due to the significant correlations found between outcome variables and both gender and self reported learning disability, multiple regression analyses using block entry were conducted to explore the contribution of these demographic variables to overall note quality and test performance. Notably, 15 participants endorsed that they did not know if they had a learning disability or not (9 from the ADHD group and 6 from the non-ADHD group). Therefore, the total n for the analyses that follow is 65.

Note Quality. In the first block, total note quality was regressed on gender and self reported learning disability. In the second block, total note quality was regressed on gender, self reported learning disability, ADHD status, outline group, transcription speed, attention, verbal working memory, and listening comprehension. The results are summarized in table 15.

In the first block, the regression model predicting note quality was significant (tolerance and variance inflation factor values were within acceptable limits; R= .531, $R^2 = .282$, $R^2_{\text{adjusted}} = .259$; F (2,63) = 12.37, $p < .001$). The model accounted for 28% of the variance in the data. The effect size, with $R^2$ used as an estimate of effect size, was large (Cohen, 1992). Both gender ($\beta = - .44$, $p < .001$) and self reported learning disability status ($\beta = -.24$, $p = .028$) were significant predictors, such that girls and non-LD students produced significantly more complete notes.

In the second block, the regression model was also significant (tolerance and variance inflation factor values were within acceptable limits; R= .862, $R^2 = .742$, $R^2_{\text{adjusted}} = .706$, $R^2_{\text{change}} = 0.46$ F (6,57) = 20.517, $p < .001$). However, once the remaining variables were added, neither gender nor self reported learning disability status remained as significant predictors. The significant predictors were ADHD status ($\beta = -.32$, $p < .001$), transcription speed ($\beta = .28$, $p = .001$), and listening comprehension ($\beta = .34$, $p = .001$). This reflects the results obtained without
including gender or learning disability, with the exception that attention no longer remained a significant predictor in the model; however, this may be due to a reduction in statistical power rather than any substantial change in the contribution of these variables.

Table 15
Summary of Regression Analysis Predicting Overall Note Quality (n = 65)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>Tolerance</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>-11.975</td>
<td>2.95</td>
<td>-.44***</td>
<td>.98</td>
<td>1.02</td>
</tr>
<tr>
<td>Learning Disability</td>
<td>-7.73</td>
<td>3.44</td>
<td>-.24*</td>
<td>.98</td>
<td>1.02</td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>-3.80</td>
<td>2.19</td>
<td>-.14</td>
<td>.70</td>
<td>1.42</td>
</tr>
<tr>
<td>Learning Disability</td>
<td>0.10</td>
<td>2.49</td>
<td>.00</td>
<td>.74</td>
<td>1.35</td>
</tr>
<tr>
<td>ADHD Status</td>
<td>-8.24</td>
<td>2.10</td>
<td>-.32***</td>
<td>.70</td>
<td>1.43</td>
</tr>
<tr>
<td>Outline Group</td>
<td>0.05</td>
<td>1.92</td>
<td>.00</td>
<td>.84</td>
<td>1.19</td>
</tr>
<tr>
<td>Transcription Speed</td>
<td>0.31</td>
<td>0.09</td>
<td>.28**</td>
<td>.72</td>
<td>1.39</td>
</tr>
<tr>
<td>Attention</td>
<td>0.77</td>
<td>0.46</td>
<td>.14</td>
<td>.67</td>
<td>1.49</td>
</tr>
<tr>
<td>VWM</td>
<td>0.06</td>
<td>0.27</td>
<td>.01</td>
<td>.61</td>
<td>1.64</td>
</tr>
<tr>
<td>Listening Comp.</td>
<td>0.96</td>
<td>0.27</td>
<td>.34**</td>
<td>.52</td>
<td>1.94</td>
</tr>
</tbody>
</table>

Note. VIF = variance inflation factor, $R^2 = 0.28$ for Step 1; $\Delta R^2 = 0.46$ for Step 2 ($p < .05$)

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

Because of the reduction in sample size (and power), the observation that the partial correlations of gender and attention were of similar magnitude (-.22 and .22 respectively), and the questionable reliability of self-reported learning disability status, note quality was regressed on the independent variables again without including the variable of learning disability. The predictors entered into the regression analysis were gender, ADHD status, outline status, transcription speed, attention, verbal working memory, and listening comprehension. Since learning disability was removed from the analysis, the sample size returned to 80 participants.

The regression model was significant (tolerance and variance inflation factor values were within acceptable limits; $R^2 = .828$, $R^2 = .686$, $R^2_{\text{adjusted}} = .655$; $F(7,73) = 22.746$, $p < .001$). The model accounted for 68.6% of the variance in the data, and the estimated effect size was large (Cohen, 1992). As suspected, significant predictors ($\alpha = .05$) included gender ($\beta = -.19$, $p = .010$), ADHD
transcription speed ($\beta = .24, p = .002$), attention ($\beta = .18, p = .030$), and listening comprehension ($\beta = .31, p = .001$).

*Test Performance.* In the first block, total exam performance was regressed on gender and self-reported learning disability. In the second block, total exam performance was regressed on gender, self-reported learning disability, ADHD status, outline group, transcription speed, attention, verbal working memory, and listening comprehension. The results are summarized in Table 16.

**Table 16**

*Summary of Regression Analysis Predicting Overall Multiple Choice Test Performance (n = 65)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>$\beta$</th>
<th>Tolerance</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>-11.45</td>
<td>6.30</td>
<td>-.22</td>
<td>.98</td>
<td>1.02</td>
</tr>
<tr>
<td>Learning Disability</td>
<td>-18.15</td>
<td>7.25</td>
<td>-.30*</td>
<td>.98</td>
<td>1.02</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>10.83</td>
<td>5.40</td>
<td>.20</td>
<td>.64</td>
<td>1.55</td>
</tr>
<tr>
<td>Learning Disability</td>
<td>-3.52</td>
<td>5.83</td>
<td>-.06</td>
<td>.73</td>
<td>1.37</td>
</tr>
<tr>
<td>Note Quality Total</td>
<td>0.69</td>
<td>0.31</td>
<td>.36*</td>
<td>.26</td>
<td>3.89</td>
</tr>
<tr>
<td>ADHD Status</td>
<td>-5.92</td>
<td>5.52</td>
<td>-.12</td>
<td>.55</td>
<td>1.81</td>
</tr>
<tr>
<td>Outline Group</td>
<td>1.14</td>
<td>4.51</td>
<td>.02</td>
<td>.83</td>
<td>1.20</td>
</tr>
<tr>
<td>Transcription Speed</td>
<td>0.37</td>
<td>0.23</td>
<td>.18</td>
<td>.59</td>
<td>1.69</td>
</tr>
<tr>
<td>Attention</td>
<td>0.23</td>
<td>1.10</td>
<td>.02</td>
<td>.64</td>
<td>1.55</td>
</tr>
<tr>
<td>VWM</td>
<td>-0.54</td>
<td>2.35</td>
<td>-.02</td>
<td>.62</td>
<td>1.61</td>
</tr>
<tr>
<td>Listening Comp.</td>
<td>2.05</td>
<td>0.69</td>
<td>.37**</td>
<td>.42</td>
<td>2.39</td>
</tr>
</tbody>
</table>

*Note.* VIF = variance inflation factor, $R^2 = 0.15$ for Step 1; $\Delta R^2 = 0.49$ for Step 2 ($p < .05$)

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

In the first block, the regression model predicting exam performance was significant (tolerance and variance inflation factor values were within acceptable limits; $R = .389$, $R^2 = .151$, $R^2_{\text{adjusted}} = .124$; $F(2,62) = 5.52, p = .006$). The model accounted for 15% of the variance in the data. The effect size, with $R^2$ used as an estimate of effect size, was medium (Cohen, 1992). Self-reported learning disability status ($\beta = -.30, p = .015$) was a significant predictor; however, gender was not. In the second block, the regression model was also significant (tolerance and variance inflation factor values were within acceptable limits; $R = .798$, $R^2 = .637$, $R^2_{\text{adjusted}} = $
.577, $R^2$ change = 0.49, $F(7, 55) = 10.712$, $p < .001$). However, once the remaining variables were added, neither gender nor self reported learning disability status remained as significant predictors. The significant predictors were note quality ($\beta = .36, p = .029$) and listening comprehension ($\beta = .37, p = .004$). This reflects the results obtained above, and suggests that including information pertaining to gender and learning disability status does not significantly improve model predictions for exam performance.

**Schools.** Due to an insufficient number of participants within the first school, the researcher expanded the study to include participants from an additional smaller high school. The total sample included participants from two high schools in Massachusetts. Therefore, a one-way MANOVA was conducted to simultaneously compare the means of the two students from the eastern Massachusetts high school ($n = 62$) and the western Massachusetts high school ($n = 19$) on the variables of note quality, test performance, transcription speed, attention, verbal working memory, and listening comprehension. Table 17 contains the means and standard deviations of the measured variables separated by school. The assumption for equal covariance matrices was met (Box’s $M = 21.81, F(21, 41710) = .903, p = .587$). The multivariate test was not significant (Wilks’ $\lambda = 0.93, F(6, 74) = 0.83, p = .328$, partial $\eta^2 = .07$, observed power = .34), indicating that the sample was homogeneous.

### Table 17

**Means and Standard Deviations by School**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Eastern MA ($n = 61$)</th>
<th>Western MA ($n = 19$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Note Quality Total</td>
<td>19.16</td>
<td>12.21</td>
</tr>
<tr>
<td>Total Exam Score</td>
<td>49.44</td>
<td>25.22</td>
</tr>
<tr>
<td>Attention</td>
<td>5.99</td>
<td>2.44</td>
</tr>
<tr>
<td>Transcription Speed</td>
<td>50.48</td>
<td>11.98</td>
</tr>
<tr>
<td>VWM</td>
<td>2.38</td>
<td>1.08</td>
</tr>
<tr>
<td>Listening Comp.</td>
<td>7.31</td>
<td>4.58</td>
</tr>
</tbody>
</table>

Note. MA = Massachusetts, VWM = Verbal Working Memory, Listening Comp. = Listening Comprehension.
Self-reported Learning Disability. Within the ADHD sample, 27% of the participants also endorsed having a reading or writing disability. A one-way MANOVA was conducted to simultaneously compare the means of the students with ADHD and self reported LD (n = 11) and the students with ADHD and without LD (n = 20) on the variables of note quality, test performance, transcription speed, attention, verbal working memory, and listening comprehension. Table 18 contains the means and standard deviations of the measured variables separated by learning disability status. The assumption for equal covariance matrices was met (Box’s M = 29.48, F(21, 1583 = .417, p = .417). The assumption of equal variance was also met. The multivariate test was not significant (Wilks’ λ = 0.83, F(6,24) = 0.83, p = .556, partial η² = .17, observed power = .27), suggesting that the sample was homogeneous. However, these results should be interpreted with caution due to the small sample size and the self-reported nature of the variable of learning disability status.

Table 18  
Means and Standard Deviations Within the ADHD group by Learning Disability Status

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADHD (n = 20)</th>
<th>ADHD + LD (n = 11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note Quality Total</td>
<td>13.65, 8.89</td>
<td>10.09, 7.11</td>
</tr>
<tr>
<td>Total Exam Score</td>
<td>41.25, 27.73</td>
<td>27.73, 15.22</td>
</tr>
<tr>
<td>Attention</td>
<td>5.65, 2.41</td>
<td>4.91, 2.39</td>
</tr>
<tr>
<td>Transcription Speed</td>
<td>47.25, 11.07</td>
<td>47.91, 12.98</td>
</tr>
<tr>
<td>VWM</td>
<td>2.60, 1.10</td>
<td>1.81, 0.96</td>
</tr>
<tr>
<td>Listening Comp.</td>
<td>6.0, 4.58</td>
<td>3.91, 2.84</td>
</tr>
</tbody>
</table>

Note. VWM = Verbal Working Memory, Listening Comp. = Listening Comprehension.

Parent Rating Form. As reported above, this study utilized a parent rating form to validate ADHD status in participants. Since only 40% of ADHD and 52% of non-ADHD participants returned the parent rating form, outcome variables were compared across groups in order to ensure that those who returned the rating forms were representative of the overall sample. Table 19 contains the means and standard deviations for the variables of total note
quality, total exam score, attention, transcription speed, verbal working memory, and listening comprehension broken down by ADHD status and rating form return status (yes/no). A one-way MANOVA was performed for both the ADHD and non-ADHD samples in order to compare the means of the students who returned the rating forms against those who did not on the aforementioned variables.

Within the ADHD group and non-ADHD groups, the assumption for equal covariance matrices was met (ADHD group: Box’s M = 24.85, F(21, 3795) = .97, p = .503; non-ADHD group: Box’s M = , F(21, 5190) = .81, p = .709) . The assumption of equal variances was also met for both groups. The multivariate tests were not significant for either group (ADHD group: Wilks’ λ = 0.91, F(6,33) = 0.52, p = .792, partial η² = .09, observed power = .18; non-ADHD group: Wilks’ λ = 0.85, F(6,33) = 0.97, p = .459, partial η² = .15, observed power = .33), indicating that the students who returned the rating forms were representative of their group.

Table 19

Means and Standard Deviations by ADHD Status and Return Status of the Rating Form

<table>
<thead>
<tr>
<th></th>
<th>Returned Rating Form</th>
<th>Did Not Return Rating Form</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>ADHD Note Quality Total</td>
<td>11.31</td>
<td>6.77</td>
</tr>
<tr>
<td>Total Exam Score</td>
<td>37.62</td>
<td>19.65</td>
</tr>
<tr>
<td>Attention</td>
<td>5.65</td>
<td>2.04</td>
</tr>
<tr>
<td>Transcription Speed</td>
<td>44.31</td>
<td>11.57</td>
</tr>
<tr>
<td>VWM</td>
<td>2.19</td>
<td>1.06</td>
</tr>
<tr>
<td>Listening Comp.</td>
<td>5.83</td>
<td>4.08</td>
</tr>
<tr>
<td>Non-ADHD Note Quality Total</td>
<td>27.14</td>
<td>12.25</td>
</tr>
<tr>
<td>Total Exam Score</td>
<td>59.05</td>
<td>22.73</td>
</tr>
<tr>
<td>Attention</td>
<td>6.93</td>
<td>1.99</td>
</tr>
<tr>
<td>Transcription Speed</td>
<td>52.85</td>
<td>11.00</td>
</tr>
<tr>
<td>VWM</td>
<td>2.55</td>
<td>0.96</td>
</tr>
<tr>
<td>Listening Comp.</td>
<td>8.39</td>
<td>3.97</td>
</tr>
</tbody>
</table>

*Note. MA = Massachusetts, VWM = Verbal Working Memory, Listening Comp. = Listening Comprehension.*
**Processing Score.** On the verbal working memory span task used in this study, 40 percent of the overall sample failed to meet the traditional processing cut-off score of 85%, as mentioned above. In order to assess whether the likelihood for achieving the 85% threshold was the same for the ADHD and non-ADHD groups, a chi-square analysis was performed. No relationship was found between ADHD status and reaching the cut-off score ($\chi^2(1, N = 80) = 0.0, p = 1.0$). In fact, the proportion of students who failed to reach the traditional processing score threshold was the same in both groups (ADHD group: 40%; non-ADHD group 40%).

**Listening comprehension.** The manual for the KTEA II listening comprehension measure utilized in this study provides information pertaining to question type. Specifically, some questions reflected information explicitly stated within the stories, and some required participants to make inferences. Dependent samples T-tests were computed in order to test for differences in mean performance on explicit and inferential questions. On average, neither ADHD ($t(39) = -0.19, p = .84$) nor non-ADHD ($t(39) = 1.24, p = .22$) students performed differently on items explicitly stated within the listening comprehension passages versus those that required them to make inferences.

In addition, a one-way MANOVA was performed to compare the means of the ADHD versus non-ADHD students on their performance on explicit and inferential items. The assumption for equal covariance matrices was met (Box’s $M = 1.05, F(3, 1095120) = 0.34, p = .80$). The assumption of equal variances was also met. The multivariate test was significant (Wilks’ $\lambda = 0.89, F(2,77) = 4.70, p < .001$, partial $\eta^2 = .11$, observed power = .77), indicating that there were significant differences according to ADHD status.

Given the significance of the multivariate main effect for ADHD in the overall test, post hoc tests were conducted in order to make univariate comparisons. A Bonferroni correction was
used to avoid Type I errors; thus, the significance level for all univariate tests was set at $p < .025$.

Post hoc ANOVAs revealed that on average, students in the non-ADHD group performed better than their ADHD peers on listening comprehension test items that were stated explicitly within the passages ($F(1,78) = 9.48, p = .003$). However, no significant difference was found on test items that required students to make inferences ($F(1,78) = 3.36, p = .071$). Table 20 shows the results of univariate tests. Of note, reliability estimates for explicitly stated items (Cronbach’s Alpha = .79) were appreciably better than those obtained for inferential items (Cronbach’s Alpha = .63), and there were fewer inferential items within the measure. Thus, these supplemental findings should be interpreted with caution.

Table 20  
Results of Univariate ANOVAs Comparing ADHD and non-ADHD Groups Across Explicit and Inferential Items on the KTEA-2 Listening Comprehension Measure.  
(n=80)

<table>
<thead>
<tr>
<th>Source</th>
<th>ADHD Group Mean</th>
<th>Non-ADHD Group Mean</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>KTEA Explicit Items</td>
<td>30.96</td>
<td>46.92</td>
<td>.003*</td>
</tr>
<tr>
<td>KTEA Inferential Items</td>
<td>31.67</td>
<td>42.92</td>
<td>.071</td>
</tr>
</tbody>
</table>

Note. Bonferroni Correction = .025  
*p < .025
Chapter V

Discussion

Note-taking is an effective and prevalent study strategy (Armbruster, 2000; Armbruster, 2000; Fischer & Harris, 1973; Kiewra, 1985; Kobayashi, 2006; Peverly, Brobst, Graham, & Shaw, 2003; Peverly et al., 2007) that has been widely studied in post-secondary settings using normally achieving students. Importantly, as students progress into their high school years, teachers increasingly rely on lectures to introduce curriculum content (Bretzing, Kulhavy, & Caterino, 1987; Ornstein, 1994). However, little is known about note-taking skills in this younger population, and even less is known about the note-taking skills of struggling learners.

The current dissertation set out to examine the note-taking skills of high school students with and without Attention Deficit-Hyperactivity Disorder (ADHD), one of the most common childhood disorders that affects school performance. Specifically, it aimed to discover if there are differences in the lecture note quality of adolescents with ADHD versus those without ADHD. Additionally, it sought to analyze the cognitive variables that have been associated with note-taking skill in previous research with adults (Armbruster, 2009; Peverly et al., 2007; Piolat, Olive, & Kellogg, 2005) in order to extend the research to adolescents with and without ADHD. It also set out to establish the importance of lecture note quality to subsequent test performance in this population. Finally, this dissertation sought to investigate the utility of providing an outline of lecture topics as an intervention for improving the quality of notes recorded by adolescents with and without ADHD.

In order to achieve these goals, students in the current study took notes on a videotaped lecture. Half of the students were provided with an outline of lecture content on which to take their notes. One week later, the students reviewed their notes and took a multiple choice test
containing memory and inferential items. The independent variables included ADHD status, outline status (yes/no), attention, transcription fluency, verbal working memory, and listening comprehension. The dependent variables were quality of notes (overall, main ideas, and details) and test performance (overall, memory items, and inferential items).

Results of this investigation indicated that there are, indeed, significant differences in the lecture note quality of adolescents with and without ADHD, such that students without ADHD produced significantly higher quality (i.e. more complete) notes. In addition, students with ADHD performed worse than their non-ADHD peers on a measure of listening comprehension, although significant differences were not found among their performances on measures of verbal working memory, attention, or transcription speed. With regard to the predictors of note-quality investigated in this adolescent sample, the variables of ADHD status, attention, transcription speed, and listening comprehension all emerged as significant predictors of note-taking skill. Multiple choice exam performance was predicted by note-quality and listening comprehension scores. Finally, the provision of an outline did not significantly impact the note quality of students with or without ADHD in the current study.

For the remainder of this chapter, discussion regarding note quality is presented first, including the difference between adolescents with and without ADHD as well as the variables that did or did not predict. Following this, discussion pertaining to which variables predicted multiple choice test performance is presented. Finally, issues related to educational implications, study limitations and possible avenues for future research, and conclusions are offered.
Note quality

The relationship between ADHD and note quality.

Armbruster (2009) suggested that typically developing post-secondary students generally record between 20-37% of all lecture ideas. There have been very few studies of note-taking skill using adolescents. One study examining a note-taking intervention in high school students by Carrier and Titus (1981), indicated that participants recorded an average of 27% of the information presented in the lecture. In line with expectations, results in the current study revealed that high school students with ADHD produced significantly lower quality (i.e. less complete) lecture notes than high school students without ADHD. Specifically, on average, students with ADHD recorded 13.5% of the overall information units presented within the lecture while students without ADHD recorded 26.3% of the information. The latter finding is comparable to the results obtained by Carrier and Titus (1981) described above. Furthermore, when quality of notes was additionally broken down, students with ADHD recorded significantly fewer information units than students without ADHD with respect to both main ideas (12.6% versus 23.6% respectively) and details (14.1% versus 28.7% respectively).

The only previous study that examined the lecture note-taking skills of adolescents with ADHD reported that the students recorded 74.2% of the target main ideas and 68.6% of the target details presented in a 30 minute lecture (Evans, Pelham, & Grudberg, 1994). While this study conceptualized note quality in a similar way as the current study (i.e. based on completeness), it found much higher rates of completeness. Notably, their findings are very unusual with regard to typical outcomes in the note-taking literature. Research with college adults indicates that they typically record no more than 40% of the information provided in the lecture (Armbruster, 2009; Kiewra et al., 1989). One possible explanation for the disparate
results could be differences in scoring methods. Although the scoring rubric for note quality within the current study included all presented main ideas and details (i.e. 69 main idea units and 76 details), an example provided within the methods section of Evans, Pelham, and Grudberg (1994), suggests that the amount of presented information that was targeted within their scoring system may have been significantly less (i.e. 16 details). In addition, the latter study did not include a non-ADHD comparison group.

**Which variables predict note-taking skill in adolescents?**

Based on previous research with typically developing adults, it was hypothesized that ADHD status, outline group, transcription speed, and attention scores would all significantly predict note quality in adolescent populations (Peverly et al., 2007; Peverly et al. (under review); Peverly, Garner, & Vekaria, 2011). Due to equivocal results regarding verbal working memory, this variable was also investigated. The provision of an outline did not significantly improve note quality scores. Additionally, verbal working memory did not explain a significant amount of unique variance in the model. However, in line with expectations, ADHD status, transcription speed, and attention scores were significant predictors of note quality. In addition, listening comprehension emerged as the strongest predictor of note quality scores. These findings reinforce and extend the existing research on the cognitive variables associated with note-taking ability to adolescents, and support that note-taking is a complex and multifaceted skill. Notably, ADHD status, transcription speed, listening comprehension, and attention scores accounted for over 65 percent of the variance in note-taking capacities among adolescents.

**Outlines.** Previous research has supported the benefits of providing an outline to improve the note quality of typical learners (Armbruster, 2009; Collingwood & Hughes, 1978; Hartley,
1976; Kiewra et al., 1989; Kiewra et al., 1995; Klemm, 1976; Morgan et al. 1988). Therefore, in the present study, it was hypothesized that providing a flexible style outline would improve the note quality for students with and without ADHD. Contrary to expectations, the provision of an outline had no effect on note quality for either group.

One possible explanation for these findings is the lack of training provided to the students. Specifically, the present study did not provide direct instruction on the use of the outline. Notably, the literature on the use of outlines with adults has generally not indicated the need for instruction with outlines of the type used in the current study (Armbruster, 2009; Kiewra et al., 1985b; Kiewra et al., 1995; Hartley, 1976; Morgan et al., 1988). However, the students in the current study were younger (i.e. high school students) than the students generally investigated in the note-taking literature (i.e. college adults), and half of them have a disability (i.e. ADHD). It is possible that these populations require more support than students from post-secondary populations, who likely represent a more select and possibly more developmentally mature population. Research on study skills suggests that explicit instruction is required for school-aged students to obtain or use study strategies effectively. Specifically, studies aimed at improving study skills have identified that most students require direct modeling in the use of a new strategy as well as opportunities to practice applying the strategy while obtaining feedback through teacher scaffolding (Gettinger & Seibert, 2002). Future studies are needed to explore the possibility that outlines may, in fact, be helpful with instruction in how to use them effectively. However, the present results indicate that simply providing high school students with an outline of lecture topics, regardless of ADHD status, does not improve their quality of notes.

**Verbal working memory.** Verbal working memory was not found to predict note quality in the current study. While it is presumed to be an important aspect of note-taking skill
(e.g. Piolat et al., 2005), all previous note-taking studies that have used a complex span task like the one used in the current study (Cohn, et al; Hadwin, et al., Peverly et al. 2007; Peverly & Sumowski, 2011) have not found a relationship between working memory and note-taking. Of note, this measure was originally designed to be individually administered, but it was administered in a group format in the current study, which may have impacted the results. However, the method of administration does not seem to matter, as previous studies failed to find a relationship regardless of whether it was administered individually (Cohn et al., 1995; Hadwin et al, 1999) or in a group (Peverly et al., 2007).

Verbal Working Memory and ADHD. Results from studies investigating the association between verbal working memory and ADHD have produced mixed results, but the majority have shown at least minor deficiencies when compared with non-ADHD peers (Barkley, et al., 1996; Frazier et al., 2004; Golden, 1996; Mariani & Barkley, 1997; Martinussen et al., 2005; McInnes et al., 2003; van der Meere et al., 1996). Therefore, it was expected that ADHD would predict performance on the verbal working memory measure used in the current study. However, no significant relationship was found. The literature does indicate that effect sizes are more robust in studies using spatially-based working memory measures than studies using verbally-based measures (for a review, see Barkley, 2006; Martinussen et al., 2005), such as the one used in the present study. In addition, within the research using verbally-based tasks, there is significant variability in the measures used. Specifically, the degree to which participants have been required to simultaneously remember and process information differs among measures. The literature suggests that in order to most effectively measure working memory capacity, tasks should include storage and processing components (Conway, et al., 2005), such as the listening span measure utilized in the current study. Thus while a large variety of tasks are referred to as
measuring working memory, it is unclear whether they are measuring the same constructs. More research is needed to further clarify and integrate the information to better understand the impact of ADHD on working memory and how this relationship affects performance on daily tasks.

**Attention.** Regarding the skills involved in taking notes during a lecture, the ability to sustain attention over time is assumed to be an important pre-requisite (Donaldson, 2005; Peck & Hannafin, 1983; Wilson & Korn, 2007). In other words, in order to effectively record the information presented during the lecture, as a first step, students must interpret what is being said. In addition, their ability to sustain attention throughout the course of the lecture is important to maintaining the continuity of the lecture content in the presence of potential distractions. Current results revealed that sustained attention is an important predictor of note-quality, which extends previous findings in adults (Peverly et al., in preparation) to high school students with and without ADHD.

**Attention and ADHD.** Given that inattention is a primary feature of ADHD, it was surprising that ADHD status was not significantly related to performance on a measure of sustained attention. However, some researchers have suggested that ADHD is best conceptualized as a disorder characterized by deficits in self-regulatory systems responsible for inhibition and self-control rather than a primary disorder of inattention (Barkley, 1997; Schachar, Tannock, and Logan, 1993). This theory indicates that while children with ADHD struggle to maintain focus, their capacity to attend is perhaps not in and of itself deficient. Instead, ADHD children are easily drawn toward novel stimuli (e.g. environmental distracters) that are often not the target of effortful endeavors, resulting in a breakdown in concentration. Research investigating the inhibitory skills of children with ADHD consistently point to deficiencies in their ability to inhibit responses to competing stimuli when engaged in goal-directed tasks.
Future research investigating the note-taking skills of adolescents with ADHD may wish to utilize a measure that more closely examines their inhibitory deficiencies, such as the Stroop Color-Word Test (see Lezak, Howieson, & Loring, 2004). Another important consideration is the possible effect of stimulant medications, which may have impacted scores on these measures. Of the ADHD group in the current study, 47% percent reported taking medication.

**Listening Comprehension and Transcription Fluency.** Transcription fluency was previously found to be of critical value in note-taking skills of adults (Peverly et al., 2007). Additionally, the importance of verbal ability to note-taking among adults was also recently established by Peverly et al. (under review). Current results suggest that note-taking skill in adolescents is also strongly related to verbal ability (listening comprehension is a strong proxy for verbal ability; Stanovich, 1986), which is a higher order skill and transcription fluency, which is a basic skill. This parallels the findings regarding other academic skills. For example, in reading, a classic theory of comprehension posits that one’s ability to comprehend is strongly related to one’s language ability and decoding fluency (Gough & Tunner, 1986; Hulme & Snowling, 2011; Perfetti, 2007).

In a similar fashion, the current findings, if replicated, suggest that note-taking in adolescents may be conceptualized as a task best facilitated by the combination of 1) listening comprehension ability, which is an excellent proxy for verbal ability (Aaron, 1997; Kintsch, 1998; Stanovich, 1986), 2) transcription fluency, and 3) attention. Presumably, the ability to take in and understand what is being said allows the listener to select relevant information to include in one’s notes, and the ability to rapidly produce letters serves to reduce the cognitive demands required to carry out the task of actually transcribing what one understands onto paper.
Therefore, note-taking, like many academic capacities, requires that multiple skills operate in parallel. However, due to the inherent confines of a limited capacity working memory system, one of these (in this case transcription fluency) must be automatized, or at least sufficiently fluent, to enable students to access and use the other processes.

*Listening Comprehension and ADHD.* Listening is, in and of itself, a complex skill (Flowerdew, 1994; McDonough, 1995; Thompson, 1995), and in order to understand spoken discourse, a listener must comprehend as they listen, retain the information in memory, and integrate it with continually incoming text while making adjustments to the current understanding according to prior knowledge and any new information that follows. This process understandably places a heavy processing load on listeners, and taxes one’s ability to concentrate. Not surprisingly, performance on the listening comprehension measure was significantly correlated with attention and verbal working memory abilities ($p < .001$), which are each implicated as areas of difficulty in ADHD populations (Barkley, 2006; McInnes, Humphries, Hogg-Johnson, & Tannock, 2003).

Previous research comparing ADHD children with normal controls has shown that children with ADHD perform as well as their peers on listening comprehension questions pertaining to information explicitly stated within discourse, but they struggle to make inferences regarding the presented information (Aaron, Joshi, & Phipps, 2004; Ghelani, Sidhu, Jain, & Tannock, 2004; Lorch, Milich, Sanchez, van den Broek, Baer, Hooks, Hartung, & Welsh, 2000; Puzzles, Lorch, Milich, & Sanchez, 1998; Sanchez, Lorch, Milich, & Welsh, 1999). Supplementary analysis of participants’ performance on the listening comprehension measure used during the present study showed that students with ADHD demonstrated no significant difference between their performance on inferential versus literal (i.e. explicitly stated) items.
Similarly, no difference was found in performance on inferential versus literal items for students without ADHD. However, when performance was compared across ADHD groups, non-ADHD students scored significantly higher than their ADHD peers on explicitly stated items. No significant difference was found between ADHD groups on inferential items. Notably, these findings should be interpreted with caution, as there were fewer inferential items represented within the measure, and reliability estimates for inferential items was not ideal (Cronbach’s alpha = .63).

*Transcription Fluency and ADHD.* While ADHD has been anecdotally linked with handwriting difficulties and empirically associated with movement and coordination disorders as well as deficiencies on tasks of graphomotor output (Barkley, 2006; Harvey & Reid, 2003; Racine et al., 2008), no previous studies were found regarding transcription speed in ADHD populations. Although the relationship between ADHD and transcription speed was not found to be significant in the current study using the Bonferroni correction, it is notable that the strength of the association did surpass conventional significance standards (<.05). Therefore, it is possible that transcription speed is also problematic for ADHD individuals. Future studies should investigate this possibility, given that fluent written output is important for any writing task among both children (Abbot & Berninger, 1993; Berninger et al., 1994) and adults (Peverly, 2006; Peverly et al. 2007; Peverly & Sumowski, 2011).

**Test Performance**

The relationship between ADHD and test performance.

Given that ADHD is associated with academic underachievement (e.g. Barkley, 2007; Loe & Feldman, 2007), it was hypothesized that students with ADHD would attain lower scores
than students without ADHD on a multiple choice test of lecture content. Results supported this hypothesis, with non-ADHD students achieving an average of 17 percentage points higher than ADHD students on the overall test score. Moreover, students within the non-ADHD group achieved significantly higher scores on both the memory items and the inferential items of the multiple choice exam. These findings lend support to previous findings of poor academic performance among ADHD students and reinforce the importance of distinguishing interventions to engender success. Some researchers argue that the act of testing itself places ADHD students at a disadvantage to their peers, given that they struggle with regulating arousal, making careful (i.e. non-impulsive) response choices, and managing their time (Loe & Feldman, 2007).

**Which variables predict multiple choice test performance in adolescents?**

Based upon findings from previous research (e.g. Bretzing & Kulhavy, 1981; Fisher & Harris, 1973; Kiewra, 1985; Kiewra et al., 1991; Kiewra & Fletcher, 1984; Peverly et al., 2003; Peverly et al., 2007; Rickards & Friedman, 1978; Titsworth & Kiewra, 2004), it was hypothesized that total note quality, ADHD status, and outline group would significantly predict overall test performance. As shown in the results, when multiple predictor variables were compared within a regression model, only listening comprehension and note quality emerged as significant predictors. Therefore, contrary to expectations, ADHD status and outline group did not significantly predict test performance when listening comprehension and note quality scores were included within the model. These important findings indicate that although ADHD students performed significantly worse on the multiple choice test than their non-ADHD peers, the overall variability in scores was best explained by students’ note-quality and listening comprehension ability. This provides valuable information for areas to target in future
intervention studies, since it implies that improving these skills could serve to improve achievement outcomes.

Additional analyses were also directed at further investigating the component memory and inferential items on the multiple choice test used in the current study. Based on previous research it was hypothesized that total note quality would predict performance on memory items (Kiewra, 1989; Kiewra et al., 1995; Peverly & Sumowski, 2011) and ADHD status would predict performance on inference items (McInnes et al., 2003). In line with these hypotheses, note-quality did explain a significant proportion of variability in memory item test scores, but did not predict inferential item test scores. This finding extends previous research with typically performing college students (Kiewra, 1989; Kiewra et al., 1995; Peverly & Sumowski, 2011), which found that note quality is a better predictor of performance on items that are explicitly stated within a lecture or text than items that require the test-taker to make inferences. Previous research indicates that students tend to take relatively unelaborated notes (Kiewra et al, 1995; Haenggi & Perfetti, 1992), perhaps due to limited time and cognitive resources (Armbruster, 2009; Piolat et al., 2005). In other words, students do not seem to have the time or resources to expansively process lecture material while simultaneously taking notes. Thus notes, in and of themselves, seem to be comprised of a written recording of explicitly presented information (Piolat et al., 2005) rather than a collection of deductions inferred from the lecture. Future research could further examine and expand these findings by designing a lecture that contains two types of main ideas: 1) those explicitly stated and 2) those that require some degree of inference. Subsequently comparing students’ ability to record these two types of main ideas in their notes and measuring how each relate to test performance would be beneficial.
As mentioned previously, current results revealed that ADHD students performed significantly worse on both memory and inferential items on the multiple choice exam. However, contrary to expectations, and similar to findings with overall test performance, ADHD status did not explain unique variance in the regression equations predicting performance on memory and inferential items of the multiple choice test. Listening comprehension emerged as the only significant predictor of performance on inferential items. These results also make intuitive sense, in that they suggest that one’s ability to organize and integrate information is associated with one’s ability to comprehend spoken language. Kintch (1998) suggests that language comprehension occurs at three different levels: propositional, local, and global. In essence, a listener must understand and formulate a series of meaningful ideas at the propositional level (i.e. clauses, sentences). These propositions are combined so that the listener can establish connections at the local level, and finally, the listener is able to comprehend the overall gist or theme of discourse by integrating these propositions at a more global level. These connections must often be inferred. Thus, answering inferential questions based upon a lecture requires all three levels, highlighting the need for ample listening comprehension skill.

**Educational Implications and Future Research**

The current findings, if replicated, have significant educational implications. Firstly, they serve to support the intuition of many teachers and educational professionals, who have suggested that ADHD students struggle with note-taking. Secondly, they uphold previous findings of reduced academic performance among ADHD populations. Moreover, given that note quality in typical populations is associated with academic performance; these results lend support to the need to help ADHD students to acquire good study strategies, including note-
taking skills. Importantly, current results also point to possible avenues for improving the lecture notes of ADHD students by targeting those skills that were found to be of importance as well as those that were significantly reduced amongst the ADHD group. Specifically, improving or supporting the listening comprehension and transcription fluency skills, or both, of adolescents with ADHD may serve to improve their note quality. Future studies aimed at remediating or providing accommodations to address these vulnerabilities are warranted.

In addition, while previous research with adults has shown the value of providing outlines as a means of improving note quality (Armbruster, 2009; Collingwood & Hughes, 1978; Hartley, 1976; Klemm, 1976), the current study failed to find these results in both ADHD and non-ADHD adolescents. If replicated, these findings indicate that the provision of outlines alone is not an effective intervention strategy for these populations. However, outlines have been found to improve the note quality of adults, and it is possible that high school students with and without ADHD require more support. Therefore, future studies that provide explicit training in the use of the outlines through direct instruction and modeling are warranted. Alternatively, providing explicit cues embedded within the lecture (e.g. Now I will begin describing the next topic on your outline) may serve to promote success with the outline format, as some benefit has been found using guided cues in studies investigating note-taking with learning disabled or second language learner populations (Titsworth & Kiewra, 2004). Another possibility, as studied in college-aged populations by Frank, Garlinger, and Kiewra (1989) would be to combine the use of an outline with headings embedded within the videotaped lecture to facilitate the use of the outline through cueing the participants when and where to record notes on their outline.
**Limitations**

Studies utilizing ADHD samples have inherent challenges, and the current study is not without limitations. Perhaps the largest limitation is the relatively limited sample size. While there were sufficient participants to attain acceptable power to test overall group differences, differences among subgroups were not sufficiently explored due to inadequate numbers. Specifically, differences across gender, comorbid learning disability status, and medication use were not able to be adequately tested due to the limited sample size. Notably, while 95% of the ADHD group self-reported that English was their first language, only 83% of the non-ADHD group reported to be native English speakers. Therefore, it is possible that differences between groups may have been even larger than the current results suggest. Moreover, due to difficulties with recruiting enough students from a single high school, the researcher needed to broaden the participant pool to include a second school. Therefore, while supplementary analyses suggested homogeneity, group differences across academic settings among students with and without ADHD cannot be ruled out, due to insufficient numbers. In addition, the overall sample was composed of a racially homogeneous group, with mostly Caucasian students. Future studies should utilize a larger and more diverse sample to suitably investigate possible differences and should sample from a wider geographical area to increase the generalizability of results.

In addition, while this study did utilize a parent rating form containing DSM-IV behavioral symptoms of ADHD, not all participants returned this rating form, and more comprehensive evaluations of ADHD status were not feasible in the present context. Therefore, it will be important to use caution when generalizing these results to high school students with clinically confirmed ADHD diagnoses. Furthermore, although all three ADHD subtypes have been shown to underachieve on academic performance measures (Barkley et al., 1990; Carlson et
al., 1986; Lahey et al., 1984), some researchers have posited that different subtypes could be affected by qualitative differences in cognitive or attentional components, or both (Carlson et al., 1999). Since the current study did not have access to confirmation of subtype, it was not possible to test any possible differences, and the generalizability of the current findings to all subtypes is equivocal. Moreover, as indicated above, a portion of the ADHD students self-reported taking medication to address inattentive symptoms. The potential effects of taking medication on performance are also unknown due to limited sample size and insufficient data regarding medication type and use.

Notably, the current study took place outside the formal structure of a regular classroom, where lecture topics are meaningful to the students in terms of providing information with which they are required to demonstrate competency. It is possible that some students were not motivated by the sheer nature of taking part in a research study. Furthermore, it is possible that motivation level was systematically tied to ADHD status. Researchers have found that children with ADHD exhibit reduced persistence of effort in laboratory tasks (August, 1987; Hoza et al., 2001; van der Meer, Shalev, Borger & Gross-Tsur, 1995). Therefore, their performances in this study may have produced underestimates of their true abilities, especially given that the degree of their effort was not tied to any positive or negative consequences. Future studies that specifically investigate motivation and its relation to note-taking in ADHD adolescents are needed. Further, research that takes place in more naturalistic circumstances, such as lectures that are tied to course grades, is required to confirm the current findings.

Finally, individual assessment of IQ was beyond the scope of the current study. In an effort to select children with comparable overall ability levels, students were sampled from the same level of tracked English classes. Importantly, previous research has established that
ADHD children exhibit an average deficit of nine (range of 7-15) points on standardized intelligence tests when compared to non-ADHD peers (Barkley, 2006). It is possible that underlying group differences in overall ability level had an impact on the differences observed in note-taking ability in the current investigation. Notably, some researchers have suggested that matching according to IQ or using IQ as a covariate is not ideal in studies utilizing samples with neurodevelopmental disorders such as ADHD, because such practices produce overcorrected findings (Dennis et al., 2009). Nevertheless, it will be important to replicate the current findings using studies that rule out gross differences in underlying intellectual ability.

Conclusions

In conclusion, the current findings support that high school students with ADHD do exhibit difficulties with the skills that underlie note-taking and demonstrate inferior note-taking skill when compared to their typically developing peers. Given the connection between note-taking ability and academic performance, which was also supported in the current study, improving the note-taking capacities of students with ADHD would likely provide a much needed route to improve their achievement. While the intervention that was investigated in the current study, a skeletal outline of lecture content, failed to impact the quality of notes recorded by either ADHD or non-ADHD students, it was suggested that perhaps adolescents require explicit training in its use.

Findings also provided an extension of previous research, to support that note-taking skill in adolescents, as in adults, is related to attention and transcription speed, and additionally pointed to the importance of listening comprehension ability. Based on the current findings, it was posited that note-taking skills may be conceptualized as being reliant upon strong verbal
ability as well as fluent letter production, similar to the combination of skills required for other complex academic skills. Finally, note-taking skill in this adolescent population was upheld as a significant predictor of subsequent academic performance. Future research aimed at replicating these findings and expanding the results to include wider samples with confirmed diagnoses was suggested.
References


Conway, A.R., Kane, M.J., Bunting, M.F., Hambrick, D.Z., Wilhelm, O., & Engle, R.W.


Evans, S.W., Pelham, W., & Grudberg, M.V. (1995). The efficacy of notetaking to improve behavior and comprehension of adolescents with attention deficit hyperactivity disorder, *Exceptionality, 5*, 1-17.


relationship with information-processing ability and academic achievement. *Journal of Instructional Psychology, 14*, 110-283.


Figure 1

Histogram of Overall Exam Scores

Exam score

Frequency

0.00 20.00 40.00 60.00 80.00 100.00

Mean = 48.40
Std. Dev. = 24.82
N = 80
Figure 2
Histogram of Exam Scores: Memory Items

Mean = 52.35
Std. Dev. = 25.70
N = 80
Figure 3
Histogram of Exam Scores: Learning/Inference Items

Learning Exam Score

Mean = 44.44
Std. Dev. = 26.79
N = 80
Appendix B

Materials Sent Home to Parents

Cover Letter.

[Letterhead]

Dear Parent,

My name is Jessica Gleason, and I am currently completing my final year as a School Psychology Doctoral student at Teachers College, Columbia University. I am interested in discovering ways to improve the academic performance of students with attention difficulties. The quality of students’ notes has been shown to be an excellent predictor of test performance. For my dissertation research study, I am examining the lecture note-taking skills of adolescents with and without attention difficulties and investigating the effectiveness of a note-taking intervention. I hope that the data gathered through my research can be used to inform the design of a note-taking intervention appropriate for adolescents with attending problems.

[School] has graciously allowed me to conduct my study at their school, and I have asked them to provide you with the enclosed Informed Parental Consent Form and short Rating Scale to be completed and returned. The informed consent form provides more information about the details of the study and affords you the opportunity to grant permission for your child to take part. The study will take place at [School]. If you allow your child to participate, he/she will miss a total of two class periods over the course of two weeks. Student participants will be thanked for their time and participation through a) being placed in a drawing to receive one of two $50 dollar Visa gift cards, and b) the provision of a Loews/AMC movie pass to all participants. The enclosed rating scale will provide me with information pertaining to your child’s typical attending behaviors and activity levels.

I hope that you will consider allowing your child to take part in this important and informative study. If you decide to allow your child to participate, please fill out both copies of the parental consent form and keep one for your records. Also, please fill out the parent rating form and seal the completed forms in the envelope provided. Have your child return the envelope containing the rating form and the parental consent form to the C-House Dean, by [Date]. Your responses to the rating form will remain sealed in the envelope until they are given to the researcher, and no one at [School] will have access to your responses. Please contact me with any questions or concerns regarding this study, and I thank you for you and your child’s time.

Very Sincerely,

Jessica D. Gleason, Ed.M.
Ph.D. Candidate – School Psychology
Teachers College, Columbia University
Jde2112@columbia.edu; (413) 222-2631
Title of Project: An Investigation of a Lecture Note-Taking Intervention for Adolescents with and without Attention Deficit/Hyperactivity Disorder

Principal Investigator: Jessica Gleason, Ed.M.
jde2112@columbia.edu

Dissertation Sponsor: Stephen Peverly PhD
Box 120 - Teachers College
Columbia University
525 West 120th Street
New York, NY 10027
212-678-3084; stp4@columbia.edu

1. **Purpose of the Study:** Quality of notes is an excellent predictor of test performance. The purpose of this research study is to explore the note-taking skills of adolescents with and without Attention Deficit Hyperactivity Disorder (ADHD) and to investigate the utility of providing an outline of lecture content as a note-taking intervention.

2. **Procedures to be followed:** This study consists of a parent rating form and 2 experimental sessions, to be held at [School]:

   **Parent rating form:** This form will help the researcher by providing information pertaining to your child’s typical attending behaviors, impulsiveness, and activity levels.

   **During the first session** your child will be asked to: (a) fill out a demographics questionnaire; (b) listen to and take notes on a videotaped lecture about a historical American ship; (c) complete a measure of listening comprehension skills, and (d) complete a measure of their ability to write quickly.

   **During the second session** your child will be asked to: (a) complete a measure of memory; (b) review their notes from session one; (c) complete a measure of attention, and (e) complete a multiple choice test based on lecture content.

   *All of the activities/ measures for the sessions will be administered in a group. Each session will take approximately one class period.*

3. **Risks and Benefits:** Student participation in this study is expected to pose the same amount of risk that students encounter during a usual classroom activity. The study represents common learning situations and measures of cognitive functions that are widely used. Some students may find the measures to be interesting, while others may find the process to be fatiguing. There are no direct benefits for participating in this study. However, the data gathered in this study could potentially inform the design of a note-taking intervention appropriate for ADHD adolescents.
4. **Statement of Confidentiality:** You and your child’s participation in this research is confidential. Only the persons listed above will have access to the data. Session data and parent rating forms will utilize ID numbers so that you and your child’s data cannot be linked to names. All forms will be stored in a locked cabinet to ensure confidentiality at Teachers College, Columbia University.

5. **Right to ask Questions:** You and/or your child have the right to ask questions about this research. Contact Jessica Gleason or Dr. Stephen Peverly if you have complaints, concerns, or questions about this research or your child’s rights as a research participant.

6. **Remuneration for Participation:** Student participants will each be placed into a drawing to win one of two $50 visa gift cards (1/50 chance) following the first session and all student participants will receive an AMC/Loews Gold Movie Ticket Pass (good for one admission with no restrictions or expiration date) after the second session for participating in this study.

7. **Voluntary Participation:** Your decision to allow your child to participate in this research is voluntary. You or your child can stop participation at any time. Your child does not have to answer any questions that he or she does not wish to answer. Refusal to allow your child to take part in or withdraw from this study will involve no penalty or loss of benefits that your child would otherwise receive.

If you agree to allow your child to take part in this study, please fill out the following:

I __________________________ (your name) give my child ____________________________ (child’s name) permission to participate in the research study outlined above.

__________________________________________
Parent’s Signature Date

Please keep this copy for your records. Please sign the other copy and have your child return it to ________________ at [School] so that we can retain a copy for our records.

**Thank you for you and your child’s participation in this study!**

Jessica Gleason, Ed.M.       Stephen Peverly, Ph.D.
Ph.D. Candidate – School Psychology      Dissertation Sponsor
Teachers College, Columbia University          Professor of Psychology & Education
                                            Teachers College, Columbia University
Parent Rating Scale.

Parent Rating Scale

Thank you for taking part in this study. Please follow the instructions below to complete this rating scale about your child’s attending behaviors and activity levels. When you have finished, please seal this rating form into the envelope provided and have your child return the envelope to ______________, the at [school]. She will give the sealed envelopes to the researcher, thus assuring that only the researcher will see your responses to this rating scale. Thank you again!

**Instructions:** Please circle the number next to each item that best describes the behavior of this child *during the past 6 months.*

<table>
<thead>
<tr>
<th>Items</th>
<th>Never or rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fails to give close attention to details or makes careless mistakes in his/her work</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2. Fidgets with hands or feet or squirms in seat</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3. Has difficulty sustaining his/her attention in tasks or fun activities</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4. Leaves his/her seat in classroom or in other situations in which seating is expected</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5. Doesn’t listen when spoken to directly</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6. Seems restless</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>7. Doesn’t follow through on instructions and fails to finish work</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>8. Has difficulty engaging in leisure activities or doing fun things quietly</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>9. Has difficulty organizing tasks and activities</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>10. Seems “on the go” or “driven by a motor”</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>11. Avoids, dislikes, or is reluctant to engage in work that requires sustained mental effort</td>
<td>0</td>
<td>1</td>
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<td>12. Talks excessively</td>
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<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>13. Loses things necessary for tasks or activities</td>
<td>0</td>
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<td>2</td>
<td>3</td>
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<tr>
<td>14. Blurs out answers before questions have been completed</td>
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<td>1</td>
<td>2</td>
<td>3</td>
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</table>

(cont.)
<table>
<thead>
<tr>
<th>Items:</th>
<th>Never or rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Very often</th>
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<tbody>
<tr>
<td>15. Is easily distracted</td>
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<td>16. Has difficulty awaiting turn</td>
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<td>17. Is forgetful in daily activities</td>
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<td>1</td>
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<td>3</td>
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<tr>
<td>18. Interrupts or intrudes on others</td>
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</table>

How old was this child when you first noticed the above problems?  

**Instructions:** To what extent do the problems you may have circled on the previous page interfere with this child's ability to function in each of these areas of life activities during the past 6 months?  

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<th>Never or rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Very often</th>
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<tr>
<td>In his/her home life with the immediate family</td>
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<td>3</td>
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<td>In his/her social interactions with other children</td>
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<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>In his/her activities or dealings in the community</td>
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<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>In school</td>
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<td>2</td>
<td>3</td>
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<tr>
<td>In sports, clubs, or other organizations</td>
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<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>In learning to take care of him/herself</td>
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<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>In his/her play, leisure, or recreational activities</td>
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<td>2</td>
<td>3</td>
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<tr>
<td>In his/her handling of daily chores or other responsibilities</td>
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Appendix C

Lecture Content

During today’s lecture we’ll be talking about an old ship called the General Harrison. We will discuss its early history, its connection to the California Gold Rush, and its rediscovery almost 150 years later.

The General Harrison has an early history that is like many other mercantile ships of its time. It was built in 1840 in Newburyport Massachusetts for a group of local merchants. It measured 126 feet in length and had a mass of 409 tons. They used her to transport passengers and cargo between Boston, New York, and New Orleans. After six years, the ship’s owners sold her to a group of residents from Charlestown MA who had connections with shipping ports all over the Pacific Ocean. The new owners sent the General Harrison on a trip around the world to trade. When it returned to America, the General Harrison was sold to a new owner, Thomas H. Perkins, Jr, who was the eldest son of one of the wealthiest men in America at the time. Thomas Perkins Jr. was in possession of the General Harrison in 1849, the year when gold was discovered in California.

The General Harrison has close historical ties to the Gold Rush. The news of gold sparked the interest of thousands of Americans, and people from all walks of life were drawn to California. Many gold seekers chose to rush there by ship, the fastest mode of transportation at the time. In fact, between 1848 and 1849 over 750 ships set sail for California from various American ports. The General Harrison’s current owner, Thomas Perkins, hoped to take advantage of the opportunity so he made plans to transport passengers and cargo to San Francisco.

The General Harrison set sail on its journey from Boston to California on August 3, 1849. It rounded the tip of South America, and made a stop in the Chilean port of Valparaiso. While in Chile, the General Harrison’s local agents E. Mickle and Company, loaded her up with all sorts of merchandise to sell once they arrived in California. Ship agents are an important part of the shipping industry. They are hired to provide onsite knowledge of the local port procedures and vendors. They coordinate all of the ships needs while in port. E. Mickle and Co had established a brand new office in San Francisco in 1849, and they were ready to take care of the ship and her cargo once it landed in California.

The General Harrison arrived in San Francisco on February 3, 1850. The passengers rushed off to the gold mines and all of the cargo was sold. It would have been ready for another voyage. However, the promise of gold overpowered the wills of General Harrison’s crew and they deserted the ship, along with hundreds of other ships on the docks of San Francisco. Just 20 days later, E. Mickle and Company was instructed to post the General Harrison for sale and E. Mickle and Co purchased the ship for themselves on March 7.

Why did E Mickle and Company want the ship for themselves? Well due to the number of ships arriving, the docks of San Francisco were constantly growing. The city was crowded beyond its capacity, and its entrepreneurs began to build up the shallow cove to gain more space. They pounded thousands of pilings into the shallows and built long wharves. Buildings were built on top of the pilings and many ships were hauled up onto the mud. There, they were converted into residences, stores and restaurants. Mr. Mickle had his workers remove the General Harrison’s masts and haul her up onto the mud. They housed over the ship, built a structure on the deck and cut doors into the hull. On the inside of the ship, the holds were
cleaned out and made ready to store cargo. In short, they had converted the General Harrison into a warehouse that now permanently sat at the corner of Clay and Battery Streets. They advertised the ship’s new purpose in a San Francisco daily newspaper at the end of May, saying that it was ready to receive merchandise of any kind.

The General Harrison had many business uses as a warehouse. E Mickle and Co. handled cargo that arrived from around the world, stored them in the holds of the ship, and arranged for their sale at auction. They collected rent for storing the merchandise and earned a 10 percent commission on the sale of merchandise they stored. They also rented the converted basement of the General Harrison to leasers looking for office space or a place to start a store. Based on figures reported about a similar ship of the time, the General Harrison was probably earning Mickle and Co. about $80,000 dollars per month in today’s money.

The General Harrison kept up a thriving business for about a year, while the city continued to expand. New construction had pushed well past the General Harrison and she was completely surrounded and closed in. Along with other converted ships, she was perched next to two and three story buildings, completely out of her intended element – the ocean.

The General Harrison was destroyed by a devastating fire on May 4, 1851. During the gold rush, San Francisco had many fires, probably due to its cramped conditions. This fire was the worst yet, and it began just after 11 pm on May 3rd and quickly spread throughout the city. The fire continued through the night and into the morning. It was impossible to see the damage until the thick smoke cleared. When it finally died, the fire had claimed several lives, nearly two thousand buildings, and millions of dollars in destroyed property and merchandise including the General Harrison.

After the fire, it was clear that the area would need to be rebuilt in a different manner. The newspaper reported that the piles that provided the foundations for the whole area had been so badly damaged in the fire that they would no longer be able to provide stable foundations for the district. Therefore, it was necessary to fill the whole area with new earth so that future foundations could be supported. Over the coming years, sand from the surrounding dunes was used to fill in and bury the old waterfront beneath 16 feet of new ground and people slowly forgot about the General Harrison.

The first time the General Harrison was seen again was in the years following a huge earthquake that occurred in 1906. The workers cleared the ruins and dug deep into the sand in order to pour new foundations for new buildings. During this process they hit the buried General Harrison, but no one remembered the ship’s name and it was mistaken for another ship from Spain. The workers actually tried to clear away the remains of the ship by chopping it up, but the old hull was too strong to break easily. Therefore, the workers gave up and decided to simply hammer a few pilings through the ship to support the new building’s foundation. Then the General Harrison was reburied and forgotten again.

The General Harrison was not thought about again until the late 1990s. Allen Pastron was an archeologist who had worked on many archeological digs in downtown San Francisco. There had been several discoveries of buried ships and buildings from the gold rush era, and these discoveries were important to historians. Therefore, San Francisco passed several laws that required companies who wished to build new construction in the area to conduct archeological investigations of the site before any construction could begin. When Allen Pastron heard that a New York firm hoped to build a new hotel on the corner of Clay and Battery streets, he began negations with them to head up the archeological dig. He believed that the remains of the General Harrison still lay buried beneath that site. Mr. Pastron had his crew used a powerful
auger, which is a large drill that collects material from the hole that it digs. The crew used the auger to drill several holes into the site. At one hole, the drill had collected a chunk of oak and copper, and they concluded that it was a piece of a ship’s wooden backbone. Everyone was excited to see how much of the ship had survived beneath the surface.

The excavation of the General Harrison began in early September, 2001. Construction crews cleared away the remains of the building that had last occupied the site, and they dug into the earth beneath it. It did not take long before the ship’s outline became visible. They found that about one third of the ship was actually buried beneath the neighboring building, but they successfully exposed 81 feet of the ship’s 126 foot hull. They were convinced that they had found the General Harrison, but they needed to make sure.

In order to confirm that the ship was in fact the General Harrison, they called in a maritime archeologist named James Delgado. When Mr. Delgado arrived at the site he was struck by the scene. He was excited that this hole in the ground could provide a glimpse of the past. The fire had burned the ship down to the waterline and only the bottom third of the ship’s hull remained. The hold was empty. A crew of salvagers from China had removed the burnt cargo right after the fire. At the time of the dig in 2001 there was still evidence of the salvaging crew. There was a thick iron crow-bar that the crew used to remove the ship’s copper bolts. There was also a broken rice bowl and several pairs of worn out boots. It was as if the workers had just left.

By the end of the dig, the archeologists had found many items that had been lost in the fire. In the nearby area, they found a crate packed with twelve bottles of German wine, still intact. They found more bottles of brandy, sherry and Champagne, some still full of liquid. They also found rolls of cloth, barrels of nails and tacks, bags of beautiful red glass beads, white beans and barley from Chile, and pieces of old furniture. These items were all relics from the past and provide insight into what life and trade was like at the time.

What would become of the General Harrison? Well, the hotel developer decided to rebury her back into the earth and rebuild on top of her remains. The new hotel that is built on the site now displays pictures and finds from the archeological dig that will remind visitors of San Francisco’s past. The buried waterfront and the bones of old ships still lie beneath the surface where the General Harrison will remain.

Word Count – 1803
Flesch Reading Ease: 59.4
Flesch-Kincaid Reading Level = 9.6
Appendix D

General Harrison Note-taking Outline

The General Harrison’s early history:

The General Harrison and the Gold Rush:

The General Harrison’s journey to California:
The General Harrison’s arrival in San Francisco:

Why did E Mickle and Company want the ship for themselves?

The General Harrison’s uses as a warehouse:
The expanding city of San Francisco:

The General Harrison’s destruction:

Rebuilding the area would need to be done differently:
The first time the General Harrison was seen again:

The General Harrison in the 1990s and new laws in San Francisco:

The excavation of the General Harrison:
A hole in the ground provides a glimpse of the past:

The archeologists found many items that had been lost in the fire:

What became of the General Harrison?

When the lecture is finished, please wait for instructions – thank you!
Appendix E

Multiple Choice Test Items

Memory Items:

1. Where was the General Harrison built?
   a. Charlestown, Massachusetts
   b. Newburyport, Massachusetts
   c. San Francisco, California
   d. New York, New York

2. Why did Thomas Perkins Jr. send the General Harrison to California in 1849?
   a. To search for gold.
   b. To find the fastest route from the East coast to the West coast by sea.
   c. To charge passengers for transport to San Francisco and to brings goods to trade in San Francisco.
   d. To sell the ship when it got to San Francisco.

3. How was the General Harrison destroyed?
   a. It sank.
   b. It was demolished to make way for new construction.
   c. It was burnt in a great fire.
   d. It was disassembled and the parts were used to make a new ship.

4. Why did they cover the ruined ships and buildings in the bay of San Francisco with new land?
   a. Because they wanted to make San Francisco bigger.
   b. Because the rotting wood from the ships was giving off dangerous fumes.
   c. Because they needed to create stable land for constructing new building foundations.
   d. Because they were hoping to prevent flooding.

5. When was the General Harrison first rediscovered after it was destroyed and covered over with landfill?
   a. In 1875 after a large flood.
   b. In 1906 after a huge earthquake.
   c. In 1999 when a firm wanted to build a hotel over the area.
   d. In 2001 when new laws required them to dig up the ship.

6. Why was the General Harrison reburied after being rediscovered for the first time?
   a. Because they decided the ship was not important enough to remove.
   b. To protect the remains for future historians.
   c. Because the workers thought it would be bad luck to remove it from where it was.
   d. Because the workers were unable to chop through the ship’s strong hull.

7. Who was the archeologist that wanted to excavate the General Harrison for the second time?
   a. Allen Pastron
   b. Thomas Perkins
   c. Mark Lehner
   d. Arthur Evans
8. Whey didn’t the excavation crew unearth the whole General Harrison in 2001?
   a. *Because one third of the ship was buried under another building.*
   b. Because they ran out of time.
   c. Because part of the ship had broken away from the main frame over the years.
   d. Because part of the ship was too deep to unearth.

9. What did the excavation crew find at the site of the General Harrison dig?
   a. Nothing.
   b. Bones from the crew that died when the General Harrison was destroyed.
   c. *Bottles of wine and brandy, pairs of warn out boots, bags of glass beads, and barrels of nails.*
   d. Bags of flour, spices, and barley.

10. Where is the General Harrison now?
    a. *It was reburied beneath the ground and it remains beneath the hotel that was built over the site.*
    b. It was dug up, and it now stands as a major exhibit at the maritime museum in California.
    c. It was chopped up and disposed in order to pour new foundations in the area.
    d. No one knows.

Inferential Items:

1. Why did Tomas Perkins Jr. think it was a good opportunity to send the General Harrison to San Francisco in 1849?
   a. Because there were many people searching for gold in California, and he expected he would be able to sell the ship for a high price once they got there.
   b. Because it as a good time to find the fastest route from the East coast to the West coast by sea.
   c. *Because there were so many people searching for gold in California that it would be a profitable place to trade.*
   d. Because he wanted to search for gold.

2. Why did Thomas Perkins Jr. sell the General Harrison?
   a. Because it was worth more to sell than to keep it for maritime trading.
   b. Because he owed money to E. Mickle and Co.
   c. Because he wanted to search for gold.
   d. *Because he had no crew to bring it back to the East coast.*

3. Why are shipping agents an important part of the shipping industry?
   a. *It is difficult for the ship’s owners or captains to know the local port procedures which might differ from port to port.*
   b. Because they help the captain to find the best restaurant in town.
   c. Because they calculate the amount of fuel needed for the ship.
   d. Because they help the ship book entertainment for the crew.

4. Why did they pound pilings into the shallow mud in San Francisco?
   a. To provide foundations for the buildings.
   b. To get out their frustrations.
   c. To have something to tie the ships up to.
   d. To serve as an alarm clock to wake up the locals.
5. Why did people pay rent to E. Mickle and company to store their merchandise in the General Harrison’s holds?
   a. Because it was easier and less expensive than maintaining their own property space in the overcrowded San Francisco.
   b. Because E. Mickle and Co. had the connections to arrange for the sale of merchandise they were holding at auction.
   c. Both a and b
   d. None of the above.

6. Why were the docks of San Francisco over-crowded in 1849?
   a. The ships that came to San Francisco had gotten stuck in the mud of the shallow cove, so it became crowded.
   b. The population had grown over the years because people had been drawn to the nice weather.
   c. Gold had been discovered and thousands of people came there by ship to search for the gold.
   d. There was a ship construction company in San Francisco that resulted in crowded docks.

7. Why did E. Mickle and Company put an advertisement into the newspaper?
   a. So people would be aware of the newly available storage space in the crowded city.
   b. To attract passengers on the General Harrison’s return trip to Boston
   c. To find carpenters to repair the General Harrison.
   d. To hire waiters and waitresses because the General Harrison had been converted into a restaurant.

8. Why are archeologists interested in excavating buried ships in San Francisco?
   a. Because they provide unique information about the gold rush era.
   b. Because they are looking for buried treasure from the gold rush.
   c. Because they want to recycle the wood for new ships.
   d. Because the ships were built better back then and they are interested in learning how to build them.

9. Why did the excavation crew drill holes into the earth at the corner of Clay and Battery streets?
   a. Because they believed that the General Harrison was buried there and it was the easiest way to loosen the ground at the excavation site.
   b. Because they believed that the General Harrison was buried there and they wanted to test that theory.
   c. Because they needed the holes to build a foundation for a new building.
   d. Because they were trying to test their equipment.

10. Why does the hotel on Clay and Battery streets display finds from the archeological dig of the General Harrison?
    a. Because the hotel believes that their guests would be interested in the unique history about the site where the hotel is built.
    b. Because the owner’s wife sank in the General Harrison and it was a tribute to her.
    c. Because there were no good Titanic relics at the auction.
    d. So decedents of the owners of the artifacts could find and claim them.