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AD/HD in adulthood is associated with ongoing academic impairments. A metacognitive theoretical framework was used to review the extant literature on cognitive deficits in AD/HD and to construct laboratory measures of metacognitive monitoring and control relevant to educational settings. Reviewed evidence of deficits in metacognitive control was strong while evidence of problems in monitoring was equivocal. Two sets of laboratory memory tasks were used to address questions of metamemory monitoring and control, as well as to examine whether a highly unstructured task would be incrementally more difficult for adults with AD/HD due to greater demands on executive functioning. Sixty-eight adults with and without AD/HD were assessed using structured interviews and self-reports and completed laboratory tasks, interviews, and questionnaires tapping metamemory. Adults with AD/HD were just as accurate as the comparison group at predicting their memory performance, despite remembering fewer words on the unstructured task. Groups did not differ in the relationship between their predictions and their study behavior (study time, item selection) nor in the amount of time they spent studying items. However, adults with AD/HD were less likely to use a self-testing strategy during an unstructured task and were less likely to report associating word pairs during a structured, computerized task. Results suggest that adults with AD/HD may not be impaired in metacognitive monitoring during a task, but they are less likely to use effective study strategies than adults without AD/HD, especially when tasks are unstructured. Several targets for intervention are discussed and it is suggested that future

research include assessments of self-efficacy, self-reported study behavior, and methods to investigate study plan formulation versus execution.

ADULT AD/HD, METAMEMORY, AND SELF-REGULATION IN CONTEXT

by

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Approved by

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Committee Chair

To my parents, William and Faye Knouse, in appreciation for instilling me with the qualities necessary to complete a dissertation—intellectual curiosity, critical thinking, and the will to persist in the face of adversity.

and

To Steve with love, for your unfailing support, unflappable patience, and your quiet sense of humor that makes the rest possible.

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

Attention-Deficit/Hyperactivity Disorder (AD/HD) has been described as a disorder of self-control (Barkley, 2006) and self-regulation (Douglas, 1998). The situations that appear to be most problematic for individuals with AD/HD are those that place greater demands on self-regulation and executive functioning. Not surprisingly, some of the most frequent and severe functional impairment associated with this disorder occurs in academic settings (Barkley, Murphy, & Fischer, 2008). Academic success involves persistence at effortful tasks involving less stimulating activities, adherence to rules and guidelines and, as students age, increasing levels of self-directed behavior. Among educational settings, a college environment requires a maximum amount of resources in terms of self-management. Yet despite the lack of fit between AD/HD deficits and the demands of a college setting, the functioning of adult students with AD/HD has been the subject of surprisingly little systematic research.

For emerging clinical research areas such as this, models and methodologies from areas of basic research can provide structure and direction. Nelson and Narens (1990) built a metacognitive research framework with the goal of explaining the behavior of an adult student studying for an exam. Yet this metacognitive framework is domain-general and models a self-regulating cognitive system that evaluates its own status and adjusts thought and behavior accordingly. Experiments based on the model give "executive control" to the participant in guiding his or her own study behavior (Nelson & Narens, 1990). For these reasons, elaborated throughout the following discussion, a metacognitive framework provides the ideal context in which to investigate the self-regulated learning behavior of an adult with AD/HD.

Using a metacognitive framework and methodology, the goal of this project was to empirically evaluate the metacognitive abilities of adults with AD/HD in a learning situation compared to those without the disorder. Awareness of memory processes and execution of effective study behavior were both considered. In addition, the study explored the influence of task complexity and ecological validity on the learning of adults with AD/HD. Finally, exploratory analyses of the predictive power of cognitive measures important to AD/HD theory—behavioral inhibition and working memory—were conducted. First, the paper presents background information beginning with an overview and integration of both AD/HD in adults and the metacognitive framework. Next, literature relevant to metacognition in adult AD/HD is reviewed and critiqued. Finally, the primary hypotheses and exploratory directions for the project are presented.

Defining Adult AD/HD

Diagnostic Features and Subtypes. AD/HD is a developmental disorder marked by deficits in attention or persistence, voluntary motor inhibition, resistance to distraction, and regulation of activity level relative to same-aged peers (American Psychiatric Association, 2000; Barkley, 2006). A person must display six or more of nine inattentive (IA) symptoms *or* six of nine hyperactive/impulsive (H/I) symptoms according to the *Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition*

(*DSM-IV*; APA, 2000). The person must also display clinically significant functional impairment across multiple settings as a result of these symptoms. The level of symptoms must be developmentally deviant compared to others of the same age. Under the current *DSM-IV* conceptualization, onset of symptoms *and* associated impairment must occur before age seven. However, the validity of this criterion has been called into serious question (there is no evidence that this cutoff identifies individuals with meaningfully different features) and some leading researchers have recommended a less specific definition of childhood onset (Barkley & Biederman, 1997). Since the symptoms of AD/HD can overlap with other disorders it is important to establish that they cannot be better accounted for by another condition. *DSM-IV* criteria were developed using a standardization sample of children age 4-16 years (Lahey et al., 1994) and thus there are currently no separate criteria or official guidelines for diagnosing this disorder in adults. Both the diagnostic thresholds for IA and H/I symptoms lists *and* the appropriateness of the content of these items for adults have been called into question with the most concern raised by the developmental appropriateness of the items on the hyperactive/impulsive list (e.g., "runs or climbs excessively," Barkley, 2006). With respect to research, this lack of standardized adult criteria complicates the selection of samples of adults with AD/HD, and samples are often heterogeneous across studies.

Three major subtypes of AD/HD can be diagnosed under the *DSM-IV* framework: Predominantly Inattentive (IA), Predominantly Hyperactive/Impulsive (H/I) or Combined (C) Type. These designations pertain to whether symptoms exceeding the threshold are present in either or both domains. While research suggests that individuals meeting criteria for Combined Type AD/HD share many features with those who fall in either IA or H/I with elevated symptoms on the opposing list, individuals with high IA symptoms and little to no H/I symptoms who also display symptoms of “sluggish cognitive tempo” (SCT; e.g. daydreaming, staring, slow-moving, clumsy) may demonstrate a different clinical picture than more traditionally diagnosed AD/HD (Milich, Balantine, & Lynam, 2001). Differences include hypoactivity, greater cognitive impairments, and increased likelihood of internalizing disorders (Barkley, 2006). Because failing to differentiate between subtypes in clinical studies of AD/HD may dilute power and hamper the interpretation of findings, the current study focuses on adults meeting modified criteria for the Combined Type of AD/HD.

Prevalence and Developmental Course. AD/HD is estimated to affect 3-5% of children based on information from the *DSM-IV* field trials with a male-female gender ratio between 2:1 and 9:1 (APA, 1994). In terms of race and ethnicity, the National Health Interview Survey found that 6.5% of whites, 4.3% of African Americans, and 3.3% of Hispanics surveyed had AD/HD (CDC, 2002). Prevalence estimates can vary greatly depending on the criteria used, the measures employed, and the informing source (Anastopoulos & Shelton, 2001). Since symptoms alone cannot define the disorder, studies relying solely on rating scales often overestimate the prevalence of AD/HD. For example, when an impairment criterion is added to rating scale data, prevalence estimates drop significantly (e.g., Wolraich, Hannah, Baumgaertel, & Feurer,1998). Using full diagnostic criteria, cross-national prevalence rates hover around five percent.

Although originally viewed as a disorder only occurring in childhood, the prevalence rate of adult AD/HD recently obtained in the National Comorbidity Survey

Replication, based on rating scale cutoffs predictive of diagnosis, was 4.4% (Kessler et al., 2006). Subtype prevalence rates in prior studies are as follows: .6-.9% Combined Type, .9-2.6% Hyperactive/Impulsive Type, and 1.3-2.2 % Inattentive Type. (DuPaul et al., 2001; Heiligenstein, Conyers, Berns, & Smith, 1998; Murphy & Barkley, 1996). However, the issue of prevalence and subtyping in adults remains controversial because absolute levels of *DSM-IV* AD/HD symptoms tend to decline across development, particularly those symptoms of hyperactivity/impulsivity (Hart, Lahey, Loeber, Applegate, & Frick, 1995). *DSM-IV* criteria may not capture forms of hyperactivity and impulsivity more common in adults (e.g. subjective restlessness, excessive talking), while the number of symptoms needed for statistical deviance from one's peers has been shown to decrease with age (Murphy & Barkley, 1996). Despite such limitations, longitudinal studies indicate that 50% to 80% of children with AD/HD continue to meet criteria for the disorder into adolescence (Barkley, Fischer, Smallish, & Fletcher, 2002; Weiss & Hechtmann, 1993;). When parent report was used in one large follow-up study, 42% of adults continued to meet criteria for the disorder while 66% retained developmentally deviant AD/HD symptoms (Barkley, et al., 2002). Similarly, a meta-analysis of follow-up studies showed that while only 15% of participants met full *DSM-IV* AD/HD-C criteria at follow-up, 65% met criteria for the disorder In Partial Remission (Faraone, Biederman, & Mick, 2006). Importantly, samples of clinic-referred adults with AD/HD often differ from adults followed from childhood on factors such as gender ratio (greater percentage female in referred samples), education, SES, and patterns of comorbidity (Barkley et al., 2008).

Functional Impairment: Focus on Academic Functioning

Impairment is a critical factor to consider in a diagnosis of AD/HD and impairment in some domains is more closely related to the diagnosis than in others., Academic and educational activities are a primary domain of impairment in childhood and often in adulthood. When considering impairment findings, it should be noted that findings on adult outcomes of those with AD/HD often differ between children with AD/HD followed through adulthood versus samples of clinic-referred adults.

Academic. Well-documented educational problems in childhood for people with AD/HD have been shown to continue into adulthood. Findings include fewer years of education, lower GPA and class rank, and significantly reduced likelihood of receiving a high school diploma or of attending and completing college (Barkley, Fischer, Smallish, & Fletcher, 2006; Murphy, Barkley, & Bush, 2002; Weiss & Hechtman, 1993;). Achievement in reading (Roy-Byrne et al., 1997) and mathematics (Biederman et al., 1995) has also been shown to be significantly lower in samples of adults with AD/HD compared to peers. A meta-analysis by Frazier, Youngstrom, Glutting, and Watkins (2007) identified 11 studies examining differences in academic achievement between adults with and without AD/HD, with a medium aggregate effect size across studies (Cohen's $d = .57$). Barkley et al. (2008) recently reported that clinic referred adults showed poorer achievement in reading comprehension, spelling, and mathematics than clinic and community controls, but not in basic word reading. Longitudinally-followed adults were impaired in reading, spelling and math.

In the longitudinal study by Barkley, et al. (2006), 21% of adults with histories of AD/HD attended college compared to 78% of the control group. Barkley et al. (2008)

reported that at the most recent follow-up, significantly fewer adults who had been diagnosed with AD/HD had completed college than the community control group. Weiss and Hechtman (1993) found that while 20% of their AD/HD sample attempted college only 5% completed. From clinic-referred samples, adults with AD/HD reported more grade retention and special services in school than matched controls (Biederman, Faraone, Monuteaux, Bober, Cadogen, 2004; Biederman et al., 1993) while a large sample of adults self-reporting an AD/HD diagnosis also reported lower proportions of high school graduation and a greater likelihood of high school grade point averages lower than C (Biederman et al, 2006).

Most recently using their large clinic-referred sample, Barkley, et al. (2008) reported impairment in educational activities was the most frequently endorsed domain of current impairment for adults with AD/HD. Current educational impairment best differentiated the group with AD/HD from both the community (OR = 6.39) and clinical controls (OR = 1.90). These adults were rated by others as significantly more impaired in several school situations including classwork, homework, and time management. Although no differences were found in high school graduation rates, significantly fewer adults with AD/HD graduated from college (30%) than clinical (62%) or community controls (54%), resulting in significant differences in total years of education. Barkley et al. also collected data from participants' high school and college transcripts. Adults with AD/HD more frequently received grades of D and F in both high school and college and had significantly lower class ranks and grade point averages. Interestingly, the adults with AD/HD did not score significantly lower on SAT Verbal or Quantitative sections, suggesting that academic impairments in the sample were not solely the result of lower levels of academic achievement.

For those adults with AD/HD who continue their education or return to school, increases in academic demands associated with higher education may be particularly challenging (Heiligenstein et al., 1999). In two studies employing general samples of college students, AD/HD symptoms were a significant predictor of lower grade point averages (Frazier et al., 2007; Schwanz, Palm & Brallier, 2007). Despite these data, little systematic research has examined the nature of academic impairments in adults with AD/HD who struggle in a collegiate setting. Two unpublished qualitative studies relying on interviews with *successful* college students with AD/HD identified barriers including lack of information about AD/HD, misunderstanding of the college system, self-regulation problems, and inadequate study strategies (Healy, 2006; Parker, 2005).

Basic research studies addressing specific academic deficits in adults with AD/HD are few and far between. A recent exception to this dearth of research is a study by Reaser, Prevatt, Petscher, and Proctor (2007). These authors examined the self-reported academic skills of 50 adults diagnosed with AD/HD at a university assessment center compared to 50 adults with learning disabilities and 50 control adults. Adults with AD/HD were diagnosed according to self-reported symptom count, childhood onset, and impairment criteria. Academic skills data were obtained using the self-report, normed Learning and Study Strategies Inventory – Second Edition (LASSI; Weinstein & Palmer, 2002). This 80-item questionnaire has 10 subscales with good reliability designed to tap factors that contribute to academic success. Strikingly, adult students with AD/HD scored significantly lower than normal controls on 8 of 10 subscales including motivation, time management, anxiety, concentration, information processing, deriving main ideas, self-testing, and test-taking strategies. They also scored significantly lower than students with learning disabilities in time management, concentration, deriving main ideas, and test-taking strategies, showing that academic impairments associated with these two conditions may be quite different. Despite these dramatic results, the LASSI failed to predict GPA within the group with AD/HD, suggesting that better instruments for predicting academic success in this population are needed. The main message from this study, however, is that adults with AD/HD display a wide—possibly heterogeneous—range of impairments in a collegiate setting.

There are practical reasons that adults with AD/HD struggle in college. Adult students are expected to work more independently and take responsibility for their own learning. Unfortunately, such demands directly tax the behavioral criteria that define the disorder (e.g. difficulty organizing tasks and activities, avoidance of tasks requiring sustained mental effort, failure to give close attention to details). Behavioral symptoms of the disorder (e.g. off-task behaviors, forgetting necessary materials, study time devoted to well-learned items rather than those that are poorly learned) may impair learning by reducing the likelihood that appropriate items will be studied and encoded. Thus, problems with self-guided study and other problems with day-to-day self-management may compound the educational problems experienced by adults with AD/HD. However, solid empirical evidence does not yet support these conjectures.

Research on interventions for academic problems in adult students with AD/HD has suffered from methodological limitations and does not appear to be guided by theory. Zwart and Kallemeyn (2001) reported that a coaching intervention for a mixed group of students with AD/HD and learning disabilities resulted in improved motivation, time management, test preparation, and self-efficacy with decreases in anxiety. Similarly, an academic intervention including informal assessment and one-on-one strategy instruction demonstrated some efficacy in improving the grades of a mixed group of students with various combinations of AD/HD and learning disabilities (Allsopp, Minskoff, & Bolt, 2005). However, these studies did not report which strategies were more helpful for those whose primary difficulties were a result of AD/HD. This is regrettable, because specific cognitive and functional impairments in those with AD/HD might better specify targets for intervention. In particular, problems with executive functioning may impair learning efficiency during study periods, while the behavioral and organizational demands of a less structured college environment may pose a particular challenge for those with inattentive and hyperactive/impulsive symptoms.

Pertaining specifically to students with AD/HD, Swartz, Prevatt and Proctor (2005) reported case study evidence in favor of a highly individualized coaching intervention involving setting of long-term goals and weekly objectives, and use of rewards and consequences within flexible, personalized client-coach interactions. They argue that the personalized nature of coaching makes empirical evaluation of its effectiveness difficult. However, Goldstein (2005) cogently argues that coaching in its current state is in need of more firm definition and more rigorous empirical study before claims can be made regarding its appropriateness as a treatment for AD/HD.

Relationships and Employment. Other areas of impairment are also briefly reviewed here. First, adults with AD/HD report more problems in domains of social, marital, and family functioning. Socially, clinic-referred adults with AD/HD report more impairment than those without the disorder (Young & Gudjonsson, 2006) and those followed from childhood report fewer close friends and more problems keeping friends (Fischer & Barkley, 2006). In an attempt to explain these findings, Paulson, Buermeyer, and Nelson-Gray (2005) found that participants who observed a videotape of an actor exhibiting AD/HD-like behavior reported a reaction of more hostile mood and were more likely to reject the actor. Others' negative reactions to and interpretations of the symptoms of AD/HD may also affect marital and family functioning. A sample of adults diagnosed in the community reported a higher rate of divorce and lower satisfaction with their family and social functioning (Biederman et al., 2006) and Barkley, et al. (2008) found greater marital dissatisfaction in their clinic sample than non-AD/HD controls. Marital and family functioning is more impaired in families in which one parent has AD/HD (Minde et al., 2003) and married couples with one partner with AD/HD show poorer dyadic adjustment and report interference of AD/HD symptoms in household organization, parenting, and marital communication (Eakin et al., 2004).

Problems in employment are likely related to the chronic educational problems experienced throughout the lifespan in this population. Those followed from childhood report poorer job status and employment performance as rated by supervisors (Barkley et al., 2006; Weiss & Hechtmann, 1993). Clinic-referred adults report more firings and quitting, more chronic employment difficulties, and more often changing jobs (Murphy & Barkley, 1996). Most recently, Barkley et al. (2008) showed that clinic-referred adults showed greater workplace impairment than clinical and community controls by clinician rating, self-report, and employer-report.

Adults with AD/HD are at higher risk for functional impairment in multiple domains and problems across domains likely influence one another (e.g., school failure → underemployment → financial problems → marital difficulties). What common deficits can account for these multiple impairments and for academic impairment in particular? Theories of AD/HD largely emphasize biological underpinnings and cognitive self-regulatory mechanisms.

Etiology and Theory

Evidence on the etiology of AD/HD and recent research efforts toward the search for neurocognitive epigenetic markers (Coghill, Nigg, Rothenberger, Sonuga-Barke, & Tannock, 2005), suggest that cognitive mechanisms are fruitful research targets in this population.

Etiology. AD/HD is a neurobiological disorder with a strong genetic component as demonstrated in family, twin, and molecular genetic studies (Nigg, 2006; Purper et al., 2005). It is considered to be one of the most heritable psychological disorders (Biederman at al., 1995). Important environmental factors are those that impact brain development including prenatal complications (Claycomb, Ryan, Miller, & Schnakenberg-Ott, 2004), acquired injuries and environmental toxins including prenatal exposure to substances such as those contained in cigarettes (Milberger, Biederman, Faraone, Chen & Jones, 1997; Nigg, 2006). The case for AD/HD as a neurobiological disorder is further strengthened by findings related to between-group differences in neuroanatomy (Castellanos et al, 1996) and neurophysiology (Tamm et al., 2004) of specific brain regions as well as performance on neuropsychological tasks, discussed below in more detail. Psychosocial factors including poor parenting and chaotic families have not been shown to contribute to risk for the disorder above and beyond genetic risk. However, parenting style and other environmental factors contribute to secondary oppositional behavior and poor parent-child relationships (Campbell & Ewing, 1990).

Cognitive Mechanisms in AD/HD Theory. A theory of AD/HD must successfully connect data on the neurophysiology and neurochemistry of the disorder to observations of behavior on laboratory tasks to naturalistic observation of behavior to domain-specific functional impairment. The most prominent explanatory models of AD/HD use deficits in cognitive processing and executive functioning to connect brain-level (presumably, congenital) abnormalities to functional impairment. The prominence of cognitive self-regulation in AD/HD theory supports the idea that a better understanding of these processes in "everyday" tasks may strengthen the connection between levels of analysis.

Two influential theories posit that behavioral inhibition is the primary cognitive deficit in AD/HD. Quay (1988; 1997) adopts Jeffrey Gray's (1987) neuropsychological model of anxiety to explain poor inhibition in AD/HD. He theorized that individuals with AD/HD have an underactive Behavioral Inhibition System resulting in impulsive behavior under conditions that would normally elicit passive avoidance. Barkley (1997) also emphasizes behavioral disinhibition as the primary deficit in AD/HD. However, Barkley characterizes behavioral inhibition as executive in nature and proposes that it sets the occasion for the operation of other executive functions including working memory, self-regulation of affect/motivation/arousal, internalization of speech, and reconstitution. Problems in these executive areas are characterized as *down-stream* effects of faulty behavioral inhibition, which results in control of behavior by the immediate context rather than goals held in mind. In these theories, the function of inhibition is to enable self-regulatory behavior. This idea of impaired metacognition, which presumably involves reflection and effortful processing, is consistent with these theories.

More recent theories and versions of theories reflect the heterogeneous nature of AD/HD while maintaining a focus on deficits in self-regulatory cognitive functioning. The most recent theoretical formulations of Nigg & Casey (2005) and Castellanos, Sonuga-Barke, Milham, and Tannock (2006) draw attention to the complex nature of cognitive deficits in AD/HD. These authors point out that, since effect sizes for any one cognitive process are only moderate in magnitude and because not all individuals with AD/HD display any target deficit, AD/HD must result from the complex interplay of multiple neurocognitive systems and risk factors. Both of these efforts point to the possible interaction of brain systems governing self-regulation in traditionally frontal “cool” types of cognition and in motivation-related “hot” circuitry. Thus, the most cutting-edge theoretical models continue to emphasize self-regulation of performance while acknowledging the developmental complexity—and possible heterogeneity—of its origins.

From this brief overview, there are clear theoretical reasons to consider the impact of cognitive self-regulatory processes in AD/HD. Theories emphasize the prominence of cognitive processes that are "executive" in nature in that they regulate ongoing processing toward a goal. As will be demonstrated, these properties map onto those contained within the metacognitive framework of self-guided learning. In addition to theoretical evidence for the importance of cognitive self-regulation, empirical findings suggest that these types of processes are more likely to be impaired in AD/HD.

Cognitive Findings

What evidence supports the application of child-based cognitive self-regulation theories to the adult population? A review of empirical evidence on general cognitive deficits in adults with AD/HD continues to turn up relatively few studies with small sample sizes. Therefore, where possible, data from meta-analyses are reported. Although results from samples of children are cited, it should be emphasized that findings of cognitive differences between participants with and without AD/HD are less robust in adults than those found in children.

Inhibition. Problems with inhibition or response suppression are the most consistent laboratory findings in the AD/HD literature—perhaps contributing to their prominence in theories of AD/HD. Noting that the term "inhibition" refers to a wide variety of cognitive phenomena, Nigg (2001) only found strong evidence for what he termed "executive inhibition" in children and specifically for motor inhibition. He recently reported an aggregate effect size of .61 across studies of children (Nigg, 2006). These deficits in motor inhibition—the ability to withhold a response—are the most consistent findings in the adult literature. The greatest volume of evidence for behavioral inhibition deficits comes from studies using CPTs and stop tasks (participant must withhold response to a target when an auditory stop signal occurs before stimulus onset). Small to moderate effect sizes have been obtained for adults with AD/HD in terms of CPT commission errors (.26-.63) with stronger effects on anti-saccade (1.38) and stop-signal tasks (.85) (Boonstra, Oosterlaan, Sergeant & Buitelaar, 2005; Hervey, Epstein, & Curry, 2004). Nigg, Butler, Huang-Pollock, and Henderson (2002) also found evidence of motor inhibition deficits as measured by the anti-saccade task. It appears that problems with motor inhibition, as measured by these tasks, persist from childhood into adulthood for groups of people with AD/HD. However, there is less evidence for problems with interference control as measured by the Stroop task when results are controlled with respect to overall slower processing speed (effect size of .15 across four studies, Hervey et al., 2004; .13 in Boonstra et al., 2005).

Attention. Despite the prominence given to attention in the naming of the disorder, researchers have generally de-emphasized specific attention deficits in favor of other deficits that may create the *appearance* of problems with attention (Douglas, 1998). Several varieties of attention tasks have failed to yield consistent results for children with AD/HD including those tapping automatic orienting (Huang-Pollock & Nigg, 2003), divided attention in dichotic listening tasks (see Douglas, 1983 for a review), and selective attention (Huang-Pollock, Nigg, & Carr, 2005). The most consistent finding relates to deficits in vigilance especially when attention and responses must be sustained throughout long, repetitive, boring tasks (Newcorn et al., 2001). Nigg (2006) describes this problem as a difficulty in maintaining readiness to respond quickly and accurately, producing variable patterns of response time and errors. Variable performance has been cited as a hallmark of the behavior of those with AD/HD in general and on specific laboratory tasks (e.g. Draeger, Prior, & Sanson, 1986; Zentall, 1985). Children with AD/HD display more off-task behavior during laboratory tasks than their peers (see Luk, 1985 for a review) and this pattern persists into adulthood (Fischer, Barkley, Smallish, & Fletcher, 2004, 2005). Vigilance has been most commonly measured via omission errors on continuous performance tasks (CPT). Adult studies have found effect sizes for omission errors that are moderate in size (.50 in Boonstra et al., 2005; .51-.76; Hervey et al., 2004; .52 in Schoechlin & Engel, 2005). In a large study of clinic-referred adults, Barkley et al. (2008) found that CPT omission errors and reaction time variability differentiated adults with AD/HD from community controls and clinic-referred adults with diagnoses other than AD/HD. Thus, the most consistent "attention deficits" obtained for adults with AD/HD pertain to sustaining readiness to respond to stimuli in underarousing tasks over long intervals.

Memory. Problems with some aspects of memory, including long-term storage and retrieval, have not been shown to be impaired in children with AD/HD (Barkley, DuPaul, & McMurray, 1990; Douglas, 1983). Rather, memory deficits are more commonly observed when tasks require more effortful processing at encoding—a finding consistent with a deficient metamemory view of AD/HD

In the vein of decrements in performance with increasing processing demands, working memory (WM) is often examined in children and adults with AD/HD. However, the tasks used to tap WM have varied considerably across studies and tend to be more closely related to conceptualizations in neuropsychology rather than cognitive psychology. This may greatly complicate interpretation of “working memory” findings since tasks may not be measuring the same construct (Conway et al., 2005). Children with AD/HD frequently perform more poorly than peers on tasks hypothesized to involve verbal working memory such as mental arithmetic (effect size of .70; Frazier, Demareem, & Youngstrom, 2004), n-back (Shallice et al., 2002) and digit span. Nigg (2006) estimates an overall effect size of .43 and notes a stronger effect for non-verbal working memory tasks of 1.0, although Barkley (2006) argues that non-verbal working memory has shown less consistent effects. Illustrating the above point, this difference appears to be a result of differences in the types of tasks considered under the rubric of non-verbal working memory. Most strikingly, Klingberg, Fernell, and Olesen (2005) recently showed that a randomized, controlled trial of practice on working memory tasks improved the performance of children with AD/HD on other executive tasks and was associated with reductions in parent rated symptoms. Thus, empirical findings support the idea that apparent deficits in memory, especially when tasks require controlled processing or control of attention, may be the result of problems in executive processing rather than primary memory deficits.

For memory deficits in adults with AD/HD, increased problems appear to be associated with encoding of more complex verbal information—a finding that may relate to use of effortful strategies. Although a small aggregate effect size was obtained for adults’ performance differences on the digit span task in the Wechsler Adult Intelligence

Scales-Revised (WAIS-R; .31; Barkley, Murphy, & Kwasnik, 1996; Hervey et al., 2004) no differences were obtained on a reading span working memory task (Ossman & Mulligan, 2003) nor on a recognition memory task (McClean et al., 2004). Barkley, Murphy, and Fischer (2008) recently reported failing to find between-group differences in immediate free recall of details from a paragraph and in word list learning when comparing adults with AD/HD to clinical and community controls. Delayed recall of paragraph information differentiated adults with AD/HD from both the clinical and community controls. Critical to the current study, no differences were found between AD/HD and community controls on word pair learning for immediate or delayed recall.

Deficits have been found for adults with AD/HD on the California Verbal Learning Task (CVLT; Delis, Kramer, Kaplan, Ober & Fridlund, 1983). Differences between adults with and without AD/HD from these studies showed a medium to large effect size for acquisition during learning trials (.91), free recall at a short delay (.59), free recall at a long delay (.60), and recognition (.90) (Hervey et al., 2004). Deficits on this task are sometimes explained in terms of inefficient semantic strategy use, as items can be studied in categories. Results from CVLT studies reporting scores for strategy use are discussed under the later review of metacognitive control. Thus, there is some evidence for memory deficits for adults with AD/HD that, similar to children with the disorder, appear to be more pronounced as processing demands—and thus, perhaps demands on metamemory—increase.

Complex Cognitive Tasks. Despite some early results and theoretical predictions, strong evidence for deficits in AD/HD associated with traditional, multi-faceted measures of executive functioning and planning have not received strong support in adult samples. The Tower of London task has traditionally been regarded as tapping planning ability; however, performance on this task has not been shown to be impaired in adults with AD/HD (Barkley et al., 2008; Riccio, Wolfe, Romine, Brandon, & Sullivan, 2004) and results from the Wisconsin Card Sort Task have been equivocal (Barkley, 2006; Schoechlin & Engel, 2005). In terms of overall intellectual functioning, the effect size from 12 studies examining WAIS Full Scale IQ was .39 (approximately 6 points), with adults with AD/HD receiving lower scores than normal controls (Hervey et al., 2004). However, as noted previously, studies using clinic-referred adults may identify groups of individuals with more education and higher IQs than adults with AD/HD followed from childhood (Barkley et al., 2008).

From this brief review of laboratory tasks tapping cognitive deficits, it appears that there is moderately strong evidence for poorer performance for adults with AD/HD in the areas of motor inhibition, vigilance, and memory tasks requiring effortful processing. Do these findings generalize to more ecologically valid cognitive challenges such as study situations? Metacognitive theory and methods were used in this study to answer these questions via review of the existing literature and collection of new data.

Metamemory Theory and AD/HD

Metacognition (literally, thinking about thinking) describes the ways in which people self-regulate their own cognitive processing. Constructs of knowledge (understanding of how cognition works), evaluation (self-assessment of processing) and regulation (adaptive modification of processing) are studied in both developmental and cognitive psychology (Knouse, 2005). The following definition was adopted in deciding which findings in the existing AD/HD literature would be relevant to the current discussion.

> Metacognitive processes are anything a person does to reflect on or modify ongoing cognitive processes including using knowledge about processes, evaluating ongoing performance or regulating ongoing processes.

Metamemory is simply the above definition applied to memory processes such as encoding and retrieval.

Metacognition connects to AD/HD on conceptual and methodological levels. Theories of AD/HD describe particular problems in situations presumed to require increasing self-regulatory control. Methodologically, metacognition tasks give executive control to participants while taking into account the putatively distinct self-regulatory functions of monitoring one's own progress versus taking the appropriate action. If "basic" memory processes are not impaired in those with AD/HD, why do adults with the disorder have such difficulty in learning situations? Deficits in metamemory might be one possible answer to this question. In the next section, a metacognitive framework particularly suited to addressing this question in adults is described.

Nelson and Narens (1990) Framework. Researchers of adult metacognition use a process-based approach and examine the reliability and validity of evaluative judgments and the underlying cognitive processes that feed into self-regulation. Importantly, much research has been aimed at exploring and explaining the many instances in which adult metacognition is inaccurate or ineffective. For these reasons, the cognitive perspective on metacognition is especially useful in studying adults with AD/HD.

The metacognitive model is based on a view of people as reflective organisms with mental mechanisms that can evaluate and change ongoing processing (Nelson & Narens, 1994). They delineated three principles: 1) Cognitive processes are split into two *or more* interrelated levels labeled *object* and *meta*, 2) The meta level contains a changing model, or mental simulation, of the object level and its relation to a goal state, 3) the meta level is "dominant" in the sense that the meta level both receives information from (monitors) and dispenses regulation to (controls) processes at the object level. *Control* takes place when the meta-level modifies the object level, which could take place by initiating, continuing, or terminating an action. *Monitoring*, occurs when the meta-level receives information about the ongoing state of the object level. Nelson and Narens (1994) posit that their model can be expanded to include multiple meta-levels, each with a prior meta-level as its object.

Nelson and Narens (1990) then mapped various types of metamemory judgments onto the stages of memory acquisition, retention, and retrieval, as monitoring components. Accordingly, various types of self-regulatory behavior during study and learning were also mapped onto these stages as control processes. The goal of subsequent metamemory research has been to clarify the relationship between these judgments and the processes that they are hypothesized to influence and, ultimately, to use metamemory principles to improve learning. A basic understanding of these metacognitive processes is necessary to predicting which processes might be problematic in adults with AD/HD.

Metamemory Monitoring. Metacognitive monitoring is a key process in the Nelson and Narens (1990) framework as it is presumed to lead to effective control. Although several types of judgments during learning have been studied in the metacognitive literature, Judgments of Learning (JOL) are emphasized because of their direct applicability to control of subsequent study. These judgments are made at some time interval after a participant has been given the opportunity to learn an item. For example, a participant is asked to study a set of paired associates (e.g., doctor – lobster, cat – fork). After studying each one, she predicts *the likelihood of recalling the response* (e.g., lobster) when later shown the cue (i.e., doctor - ?) on a scale of 0 to 100.

Evidence supports the idea that metacognitive judgments, like other probabilistic judgments (e.g. Tversky & Kahneman, 1974), are inferential in nature. However, the information available to the learner when drawing such inferences depends on the type of judgment being made. For example, familiarity with a cue would be less likely to influence a JOL made immediately after an item is studied because a person has no prior experience with that particular item pair. Begg, Duft, Lalonde, Melnick, and Sanvitor (1989) found instead that subjective ease of processing influenced immediate JOL—a finding which was later replicated (Hertzog, Dunlosky, Robinson & Kidder, 2003). Immediate JOL generally yield modest correlations with recall (e.g. gammas of +.38 in Nelson & Dunlosky, 1991). However, when participants make JOL at a delay from when items are studied, JOL are highly accurate at predicting later recall (gamma = +.90; “delayed JOL effect;” Nelson and Dunlosky, 1991) because the learner can rely on whether an answer can be retrieved and, if so, how quickly.

The finding that metacognitive judgments may be largely inferential in nature and may rely on basic memory processes (e.g. familiarity, ease of processing) has implications for predicting results for those with AD/HD. As processes of less effortful encoding, storage and retrieval have been shown to be intact in this disorder, one might not necessarily predict inaccurate metamemory monitoring. This question is examined in the current study.

Control Processes in Learning. As mentioned previously, several lines of evidence suggest that memory deficits are more prominent in those with the disorder when tasks are effortful and require greater self-regulatory control. The following section focuses on metacognitive control findings relating to item selection and study allocation because of their direct applicability to the study behavior of adults with AD/HD.

Nelson and Leonesio (1988) found that people appeared to allocate more study time to less-well-learned items (lower JOL) as indicated by negative correlations ranging from -.15 to -.30. Observing these correlations, Theide and Dunlosky (1999) posited the *discrepancy reduction hypothesis* to describe the presumably optimal strategy of selecting and studying the items that are the furthest away from the goal state (those with the lowest JOL), also termed the *norm of study* (Le Ny et al., 1972; see also Dunlosky & Theide, 1998). In a review by Son and Metcalfe (2000) 35 out of 46 conditions showed the characteristic negative correlational pattern suggesting discrepancy reduction. However, Theide and Dunlosky (1999) found that, given a time limit, people showed a *positive* relationship between their JOL and study time meaning that they devoted more time to easier items. In a later study, they found this strategy to be more efficient when people adopted a low performance goal (Dunlosky & Theide, 2004). They also found that ease of planning and cognitive capacity—variables related to executive functioning—influenced the behavior of participants with respect to strategic study time allocation. Resolving this variability in item selection, Metcalfe (2002) proposed a *region of proximal learning hypothesis* (RPL), which predicts that people will devote the most *time* to items of medium difficulty (those just beyond their current grasp) but will choose to study the easiest items first in order to reap maximum returns immediately. Metcalfe and Kornell (2003) provided evidence for the RPL hypothesis, finding that people's item selection and study time adhered to this pattern and calculated a "gain per unit of time" score to describe the efficiency of learning for each item.

From these findings concerning how people select items to study, variability in task, strategy, and learning goals can influence the way in which a participant proceeds with learning. It is likely that individual differences associated with AD/HD such as reduced working memory capacity, poor behavioral inhibition, and poor sustained attention could influence the relationship between monitoring and control.

Prior Empirical Evidence

Although a metacognitive model has not previously been applied to the study of AD/HD, mapping prior empirical work onto the model should guide its application in the current study. Although some relevant findings from the child literature are briefly cited, the reader should keep in mind that between-group metacognitive differences earlier in development do not necessarily apply to adult outcomes.

Monitoring. This section focuses on literature exploring *task-specific* predictions and confidence judgments related to memory and other cognitive tasks. As global self-evaluations and social judgments may have an entirely different set of relevant variables and judgment inputs, these studies are not discussed here. (However, for interesting recent findings on adult global self ratings, see Golden, Owens, Evangelista, & Michel, 2006).

Several studies on children with AD/HD demonstrate patterns of performance and self-evaluation in less ecologically valid cognitive tasks that often differ from non-affected peers (Hoza et al., 2001; Milich & Okazaki, 1991; Ohan & Johnston, 2002; O'Neill & Douglas, 1991; Whalen et al., 1991). On such tasks, children with AD/HD sometimes give overly optimistic ratings of the future performance compared to peers, sometimes described as the "positive illusory bias." At post-task, their ratings are comparable, but a wider gap may still remain due to poorer performance in the group with AD/HD. Findings are frequently difficult to interpret due to lack of statistics directly addressing the source of these discrepancies—poorer performance or overly inflated ratings. Only two studies have examined monitoring of cognitive performance in adult samples. Rapport, Friedman, Tzelepis and Van Voorhis (2002) had adults identify animals and facial expressions when presented rapidly on a tachistoscope. After each item, they gave a retrospective confidence judgment (RCJ) of their confidence in response accuracy (*not at all* to *completely*). There were no differences in mean confidence ratings for either type of stimulus despite poorer performance for adults with

AD/HD in identifying happy, angry, and fearful faces. Another study, discussed below, failed to find evidence for memory monitoring deficits in adult AD/HD.

Conceptual and methodological problems in prior research on self-evaluation in AD/HD were addressed in the current study. First, the tasks for which participants make evaluations in these studies often bear little resemblance to functionally relevant tasks in learning situations. Second, many studies measure performance and self-evaluative judgments on non-comparable scales or failed to assess performance altogether. Statistically, the scale of the self-estimate and the scale for performance must be in the same metric so that the values from each scale are directly comparable. Although several studies attempt to solve this problem by using discrepancy scores this method is inappropriate because one can reasonably predict performance differences between AD/HD and control groups. Differences in criterion performance level between groups confounds the interpretability of discrepancy scores (Schwartz & Metcalfe, 1994) because if all participants anchor their judgments at a similar point in the scale, then the discrepancy score's magnitude is entirely dependent on the participant's level of performance.

Connor, Dunlosky, and Hertzog (1997) found that younger and older participants tended to anchor their memory predictions around the midpoint of the scale. Because younger adults tended to remember more items and thus had recall levels closer to 50%, their monitoring judgments looked more accurate than those given by the older adults. The apparent overestimations by older adults were an artifact of their performance deficit. Thus, self-evaluation "deficits" may actually be artifacts of the poorer base performance of a group with AD/HD if this variable is not taken into account. While Owens, Goldfine, Evangelista, Hoza, and Kaiser (2007) provide arguments for the conceptual validity of discrepancy scores in studies of the “positive illusory bias” in children with AD/HD, they also point out that those with AD/HD are statistically more likely to overestimate due to their poorer criterion performance.

Knouse, Paradise, and Dunlosky (2006) addressed the limitations of the discrepancy score by also measuring relative accuracy for each subject. Relative accuracy, or *resolution*, is the degree to which an individual’s judgments discriminate between performance across items. Importantly, relative accuracy is largely independent of criterion task performance. To measure relative accuracy, a participant’s judgments would be correlated with actual test performance. The Goodman-Kruskall Gamma correlation is frequently used because it addresses the ordinal nature of relative accuracy, comparing a continuous (0-100) and dichotomous (correct/incorrect) variable. Twenty-eight adults with AD/HD and 28 comparison adults completed a paired-associate learning task and made immediate and delayed judgments of learning (JOL). No differences were found between groups in the magnitude of absolute judgment accuracy, nor in terms of test performance (cued recall). Not surprisingly, no differences were detected in terms of discrepancy scores since these scores are calculated by subtracting performance from judgment. For relative accuracy, both groups showed the *delayed JOL effect* in that their relative accuracy increased dramatically when they made their JOL at a delay from study of the item. For these delayed JOL, adults with AD/HD actually showed higher relative accuracy than comparison participants. These results differ from the pattern seen in prior studies of metacognitive monitoring with children and the authors suggest that the lack of between-group differences on the performance measure may have been a critical factor. The current study replicates the methodology of this prior study across three tasks to further explore metamemory monitoring in adults with AD/HD.

Control. This section focuses on evidence of metacognitive control problems in people with AD/HD specifically related to cognitive strategies and study behavior. Evidence from studies of children with AD/HD largely supports the idea that memory and verbal learning deficits are most likely in situations that require more effortful encoding strategies (August, 1987; Benezra & Douglas, 1988; Cornoldi, Barbieri, Gaiani, and Zocchi, 1999; O'Neill & Douglas, 1996; Voelker et al., 1989). Most relevant to the current study, O'Neill and Douglas (1991) found that boys with AD/HD devoted less study time and examiner-rated effort to a learning task, while also using a less effortful strategy. In these studies, children with AD/HD make less frequent use of effortful but effective memory strategies and also exhibit poorer recall when tasks demand more effortful processing.

A handful of results provide data on strategic memory processes in adults with AD/HD using the California Verbal Learning Task (CVLT; Delis, Kramer, Kaplan, Ober & Fridlund, 1983). The CVLT requires participants to learn a 16 item list over five trials. Items fall into four categories of four items each and semantic and serial clustering scores can be derived for each trial, indicating strategy use. Holdnack, Moberg, Arnold, Gur, and Gur (1995) found that adults with AD/HD had a reduced semantic clustering score overall and recall deficits on the final learning trial. Seidman, Biederman, Weber, Hatch, and Faraone (1998) also found significantly less clustering for adults with AD/HD across all learning and recall trials. Roth et al. (2004) also found less clustering and poorer recall for adults with the disorder, although they questioned whether these differences were related to AD/HD specifically or another confounding variable (e.g., state anxiety). Most recently, Young, Morris, Toone, and Tyson (2006) found that adults with AD/HD were less likely to use a sequential search strategy during a working memory task—however, differences in strategy use did not entirely account for between-group differences in working memory. As a whole, these studies indicate less use of effortful but effective learning strategies during memory tasks for groups of adults with AD/HD.

Across studies, recall differences between participants with and without AD/HD often persist even when differences in selection of a particular strategy cannot be identified. What other variables might account for differences in effort-demanding tasks? As previously noted, control processes include not only which strategy is selected, but also whether that strategy is initiated, maintained, and terminated efficiently. Dunlosky (2003) suggests that factors other than which strategy is selected—such as motivation, arousal, and environment—could be examined as part of metamemory control.

Self-guided study situations require the individual to set his or her learning goals and to choose items to study based on those goals and the demands of the situation. What happens when individuals with AD/HD must allocate their efforts across tasks in a strategic way? The Six Elements Task (SET; Burgess, et al., 1996) has been used to examine this question in adolescents and children with AD/HD. In the SET, participants must work on some portion of each of six open-ended tasks during a 10-minute interval and participants are given a list of the tasks and a stopwatch to use if they wish. Two studies show deficits in SET performance for children with AD/HD (Chan et al., 2006; Siklos & Kerns, 2004). In a single study on adolescents, Clark, Prior, and Kinsella (2000) found that a group with AD/HD attempted significantly fewer tasks than controls, even when IQ was taken into account. The authors characterized their AD/HD sample as having deficits in the ability to, "…strategically plan and organize information and monitor ongoing performance." Although no data on SET performance in adults with AD/HD are currently available, the adolescent data suggest that in an open-ended study situation involving many tasks and goals, individuals with AD/HD may have more trouble organizing their behavior and allocating their attention among tasks or items.

Evidence for AD/HD-related deficits in metamemory is strongest in the area of control. However, potentially fruitful lines of research have been largely ignored in the literature and are addressed in the current study. As O'Neill and Douglas (1991) aptly note, too often researchers *infer* ineffective study strategies rather than directly examining what subjects are actually *doing* during the study interval. The lack of observational and verbal report data is somewhat puzzling given the successful use of observational methods in the AD/HD literature with respect to parent-child and social interactions (e.g. Cunningham & Barkley, 1979). Closer examinations of the observed behavior and subjective reports of adults with AD/HD during study tasks may yield useful information. In addition to unexplored sources of data, the ecological validity of the tasks examined thus far does not seem to be considered in any systematic way. Although the use of specific laboratory measures is crucial to a fine-grained analysis of deficits, simpler cognitive measures often fail to yield strong performance deficits in those with AD/HD (Douglas, 1998).

Ecological Validity and Executive Functioning

Critics of research involving laboratory behavioral tasks often decry the absence of "ecological validity" in these experimental settings. The term is sometimes confused with external validity but actually refers to the degree of similarity between the experimental methods, materials, and settings and "real life." Ecological validity is not a prerequisite for external validity, nor does it guarantee generalizability. However, consideration of ecological validity in research on AD/HD is important for two reasons. First, ecological validity may serve as a proxy for task complexity and hence the level of self-regulation required in a given situation. Second, research in children with AD/HD has identified situational variability in symptom expression as an associated feature of the disorder.

In children, the primary symptoms of AD/HD show significant fluctuations across settings and task demands (Anastopoulos & Shelton, 2001; Barkley, 2006). Situational factors associated with *less* symptom expression include novelty, salience, lack of situational complexity, and low executive demands. These descriptors all relate to situations that are less demanding of self-regulation. Although these observations pertain to children, the types of difficulties reported by adults with AD/HD also appear to fall within these more regulation-demanding scenarios (academic settings, social situations, work roles). In earlier stages of cognitive research on children with AD/HD, Zentall

(1985) cautioned researchers to carefully consider the demands imposed during behavioral tasks. This advice should also apply to current adult AD/HD research.

How should ecological validity as self-regulatory demand be taken into account in AD/HD research? Ecological validity *per se* is not critical if it does not influence the level of self-regulation and control required from the participant. In other words, it is not necessarily critical that laboratory materials exactly match what a participant might study in a college class and that the research take place in a classroom setting. It *is* critical that the researcher be aware of what sorts of demands are imposed by the chosen stimuli and setting. Are stimuli presented in a structured or unstructured format? Can the participant regulate the presentation rate or is it fixed? Can he or she choose items to study or are all stimuli presented? Does the noise level and physical space enhance or reduce distraction? Awareness of these factors and their relationship to those present in “real world” settings should lead to more informed interpretations. For example, Biederman et al. (2005) created a simulated workplace environment incorporating tasks based on the Secretary of Labor’s list of necessary workplace skills and found differences between adults with and without AD/HD on a variety of measures including task performance, self-report, and observed behavior.

In addition to being aware of the impact of ecological validity, a researcher can methodically vary the level of self-regulatory demands within a task. Given a lack of findings in simpler and more externally-controlled cognitive tasks, a potentially profitable research strategy would be to select measures that give increasing “executive control” to the subject and to determine the point at which those with AD/HD show the greatest decrement in performance. In studies that attempt to give control to participants with AD/HD, the demands can be systematically increased to identify factors that contribute to problems in self-regulated behavior. Lawrence and colleagues (2004) have argued the merits of investigating AD/HD in experimental situations that include layers of complexity encountered in everyday tasks. The current study includes tasks that vary in the extent to which control is given to the participant versus imposed by the task itself.

Implications for the Current Study

Does AD/HD affect metacognition in adults? If so, which processes—monitoring or control—are affected? As described above, the question of monitoring deficits in adults with AD/HD is controversial. The self-evaluative abilities of those with AD/HD, especially with regard to predicting and evaluating behavior on specific tasks, have not been adequately tested. Measurement problems, including different base rates of performance, have led to the premature conclusion that these individuals are globally unable to evaluate their own behavior as accurately as others. More rigorous tests of monitoring accuracy within learning tasks and in "everyday" contexts are needed. Critically, such tests must take performance level into account and measure both relative and absolute accuracy. In the current study, metacognitive monitoring is examined and replicates the author's thesis work using a more rigorously defined sample of participants with AD/HD.

In the Nelson and Narens (1990) framework, accurate monitoring does not improve learning unless it is connected to more effective control. Thus, another important step is to objectively evaluate the relationship between the accuracy of self-evaluative judgments and *actual behavior*—a key connection that has not been investigated in those with AD/HD. It may be that individuals with AD/HD can make accurate judgments but do not consistently use them to guide behavior such as which items to study and for how long. Indeed, the best evidence for problems with metamemory for adults with AD/HD lies in the realm of metacognitive control. Thus, a logical research question is whether adults with AD/HD will show deficits in their allocation of study time, item choice, and strategy selection during learning tasks. In addition, the relationship between monitoring, or Judgments of Learning during study, and these control factors must also be examined.

What is the best context for testing whether adults with AD/HD will show metacognitive monitoring and control deficits? The ecological validity of experimental tasks should be considered to the extent that it influences the degree of self-regulation and cognitive control required in the task. Evidence from the literature on children with AD/HD suggests that performance will deteriorate more quickly compared to those without the disorder when demands for self-regulation are imposed. Metacognitive tasks systematically vary such demands. As Nelson and Narens (1990) suggest, a key element in any metacognitive task is to give some degree of executive control to the participant and to observe resulting behavior. As such, tasks in the current study were carefully selected with respect to their executive demands—for example, the amount of structure externally imposed versus flexibility given to the participant—to determine whether the opportunity for self-regulation was beneficial versus detrimental to adults with AD/HD.

Varying task structure experimentally may also provide information regarding possible interventions to improve the efficiency of self-guided study. If metacognitive research demonstrates that individuals with AD/HD *can* make accurate judgments of their own learning under the right circumstances, intervention should primarily focus on helping them *make sufficient use of these accurate judgments* in guiding their academic behavior. If problems in item selection are detected, an effective intervention might be to have a computer determine to-be-studied items based on the results of a pretest. If the problem, however, lies in study time allocation, external control of this variable might be more effective.

Metacognitive methods also provide guidance on the collection and use of valid self-reports of participant study behavior. The current study uses immediate verbal self-report data to more richly understand what those with AD/HD are actually doing (or *think* they are doing) during a study task. These methods were carefully chosen, executed, and interpreted according to what is known about factors affecting their validity (Ericsson & Simon, 1980). Self-reports were augmented with observation for a critical study strategy of self-testing.

Research Questions

The overarching question posed by the current study is whether there are systematic differences in the metamemory processes of adults with AD/HD in a learning situation compared to those without the disorder. Using a metacognitive framework, the study explores the locus of those deficits at the stages of monitoring versus control. The extent to which the level of externally-imposed task structure would differentially impact adults with AD/HD was also explored.

In the current study, adults diagnosed using research criteria for AD/HD Combined Type were compared to a matched comparison group without AD/HD on a variety of laboratory tasks. Included were laboratory study and judgment metamemory tasks where judgment accuracy, self-reported strategy use, observed strategy use, item selection, and study time allocation were examined in relation to recall performance. Self-report ratings of cognitive control problems in everyday life were also collected. In addition to addressing the three main metacognitive hypotheses, data on key cognitive and behavioral measures that are important to theories of AD/HD—working memory and behavioral inhibition on a continuous performance test—were collected from a subset of participants for use in exploratory analyses.

Hypotheses

Hypothesis 1. Some studies in children indicate problems with self-awareness for specific task performance, but there is little evidence in adults to address this question. In metacognitive theory, accurate monitoring is necessary (but not sufficient) for effective control. Therefore, the first hypothesis states that adults with AD/HD will show poorer metacognitive monitoring than adults without AD/HD as evidenced by poorer relative and absolute accuracy of Judgments of Learning in relation to measured recall during learning tasks.

Hypothesis 2. Much more evidence from prior research supports problems in situations requiring strategic behavior for adults with AD/HD, although no prior research has investigated the possible relationship between monitoring and control. The second hypothesis states that adults with AD/HD will show poorer metacognitive control than adults without AD/HD as evidenced by, 1) poorer recall, less study time, and use of fewer normatively effective strategies during an unstructured learning task, and, 2) lower correlations between Judgments of Learning and control processes (item selection, study time allocation) in computer administered learning tasks.

Hypothesis 3. Studies of children with AD/HD identify situational factors that are associated with more difficulties in performance, including the need for executive functioning and effortful processing. This question has not been directly examined in adults, especially with respect to the way different contexts could affect learning efficiency. The third hypothesis states that the magnitude of differences in cognitive control and recall performance between adults with AD/HD and adults without AD/HD will correspond to the level of externally imposed task structure. The magnitude of between-groups effect sizes will be greatest for an unstructured learning task and least for a task where item presentation is controlled. An intermediary condition (computer presentation with free time allocation) will result in correspondingly intermediary effect sizes.

CHAPTER II

METHOD

Participants

To be eligible for the group with AD/HD in the current study, participants had to: 1) endorse at least 6 of 9 inattentive and 4 of 9 hyperactive-impulsive symptoms[1] on either a modified version of the AD/HD module on the *C-DISC-IV* or on a modified adult self-report version of the *ADHD Rating Scale* (DuPaul, Power, Anastopoulos, & Ried, 1998), 2) meet criteria for statistical deviance of AD/HD symptoms in reference to population norms (93rd percentile/*t* score of 65 or higher) on at least one *DSM-IV* derived subscale[2] (inattentive or hyperactive-impulsive) on the *Conners Adult ADHD Rating Scale* (*CAARS*), 3) demonstrate evidence of symptom onset during childhood (prior to age 12) by self-report, other-report, or evidence from records and, 4) endorse functional impairment that could be reasonably related to symptoms in at least two domains of daily functioning (e.g. educational, occupational, home life, relationships, personal distress, etc.) on the *C-DISC-IV* module or the Functioning Scale. Combined, these inclusion procedures were designed to identify a group of adults with significant symptoms and impairment.

Participants in the comparison group had no reported, documented, or suspected history of AD/HD. They endorsed fewer than 6 of 9 inattentive and 4 of 9 hyperactive-impulsive symptoms on *both* the AD/HD module in the *C-DISC-IV* and the adult version of the *ADHD Rating Scale* (DuPaul et al., 1998). Further, participants in the comparison group had to score at or below the 84^{th} percentile (*t* score of 60) on both *DSM-IV* derived subscales (inattentive and hyperactive-impulsive) on the *Conners' Adult ADHD Rating Scale* (*CAARS*), signifying that their symptom level was significantly lower than those in the group with AD/HD relative to population norms. In one instance, however, a male control participant obtained a *t*-score of 62 (88^{th} percentile) on the inattentive subscale of this measure. Because no other measures indicated significant elevations in AD/HD symptoms (*C-DISC-IV Module, AD/HD-RS*), the decision was made to retain this matched control for the analyses.

Participants were excluded from the study altogether if they reported a history of mental retardation, psychosis, neurological conditions, closed head injury, or major sensory or motor impairment. Participants were also excluded if they reported a history of autism, Asperger's disorder or other pervasive developmental disorder. In addition, because the study involved verbal learning tasks in English, participants were required to be native English speakers.

Thirty-four adults (age 18 to 39) who met inclusion criteria for the group with AD/HD and 34 age- and gender-matched adults with no evidence of AD/HD completed the study. This number of participants provided power of .84 to detect a medium effect size (d = .5) at an alpha level of .05 in an independent samples t-test (Cohen, 1988). Table 1 displays the demographic characteristics of the sample. Across the entire sample, the mean participant age was 26.85 years with a range of 18 to 39 years. Fifty-nine percent of the sample was female. Participants reported a mean of 15.15 years of education with a range of 10 to 20. Thus, the average participant in this study had at least some post-secondary education. Forty-two percent of the sample reported incomes below $10,000 and approximately 77 percent reported incomes below $35,000. Thirty-seven percent of the sample reported their primary occupation as student, with 5% reporting that they were unemployed and the remaining participants employed. Eighty-four percent self-identified as White, with 18% African-American, 3% Hispanic or Latino, and 3% Native American. (Participants could self-identify more than one race or ethnicity.)

Participants' self-identified race and ethnicity did not significantly differ between groups, $X^2(1, N = 68) = 3.86$, $p = .43$. Participants with and without AD/HD did not differ significantly in their self-reported years of education, $t(67) = 1.44$, $p = .16$. Overall self-reported job status did not differ between groups with 37% of the overall sample indicating "student" as their primary occupation. Groups did differ, however, in self reported income, $X^2(5, N = 68) = 12.60$, $p = .03$, with a greater proportion of participants in the group with AD/HD reporting gross household incomes below $25,000.

Distribution of participants from the various referral sources were as follows. For the group with AD/HD, 13 were referred through the AD/HD Clinic at UNCG, 9 through word-of-mouth in a university setting, 6 through the UNCG Office of Disability Services, 3 through word-of-mouth in the community, and 3 through the North Carolina Genetics of AD/HD Project (NC-GAP). For the comparison group, 11 participants were referred through word-of-mouth in the community, 10 through word-of-mouth in the university setting, 5 were matched controls referred by participants with AD/HD, 4 through the NC-GAP Project, and 4 through the university's mass screening of psychology students.

Information about previous AD/HD diagnosis and treatment was collected from the group with AD/HD. Three members of the group with AD/HD had not received a formal diagnosis of AD/HD, but met study criteria and were identified as at-risk for AD/HD through the North Carolina Genetics of AD/HD Project. Of the remaining participants with AD/HD, 31.3% reported receiving their first formal AD/HD diagnosis by age seven or earlier, 62.5% had been diagnosed by adolescence, and 87.5% were diagnosed by their 20s. Most of the participants had been evaluated and diagnosed by a psychologist other than the UNCG Psychology Clinic (41%) with 21% diagnosed at the UNCG Psychology Clinic. Twenty-one percent were diagnosed by a psychiatrist. Eighteen percent had been evaluated and diagnosed by pediatricians and only 9% diagnosed by other medical doctors. (Participants could indicate being diagnosed by more than one type of professional). On the *C-DISC-IV* structured interview, the mean age of symptom onset reported retrospectively by participants was 6.26 years (*SD* = 1.29). (Note that if participants reported that onset was in childhood generally or "as long as I can remember" this was entered as age 7.)

Fifty-six percent of the group with AD/HD were not receiving medication treatment for their AD/HD symptoms at the time of the study. Of those taking medication for AD/HD, the majority were taking short- or long-acting Adderall (73%), followed by Straterra (20%), Welbutrin (13%), and Ritalin (6%). 66% of those taking medication reported taking it daily, 27% reported as-needed use, and one participant reported taking medication only on weekdays.

Materials

Clinical Measures. Participants completed a series of self-report measures and computer-based tasks. Clinical measures were administered for the purpose of diagnostic assessment and defining group characteristics. Due to their clinical nature, these measures were administered by a Master's level clinical psychology student enrolled in the doctoral program at UNCG under the supervision of a Ph.D. level licensed psychologist.

Screening. A questionnaire developed specifically for this study requested information about prior AD/HD diagnoses and prior and current medications. The questionnaire also assessed history of neurological conditions or injuries, as well as history of reading disorder or other psychiatric diagnoses (See Appendix C).

AD/HD Symptoms-Interview. A modified version of the AD/HD module in the *National Institutes of Mental Health Computerized Diagnostic Interview Schedule for Children* (4^{th} ed.; *C-DISC-IV*) (Shaffer, Fisher, & Lucas, 1997) was administered to participants (Appendix D). Standardized, structured diagnostic interviews represent the "gold standard" for reliable clinical diagnosis but these measures are unavailable for assessing AD/HD in adults. The *C-DISC-IV* was selected due to its widespread use in clinical and research contexts. It includes sections assessing the 9 inattentive and 9 hyperactive-impulsive symptoms, to which participants respond yes/no, as well as their onset, course, and impact on domains of functional impairment. Wording of some items was modified to reflect manifestations of AD/HD symptoms more commonly seen in adults and noted in *DSM-IV* (e.g., subjective restlessness vs. overt hyperactivity).

Symptom counts from this measure were used in determining eligibility for the AD/HD and comparison groups.

AD/HD Symptoms-Self-Report. Two scales were used to gather self-report data on symptoms of AD/HD—one widely-normed scale focusing on current symptoms and including items other than those contained in *DSM-IV* and another assessing only *DSM-IV* symptoms both currently and retrospectively. A modified version of the *ADHD Rating Scale* (DuPaul et al., 1998) lists the *DSM-IV* criteria for the disorder and asks participants to rate the frequency of each behavior based on a four-point Likert scale (0=Never or rarely, 1=Sometimes, 2=Often, 4=Very often) across several time periods. Ratings of prior to age 7, prior to age 12, and the past six months were analyzed in the current study. Internal consistency for this measure was very good for symptoms rated at all three time points (α = .98; .98; .97, respectively). Items rated "Often" or "Very Often" for current symptoms were used to index inattentive and hyperactive-impulsive symptom counts in addition to those obtained via the structured interview. The *Conners' Adult ADHD Rating Scale* (*CAARS*; Connors, Erhardt & Sparrow, 1999) is a normative rating scale that allows for the assessment of problematic AD/HD symptoms continuing into adulthood. It is a 66-item self-report measure containing several subscales. Internal consistency for the *CAARS* in the current study was very good (α = .99). The subscales using *DSM-IV* items for inattentive and hyperactive-impulsive symptoms were specifically used in this study, employing cutoff scores at the 93rd percentile (*t* score of 65) in defining the group with AD/HD.

AD/HD Symptoms-Functional Impairment. A functional impairment scale was created based on a subset of items from the *AD/HD Current Symptom Scale* (Barkley & Murphy, 2006; Appendix E). Participants were asked to indicate the extent to which problems indicated on the *ADHD Rating Scale* (i.e. problems with inattention, hyperactivity and impulsivity) interfere with their ability to function in several areas of life and activities. These items were rated on a scale identical to that of the *ADHD Rating Scale*. Total scores as well as number of areas rated "Often" or more were used in this study as an index of AD/HD-related functional impairment.

Comorbid Symptoms. In addition to self-report of psychiatric diagnoses, information on comorbid psychopathology symptoms was collected using the Symptom Checklist 90 – Revised (*SCL-90-R*; Derogatis, 1975), the Beck Depression Inventory-II (*BDI*-II; Beck, Steer, & Brown, 1996), and the Beck Anxiety Inventory (*BAI*; Beck & Steer, 1993). The *SCL-90-R* is a 90-item, multidimensional self-report inventory designed to screen for a broad range of symptoms of psychopathology. It yields three global indices for Global Severity, Positive Symptoms, and Positive Symptom Distress. Reliability for this measure in the current study was very good ($\alpha = .98$). T-scores from the Global Severity Index were used to compare the groups on overall severity of psychiatric symptoms. Two additional measures were used to tap symptomatology of disorders very commonly comorbid with AD/HD in adults. The *BDI*-II and *BAI* each contain 21 items tapping depressive symptoms and anxiety symptoms, respectively, rated on a 0-3 scale. The *BAI* was specifically designed to discriminate anxiety from depression; thus, its items largely focus on somatic symptoms of anxiety. Scores on the *BAI* and *BDI-II* were used to characterize levels of depression and anxiety symptoms between groups and both had a high degree of internal consistency in the current study (*BAI*: $\alpha = .92$; *BDI*: $\alpha = .92$).

Intellectual Ability. Some participants in the group with AD/HD had received the full *Wechsler Adult Intelligence Scale-Third Edition* (WAIS-III; Wechsler, 1997) as part of recent clinical evaluations. Participants without prior WAIS-III data completed the Vocabulary and Matrix Reasoning subtests during the experimental session, which were used as estimates of intellectual ability in verbal and performance domains. These subtests are some of the most reliable subtests within their domains (Wechsler, 1997). Vocabulary correlates highly with Verbal ($r = .83$) and Full Scale IQ ($r = .80$). Matrix Reasoning is correlated with Performance ($r = .65$) and Full Scale IQ ($r = .69$). This dyad showed good reliability ($r = .94$) in the standardization sample for the WAIS-III (Sattler, 2001). From these scores, estimated Full Scale IQ scores were also calculated according to tables published by Sattler. These data were used to examine between-group differences in intellectual ability.

Cognitive Task Factors Questionnaire. This self-report measure was designed to assess external factors known to contribute to performance on memory and attention tasks including the number of hours of sleep the participant had the night before, the number of hours since the participant had awakened, and whether he or she had used caffeine, cigarettes, alcohol, or other drugs and, if so, how recently (Appendix F).

Cognitive Assessments. The second set of tasks consisted of laboratory measures and self-report measures designed to assess metamemory judgment accuracy, metamemory control, working memory span, behavioral inhibition, and vigilance. Self-report data was collected regarding everyday memory and cognitive functioning. These measures were administered by the primary investigator or by graduate research assistants with supervision from the primary investigator.

Metamemory Monitoring and Control: Card Task. Participants completed a self-paced study and cued recall task that involved minimal experimental constraints similar to Murphy, Schmitt, Caruso, & Sanders (1987). They were given 40 pairs of unrelated nouns printed individually on one side of a set of laminated cards. No two nouns in the *entire* set of stimuli used in this study (240 nouns) were related to one another any greater than .15 forward or backward association strength according to the University of South Florida Word Association Norms (Nelson, McEvoy & Schreiber, 1999). This was done to reduce the potential impact of proactive interference across tasks.

Participants were instructed to try to learn as many of the pairs as they could for the test and to study in any way they chose. They were told that during the test, they would see the cue word and have to type in the word that had been paired with it. Participants were to study the word pairs and signal the experimenter that they were ready to test by placing a red card atop the stack of study cards. Participants were not explicitly told how long they could study and, if they asked about time limits, they were told simply to let the experimenter know when they were ready to take the test. The experimenter observed and recorded the study period via video camera. An upper limit of 15 minutes was placed on the study period at which point the experimenter interrupted the participant's study (if they had not given the signal) and moved them to the test phase. The time the participant took in seconds from the start of study until when he or she signaled the experimenter was measured and recorded. 900 s was recorded for participants interrupted at 15 minutes.

At the end of study, the experimenter returned to the room, removed the cards, and conducted a brief semi-structured interview with the participant about what they were doing to study (see section on Memory Task Interview and Appendix G). Interviews took approximately 5 minutes. Judgments of learning and recall trials were then administered via computer. All computerized metamemory protocols were programmed using E-Prime Software Version 1.2 (Psychology Software Tools, Pittsburgh, PA) and conducted on Dell PC laptops using keyboard inputs. Participants were prompted with the first word of each pair and made delayed JOL for each item based on a scale of 0 to 100 where 0 represented "definitely will not be able to recall" and 100 represents "definitely will be able to recall." After making JOL for all items, participants completed a cued recall test. The first word of each pair was presented in a randomized order and participants typed in their response. Recall was self-paced.

As mentioned above, the study period and brief interview section of this task were recorded via video camera and DVR technology. These data were obtained for observational and interview coding.

Metamemory Monitoring and Control: Computer Administered. An initial sample of participants completed two fully computerized metamemory tasks that measure judgments about to-be-recalled items, actual recall of items, and the selection of items for re-study across several study-tests trials. An additional sample completed only the self-controlled version of the task as described below. These study-judge-recall tasks were modeled on a method used by Nelson, Dunlosky, Graf, and Narens (1994) and replicated with older adults by Dunlosky and Hertzog (1997). One of the tasks also included elements of study time allocation from a method employed by Dunlosky and Connor (1997) in a study with older adults. Stimuli for these tasks were two completely different sets of 40 unrelated paired-associate items (described above). For both computerized tasks, participants first studied, judged, and then selected up to 20 items for re-study after which they completed an initial test trial. In subsequent study periods, they were only presented with the items they selected for re-study. The two conditions differed in whether the participant could control how much time he or she spent re-studying items or whether the computer controlled this variable. In the initial sample, each participant completed both conditions in a counterbalanced order across experimental groups. The two sets of noun-noun stimuli were also counterbalanced across tasks and order of completion. This was done to reduce any effects of proactive interference or participant fatigue on any particular condition or item set.

In both computerized tasks, participants first studied each of 40 paired associate items in a randomized order for 6 seconds. They then made a delayed JOL for each item based on a scale of 0 to 100 where 0 represents "definitely will not be able to recall" and 100 represents "definitely will be able to recall." As in the card task, participants were cued with the first word of the pair when making their JOL. Immediately after an item was given a JOL, participants were prompted to indicate whether they wanted to re-study that item at a later study opportunity. The participant was instructed that they could choose up to 20 items to study again later. The computer screen displayed both the number of items currently selected for restudy and the number of remaining items to aid the participant in keeping track of their selections. If a participant chose more than 20 items, the 21st item and subsequent items were not presented again. If the participant chose less than 20 items, the "empty slots" for these items were filled during restudy with a blank. Participants were verbally informed of this situation prior to beginning the task.

Following JOL and item selection, participants completed a recall trial. Items were again randomized and participants entered their response when presented with the first word of the pair. Misspellings and plural responses were counted as correct and all items were scored by the computer and then reviewed manually.

Following the test trial in both computerized tasks, participants entered another study phase. The computer presented the 20 items the participant previously selected for re-study in a randomized order. In the computer-controlled condition, the re-study items were presented for 5 seconds each. In the self-paced condition, participants could study each item for as long as they wished and advanced to the next item by pressing the space bar. After re-study of selected items, participants completed another test trial identical to that first described. (However, items were randomized anew.) After this second test, they had a second phase of re-study for selected items, followed by a third and final test. When they had completed both versions of the computer-administered metamemory task, participants completed another metamemory task interview.

Metamemory Task Interview. Participants completed this interview twice: once after the study period during the card task and once after they had completed both computer-administered tasks (see Appendix G). As recommended by Ericsson and Simon (1980), each interview began with an open-ended question about the participants' approach to the task, i.e., "What were you doing to try to learn the words?" The experimenter coded the participants' response using a pre-printed sheet with checkboxes for various strategies (e.g., imagery, rote rehearsal, self-testing, and categorization of cards) and space to record idiosyncratic strategies. (Note that data for the card task interview reported here are gleaned from coding of videotaped interviews rather than the experimenter's "live" coding at the time of the interview. See section on Interview and Observational Coding.) The participant was then specifically asked how frequently they had used a self-testing strategy using a Likert scale. He or she then answered questions about other aspects of the task, such as how they had decided when they were ready to take the test or how they had decided which items to select for later study. Finally, participants provided ratings on a Likert scale of task difficulty and their own level of effort during the task.

Working Memory. A subset of participants completed automated, computerized operation span and reading span working memory tasks. These span tasks are designed to tap domain-general processes of executive attention that are active during states of interference and have demonstrated good psychometric properties in prior research (internal consistency, $\alpha = .70$ to $.90$; test-retest reliability, $r = .70$-$.80$; Conway et al., 2005). In each task, participants first completed a block of practice trials where they were to recall a sequence of letters in order. They saw a screen displaying 12 to-be-remembered letters and were to click the boxes to display the order of letters they had just seen. They received immediate feedback on their letter performance. Participants then practiced the processing component of the task. For the Operation Span Task, they verified given answers to math problems. For the Reading Span Task, they read a sentence and indicated whether it made sense. The program computed each participant's average time to complete these items and then used the mean plus 2.5 standard deviations as a time limit for the processing components of the practice and experimental trials.

For full practice and experimental trials, participants received a processing item, made a response and were then presented with a to-be-remembered item for 800 ms. If the participant failed to respond before the time limit, the task continued and counted that trial as an error. After a series of processing – letter pairs had been presented, participants were prompted to recall the letter string. Experimental trials included three trials each of set sizes 3-7 for a maximum score of 75 for each span task. Importantly, participants were prompted to try to maintain accuracy of the processing component above 85% and they received feedback on this accuracy rate after each full trial. This was done to decrease the likelihood that participants would neglect the processing task in an effort to remember the letters.

Behavioral Inhibition and Vigilance. The Conners Continuous Performance Test-Second Edition (CPT-II; Conners et al., 2004) is a neurocognitive task that yields indices of vigilance/inattention (omission errors) and impulsivity/inhibition failure (commission errors, perseverative errors). During the task, participants perform continuous key presses in response to high-frequency letter stimuli while withholding a press for a low-frequency target stimulus (letter X). Commission errors and perseveration errors were included as measures of behavioral inhibition in the current study with omission errors as an index of inattention. In the standardization sample for the CPT-II, reliability for omission errors was better than for commission errors as measured by both split-half (.94 vs. .83) and test-retest (.84 vs. .64) (Conners et al., 2004). Test-retest data available for perseverative errors showed especially low reliability (.43). Given that this task is so widely used in assessments of AD/HD, these measures were retained in the current exploratory analyses despite reliability concerns.

Everyday Memory and Cognitive Functioning. The original Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, FitzGerald, & Parkes, 1982) is a 25-item self-report measure designed to assess a single factor of "cognitive failure." More recently, some investigators have identified distinct factors within the measure including those related to distractibility and memory problems (Wallace, 2004). The original CFQ was shown to correlate with adults' self-reported AD/HD symptoms with inattentive symptoms showing the highest correlations (Wallace, Kass, & Stanney, 2002). For this study, a modified and expanded version of the CFQ was administered (Appendix H). This measure contains additional items related to everyday lapses of attention, awareness, and instances of "automatic" processing. A total score from the CFQ was used in the current study as subscale data on this modified version were unavailable. Internal consistency in the current study was very good ($\alpha = .99$).

Procedure

Recruitment. Participants in the group with AD/HD were recruited from a number of sources including the AD/HD Clinic at UNCG, the Office of Disability Services at the University of North Carolina at Greensboro, and the North Carolina Genetics of AD/HD Project (NC-GAP). Volunteers contacting the study through word-of-mouth referrals were also included in the group with AD/HD, provided they met inclusion criteria and could provide documentation of their diagnosis. In the AD/HD Clinic at UNCG, adults who received feedback on their comprehensive psychological evaluations were presented with study information if their evaluation results indicated that they met criteria. For the NC-GAP project, the self-report results of parents in participating families were reviewed and eligible parents were invited to participate. Interested persons from the UNCG Office of Disability Services and word-of-mouth referrals had to pass a telephone screening consisting of the *C-DISC-IV* AD/HD Module and also provided evidence of a documented AD/HD diagnosis.

Initial eligibility for the group with AD/HD was determined using data regarding *DSM-IV* AD/HD Combined Type diagnostic criteria gleaned from a telephone screening or review of documentation. Additional data for eligibility were collected during the session. Participants in the comparison group were recruited using a social nomination procedure, from the undergraduate subject pool at UNCG, from the NC-GAP project, and from interested volunteers contacting the study. Participants with AD/HD were invited to nominate an individual of their gender and similar age to participate in the study, increasing the likelihood that the match would be similar in terms of socioeconomic status and education level. One exception to the gender rule was that individuals were allowed to nominate opposite-sex spouses or partners, because this relationship was considered to provide a high degree of match. Because many participants with AD/HD could not provide an appropriate referral for matching purposes, control participants were recruited from the additional sources mentioned. A table listing each Participant with

AD/HD in his or her age/gender category was used to track incoming matches, guide recruitment, and ensure that the groups were balanced.

Eligible comparison group volunteers contacting the study via word-of-mouth referrals were included if they matched a participant with AD/HD in age and gender. Additional control matches were recruited from parents of children in the NC-GAP project whose scores on the *CAARS* and *AD/HD-RS* were sufficiently low. Finally, for participants with AD/HD remaining unmatched, matches were recruited from the undergraduate subject pool at the University of North Carolina at Greensboro. Members of the pool participating in mass screening at the outset of a semester had completed the *ADHD Rating Scale*, thus enabling the selection of age and gender matches known to be low in AD/HD symptoms.

Participants were not excluded from either group based on meeting criteria for most psychiatric disorders other than AD/HD. Information on additional diagnoses was collected via self-report, and rating scale data on depression, anxiety, and other psychiatric symptoms were collected for purposes of between-group comparisons. Information about learning disability/disorder in reading was gathered using information from self-report on a screening questionnaire.

Stimulant medications prescribed to treat AD/HD have been shown to improve performance on laboratory tasks tapping vigilance, impulsive responding, short-term memory, reaction time and problem-solving (e.g. Tannock, Schachar, & Logan, 1995). Prior to each experimental session, participants in the group with AD/HD who were taking stimulant medications for their symptoms agreed to discontinue stimulant dosing the evening before the testing session. Participants were given flexibility to schedule their sessions on days and at times when they did not normally take medication. Participants reporting daily use were asked to obtain written permission from their prescribing physician prior to participation in the study. Participants were instructed to resume normal dosing following study participation. Information regarding psychotropic medications being taken by participants in either group was collected using the screening questionnaires.

Experimental Sessions. An initial sample of 52 eligible participants completed the study measures during two separate sessions lasting approximately 90 minutes each. The two-session format was used to reduce participant fatigue across tasks and to reduce proactive interference between the tasks using paired-associate stimuli. Sessions were scheduled a minimum of 24 hours and a maximum of 2 weeks apart. In order, Day 1 tasks included the informed consent process (see consent forms, Appendix I), *C-DISC-IV* Interview, WAIS-III Subtests, Card Task with Memory Task Interview, completion of half of the questionnaire measures, and the Operation Span and Reading Span working memory tasks. In order, Day 2 consisted of one of the computerized memory tasks, the other half of the questionnaires, the other computerized memory tasks followed by the memory task interview, and finally the CPT-II. Not all participants completed all measures during these sessions because portions of these data had already been obtained from some participants' AD/HD evaluations (e.g., WAIS-III scores). These participants signed HIPAA-compliant release forms allowing the experimenter to access their clinical data for research purposes.

Data from 16 additional participants (8 in each group) were collected during a single two-hour session. The purpose of this additional data collection was to increase the power to detect between-group differences in measures that showed evidence of effects in the initial sample. Thus, this single session only included measures pertinent to the main study hypotheses that demonstrated the potential for between-group differences in the initial sample. In order, single-session tasks included the consent process, *C-DISC-IV* Interview (if not already collected via telephone), WAIS-III Subtests, Card Task with Memory Task Interview, completion of all of the questionnaire measures, and the self-controlled computerized memory task *only* followed by the memory task interview. Thus, data from the Operation Span and Reading Span working memory tasks, the computer-controlled computerized memory task, and the CPT-II were not collected from these 16 participants.

Experimenters conducting participant sessions were not blind to group status due to limited personnel. However, many of the cognitive tasks were computerized, potentially reducing the impact of any inadvertent variability in experimenter behavior based on group status on these measures.

Following the completion of the laboratory measures participants with AD/HD were invited to identify a matched control to be contacted for participation. Each participant was then given the opportunity to ask questions about the study and was paid $50.00 for participation. Participants later received feedback on their performance in the form of a brief letter describing their general level of performance on some of the tasks (Appendix J). This feedback also included a list of helpful memory strategies derived from research in cognitive psychology and an overview of the purposes of the study written in consumer-friendly language.

Interview and Observational Coding. A video recorded segment of each participant's experimental session was used as a data source. The recorded segment took place during the card task and included each participant's study period (up to 15 minutes) and the memory interview conducted by the experimenter. Footage of study behavior was observed for a single behavioral code—whether the participant had self-tested in a way consistent with how he or she would later be tested on the items. During the interview portion, the interviewer coded each participant's responses; however, recorded interviews were re-coded for data analyses reported here.

To characterize each participant's responses to the open-ended question, "What were you doing to learn items?" an interview coding system was developed using the following procedure. Initially, a set of ten non-mutually-exclusive codes was compiled based on face validity and experience with pilot participants. This original set was used to code each participant's responses "live" by the experimenter during the session. The decision was made to refine the coding scheme for use when re-coding the video recorded interviews. Two raters (non-blinded) viewed the recordings from the initial sample using the original coding scheme and independently rated each memory strategy as present or absent. Kappa statistics were calculated for each code, and codes with poor Kappas were modified or defined more stringently to improve their reliability. Eleven codes comprised the final coding scheme. These included: *Rote Rehearsal* (study of items by simple repetition, silently or aloud), *Repeat Aloud* (study of items by saying them out loud), *Sort by Categories* (sorting pairs by categories based on either word of the pair ACROSS CARDS), *Associate* (any attempt to connect the words semantically even if the method is not further specified), *Sentence* (constructs a sentence that associates both words in a pair WITHIN PAIRS ONLY), *Story* (constructs a story that linearly connects pairs to one another ACROSS PAIRS), *Personal Reference* (relates at least one pair to a personal experience), *Visual Imagery* (reports relating items by mentally visualizing them together or interacting in some way) *Self-Test*, (testing self on items during the study period), *Chunking* (breaks entire list of items down and studies in smaller sets) and *Monitoring Affects Control* (Reports BOTH judging items based on difficulty AND treating them differently based on these judgments). See the entire coding scheme contained in Appendix K for more detailed descriptions and examples of responses for each code.

The videos from the initial sample were then re-coded by both raters using the new scheme and disagreements were resolved by the coders viewing the disputed videos together and deciding upon the appropriate code. Both raters, one blinded and one unblinded, later viewed the tapes from the additional 16 participants and independently rated them using the coding scheme. Kappas for each code in this sample ranged from .83 to 1.0, indicating good inter-rater reliability for the interview coding. In a few cases in the additional data sample, the experimenter had directly prompted participants with coding scheme items after asking the initial open-ended questions. In these cases, responses were only coded until the time of the inappropriate prompt.

A single observational code (present/absent) was applied to each participant's study during the card task. Video recordings were coded as to whether or not the participant had used a cue-based self-testing strategy at any time during the observed study period. This behavior was defined as the participant occluding the response word (second word) of the word pair with another card or his or her hand, looking at the cue word, and pausing briefly before revealing the response word. This behavior was judged to be an especially effective strategy in this task because it simulated the later test. (Note that participants *were* explicitly informed of the nature of the test in the task instructions.) Each recording was coded for this behavior by two raters, one blinded and one not blinded to group status. Kappa for this code across the entire sample was .91, indicating good inter-rater reliability. Again, disagreements in coding (3 out of 68 videos) were resolved by raters viewing the video in question again and deciding together on the appropriate code.

CHAPTER III

RESULTS

Dependent Variable Distributions

Prior to the main analyses of interest, descriptive statistics and box plots for all dependent variables were examined to identify possible outliers or miscodings and to determine whether variables met the assumptions for parametric analysis. In several cases, dependent variables were severely skewed (skewness > 1 or < -1). For these variables, a variety of transformations were performed to normalize the distributions and then these transformations were subjected to parametric analysis. Transformations are specified in the tables in which these variables appear. Descriptive statistics for the non-transformed scores appear in the text for ease of interpretation. In the case of three dependent variables—relative accuracy calculations for the three memory tasks—transformations did not result in normalized data. In these cases, nonparametric Wilcoxon-Mann-Whitney *U* tests were performed, which do not assume normality.

Group Characteristics

As expected given the inclusion criteria for the study, dimensional measures of AD/HD symptoms indicated substantial between-group differences (Table 2). This was the case for self-reported childhood and adult symptoms (*AD/HD-RS*) and *t*-scores from a normed scale (*CAARS*). *DSM-IV* inattentive scores for the comparison group fell at about the 23^{rd} percentile compared to the 99.9^{th} percentile for the group with AD/HD. *DSM-IV* hyperactive-impulsive symptoms for the comparison group fell at about the 12th percentile while these symptoms for the group with AD/HD fell at the 96.8th percentile. Self-reported impairment related to AD/HD symptoms on the functioning scale was also more severe for the group with AD/HD (M = 17.29, SD = 4.81) than the comparison group (M = 2.41, SD = 2.66).

Across groups, participants were comparable on several important dimensions relevant to memory task performance. In Table 3, significant differences did not emerge on the *WAIS-III* Estimated Full-Scale IQ, $t(67) = 0.36$, $p = .72$, or on either the Verbal or Non-Verbal subtests. Overall, participants had mean Estimated Full Scale IQs in the upper reaches of the average range to the above average range and the ranges of scores were quite similar across groups. Thus, this sample of adults appears to be higher functioning intellectually than samples of longitudinally-followed adults with childhood AD/HD but is more similar to samples referred to clinics in adulthood (Barkley et al., 2008). Groups also did not significantly differ in a variety of recent lifestyle factors that may affect performance on cognitive tasks prior to their experimental sessions. Many of these variables were highly skewed, could not be transformed, and so non-parametric Wilcoxon-Mann-Whitney U Tests were used to test between-group differences on continuous measures. Groups did not differ on hours of sleep the previous night, hours of wakefulness before the session, cigarettes smoked the morning of testing and in the prior 24 hours, alcoholic beverages consumed in the prior 24 hours, number of caffeinated beverages consumed prior to the session, whether they had used illegal drugs (only drug reported was marijuana) in the prior 24 hours, week, or two weeks and whether they had used over-the-counter drugs in the prior 24 hours or taken any prescribed medication that morning or in the past 24 hours.

In line with prior research, adults with AD/HD in the current study reported higher levels of other psychiatric symptoms other than AD/HD than their non-affected peers (Biederman et al., 2006; Biederman et al., 2004; Biederman et al., 1993; Miller, Nigg, & Faraone, 2007; Murphy, Barkley, & Bush, 2002; Wilens, 2004). Adults with AD/HD in the current study also self-reported higher rates of current and past psychiatric diagnoses. Significantly more adults with AD/HD reported past diagnoses of depression (11 AD/HD vs. 1 control; X^2 (1, N = 68) = 10.12; p = .001), anxiety disorders (8 vs. 1; X^2 (1, N = 68) = 6.28; p = .01), and reading disorder (6 vs. 0; X^2 (1, N = 68) = 6.58; p = .01). Differences in reported diagnoses of bipolar disorder (1 vs. 0) mathematics disorder (0 vs. 1) and eating disorder (0 vs. 1) did not differ significantly between groups. More adults with AD/HD also reported current diagnoses of depression (12 AD/HD vs. 1 control; X^2 (1, N = 68) = 11.51; p = .001) and anxiety disorders (9 vs. 2; X^2 (1, N = 68) = 5.31; p = .02). Differences in reported rates of current bipolar disorder (2 vs. 0) and fibromyalgia (1 vs. 0) did not differ significantly between groups. It should be noted that over half of the group with AD/HD (18 participants, 52.9%) did not self-report any current or past psychiatric diagnoses other than AD/HD.

Consistent with the above categorical results, adults with AD/HD also reported more psychiatric symptoms using dimensional measures. In Table 3, the group with AD/HD reported significantly greater severity of depressive symptoms on the *BDI-II,* $t(67) = 5.10$, $p < .001$ (Non-AD/HD: $M = 4.26$, $SD = 4.85$; AD/HD: $M = 12.47$, $SD =$

9.47). The group with AD/HD also reported significantly greater severity of anxiety symptoms on the *BAI,* $t(67) = 5.32$, $p < .001$ (Non-AD/HD: $M = 4.26$, $SD = 6.85$; AD/HD: $M = 12.94$, $SD = 9.36$). Mean scores for both depression and anxiety symptoms in the group with AD/HD fell in the mild range, while scores for the comparison group fell in the normal range. Also in Table 3, *SCL-90-R General Symptom Inde*x t-scores for the group with AD/HD were significantly higher for the group with AD/HD, falling at approximately the 94th percentile while scores for the comparison group fell at about the 39th percentile, $t(67) = 8.10$, $p < .001$. Because comorbid psychopathology could reasonably be related to AD/HD in a meaningful way (e.g., AD/HD as a stressor contributing to failure and thus to depressive symptoms), comorbid symptoms were not considered as a covariate in the between-group analyses (Miller & Chapman, 2001). For a further discussion of this issue, see the Limitations section of the Discussion.

Rate of current treatment with psychotropic medications was higher for the group of adults with AD/HD, as none of the participants in the comparison group reported current prescriptions for psychotropic medications. In the group with AD/HD, 12 participants reported ongoing treatment with stimulants, 5 reported treatment with selective serotonin reuptake inhibitors (SSRIs), 7 treatment with other anti-depressants (Effexor, Welbutrin, Cymbalta), 3 reported treatment with mood stabilizers, and 2 treatment with Straterra (a long-acting selective norepinepherine reuptake inhibitor indicated for treatment of AD/HD). As noted above, participants taking stimulants for AD/HD agreed to discontinue their medication prior to experimental sessions. It should be noted that other medications, however, could not be discontinued for the purposes of the study. Fourteen participants with AD/HD reported no prescriptions for psychotropic medications (41.1%). Consistent with the above, more participants with AD/HD reported having taken prescribed medication during the week prior to the first testing session, AD/HD = 19; Control = 10; X^2 (1, N = 68) = 4.46; p = .04.

Calculations for Dependent Variables

JOL Accuracy. To index absolute JOL accuracy, difference scores were created by subtracting each participant's test recall performance from the mean of his or her item-by-item JOL. Using this score, positive values represent overestimations and negative values, underestimations. To index relative JOL accuracy, Goodman-Kruskall gamma coefficients were calculated for each participant between item-by-item JOL and recall accuracy (yes/no) at test (Nelson, 1996). This correlation compares a continuous measure (0-100 JOL) to a dichotomous outcome (correct vs. incorrect).

In a few cases in the card task, a gamma correlation could not be computed because either JOL or recall was invariant (e.g., participant got all items correct or all items incorrect). This situation occurred for eight participants in the comparison group and for five participants in the group with AD/HD. (One participant in the comparison group had invariance for both recall and JOL.) Between-group analysis *excluding* these invariant cases showed the group with AD/HD (n = 29; M = .92, SD = .13) as having significantly higher relative accuracy than the comparison group (n = 25; M = .61, SD = .67), $t(52)$ = 2.40, p = .02. However, excluding these cases completely may have put the group without AD/HD at a disadvantage, since its most accurate participants (those getting all items correct) did not produce correlations contributing to their group mean.

Therefore, to be conservative in drawing conclusions, one data point for the invariant factor for each participant displaying invariance on card task relative accuracy was changed so as to produce the higher gamma correlation. For example, if a participant got all of the items correct, the item for which he or she gave the lowest JOL was changed to incorrect. These modified values are reported and analyzed in the results section.

Invariance also occurred for gamma correlations indexing relative accuracy on the computerized tasks. However, the disparity between groups was much less than for the card task, and since significant results did not emerge on the existing data, the above conservative scoring method was not employed for these correlations. Reduced sample sizes are indicated in tables where applicable.

Monitoring Affects Control. To examine the relationship between study and control, a series of within-subjects correlations was calculated among JOL, study time, item selection, and test performance. These correlations were treated as dependent variables. Correlations of JOL with item selection and test performance with study time were Goodman-Kruskall gammas while correlations of JOL with study time were Pearson's *r*. Negative correlations of JOL or test accuracy with item selection or study time indicate more effort being directed toward more difficult or less well-learned items (those with a low JOL or those gotten incorrect at test). Because correlations cannot be calculated when one input is constant, the sample size for some of these between-group correlation comparisons is reduced. However, invariance occurred with comparable frequency across the groups. Reduced sample sizes are indicated in footnotes in tables where appropriate.

Hypothesis 1

Adults with AD/HD will show poorer metacognitive monitoring than adults without AD/HD as evidenced by poorer relative and absolute accuracy of Judgments of Learning in relation to measured recall during learning tasks.

Card Task. In Table 4, results revealed that adults with AD/HD gave significantly lower mean delayed JOL than their comparison group counterparts, $t(67) = 2.91$, $p = .01$. Neither absolute nor relative accuracy differed significantly between groups. Across groups, participants had high absolute accuracy with mean values very close to zero (perfect prediction). Relative accuracy was also high, as is often the case with delayed JOL.

Computer Tasks. Table 4 shows that, during both the self- and computer-controlled tasks, neither group gave significantly higher mean JOL. Both relative and absolute judgment accuracy did not differ between groups. Across both groups, participants were slightly more overconfident with respect to absolute accuracy during the computer tasks than during the card task. However, relative accuracy remained high on these tasks.

Hypothesis 2

Adults with AD/HD will show poorer metacognitive control than adults without AD/HD as evidenced by, 1) poorer recall, less study time, and use of fewer normatively effective strategies during an unstructured learning task, and, 2) lower correlations between Judgments of Learning and control processes (item selection, study time *allocation) in computer administered learning tasks, and, 3) lower scores on a questionnaire measure of cognitive control in daily life.*

Hypothesis 2 was tested in a variety of ways across the three memory tasks. First, data from the task itself (Task Measures) were used as indices of control, including recall accuracy and amount of study time. Second, the relationship between monitoring and control was examined using correlations between JOL or test performance and item selection or study time (Calculated Measures). Data about strategy use were collected via self-report interview and serve as another index of participant control behavior (Verbal Reports). Finally, self-testing behavior during the card task was indexed via observational data from video recordings (Observation). Results from each type of data are presented in turn for each task.

Card Task Measures. In Table 5, adults with AD/HD were impaired in their recall of word pairs compared to the comparison group on the card task by, on average, over seven words[3], $t(66) = 2.54$, $p = .01$. Adults in the comparison group remembered approximately 75% of the words while adults with AD/HD remembered about 57%. Although adults with AD/HD, on average, studied for nearly one minute less than control adults, this difference was not significant via *t*-test. Also in Table 5, the rate of learning (words per minute of study) by adults with AD/HD ($M = 2.19$; $SD = 1.58$) was not significantly lower than those without AD/HD ($M = 2.44$, $SD = 1.09$), $t(67) = 1.44$, $p = .16$.

Card Task Verbal Reports. In Table 5, adults with AD/HD rated the task as more difficult than did adults in the comparison group, although this difference only reached marginal significance, $t(67) = 1.80$, $p = .08$. No significant differences were found in self-reported effort on the task between groups, nor in the total number of strategies spontaneously reported by the groups during the interview. Likewise, no significant between-group differences were obtained for any individual strategy coded during the interview using chi-square analyses. Results for two strategies, however, approached statistical significance and deserve mention. A "sort by categories" strategy was reported by a small number of participants; one in the comparison group and five in the group with AD/HD, $X^2(1, N = 68) = 2.96$, $p = .09$. Fewer participants with AD/HD (62%) than controls (79%) spontaneously reported trying to associate the words within a pair, $X^2(1, N = 68) = 2.56$, $p = .11$. Although no differences in *spontaneous* reports of self-testing were obtained, when asked about the extent to which they used a self-testing strategy using a continuous scale, adults with AD/HD reported significantly less *frequent/consistent* use of this strategy (as rated on a Likert scale) compared to non-AD/HD adults, $t(67) = 2.71$, $p = .01$ (see Table 5).

Card Task Observation. Chi-square analyses revealed that significantly fewer participants in the group with AD/HD were observed to use a self-testing strategy that mimicked the later test[4]. While 82% of the comparison group used this strategy, only 52% of the group with AD/HD did so, $X^2(1, N = 67) = 7.22$, $p = .01$. Using a two-way ANOVA[5], the interaction effect of diagnostic group and self-testing was not significant, indicating that self-testing was similarly associated with performance across both groups, $F(1, 62) = 0.69$, $p = .41$. The analysis yielded a significant main effect for self-testing, such that participants observed to self-test ($M = 30.47$, $SD = 11.01$) remembered more words than those who did not ($M = 18.18$, $SD = 11.19$), $F(1, 62) = 13.04$, $p = .001$.

Computer-Administered Task Measures. As shown in Table 6 and illustrated in Figure 3, the number of items recalled on any of the three recall trials in the computer-controlled task by adults with AD/HD was not significantly different (note that data are for the initial sample only). For example, on the final recall trial of the computer-controlled task, participants with AD/HD recalled 25 words while comparison participants recalled approximately 29 words, $t(51) = 1.30$, $p = .20$. Also in Table 6, the number of items recalled during the self-controlled task by adults with AD/HD was not significantly different compared to controls (includes data from the entire sample), $t(67) = 1.68$, $p = .10$. No significant between-group differences were found in the amount of time participants spent studying each word for either the first (non-AD/HD: $M = 7.02$, $SD = 4.00$; AD/HD: $M = 6.99$, $SD = 4.99$), $t(67) = 0.32$, $p = .75$, or second opportunity for re-study (non-AD/HD: $M = 2.91$, $SD = 3.46$; AD/HD: $M = 3.13$, $SD = 2.59$), $t(67) = 0.16$, $p = .87$. Participants spent an average of approximately 10 seconds re-studying each word during the two re-study opportunities combined—comparable to the 10 seconds of re-study automatically allotted in the computer-controlled condition.

Computer-Administered Task Calculated Measures. Comparisons of correlations among monitoring and control measures were used to investigate whether adults with AD/HD showed a weaker monitoring-affects-control relationship. Table 6 shows that during the computer-controlled task (initial sample), groups showed correlations between JOL and selection that were comparable in magnitude (Non-AD/HD: -.44; AD/HD: -.37), *t*(49) = 0.74, *p* = .47. Correlations for both groups were negative, indicating that lower JOL items were more likely to be chosen for restudy. In the self-controlled task, which included the full sample of participants, this relationship approached significance with the group with AD/HD showing a negative correlation smaller in magnitude than the comparison group (-.67 vs. -.36), *t*(63) = 2.05, *p* = .05.

In the self-controlled task, study time measures were also available as indices of metacognitive control and were used in monitoring-affects-control analyses. In Table 6, there were no significant differences in the magnitude of correlations between JOL and study time for both the first, *t*(57) = 0.72, *p* = .48, and second re-study periods, *t*(57) = 0.81, *p* = .42. Both groups showed negative correlations between JOL and study time, indicating that items with lower JOL were more likely to be studied longer. Negative correlations between test performance and study time at the next re-study opportunity for both the first (Non-AD/HD: -.76; AD/HD: -.70), *t*(40) = 0.22, *p* = .83 and second (Non-AD/HD: -.80; AD/HD: -.68) study periods, *t*(53) = 1.15, *p* = .26, indicated that participants studied items had gotten incorrect on the test for a longer period of time.

Computer-Administered Task Verbal Reports. Adults with AD/HD did not rate the computer-administered tasks as significantly more difficult (*M* = 3.84, *SD* = 0.99) than the comparison group (*M* = 3.44, *SD* = 1.08), *t*(65) = 1.58, *p* = .12[6]. Similarly, they did not report putting significantly more effort into the task (AD/HD: *M* = 4.38, *SD* = .79; Control: *M* = 4.03, *SD* = 0.72) *t*(65) = 1.86, *p* = .07. Similar to the card task, no significant between-group differences emerged with respect to the total number of strategies spontaneously reported (AD/HD: *M* = 2.09, *SD* = 1.08; Control: *M* = 2.09, *SD*

= 0.83) $t(65) = .00$, $p = 1$. However, significantly fewer adults in the group with AD/HD reported trying to find an association between words in the pair (58%) compared to the comparison group (85%) $X^2(1, N = 67) = 6.33$, $p = .01$. No differences in other strategies spontaneously reported were obtained. Self-testing occurred very rarely and did not differ across groups.

Participants reported on how they had selected items to study again during both versions of the computer-administered task. In both groups, most participants reported choosing the more difficult or less well-learned items (AD/HD: 56%, Control: 71%). Fewer participants chose to study the easier items or the items they had learned well (AD/HD: 21%, Control: 18%). Even fewer used a mixture of these two strategies, some switching strategies between versions of the task (AD/HD: 6%, Control: 9%). Finally, a few participants reported having no strategy for selection or choosing items randomly—5 participants in the group with AD/HD and 1 participant in the comparison group (AD/HD: 15%, Control 3%). An overall test of the distribution of these strategies across groups, however, did not indicate a significant difference, $X^2(3, N = 67) = 3.59$, $p = .31$. A test of how many participants in each group reported any strategy versus no strategy/random selection also did not yield a significant difference, although the significance value was marginal, $X^2(1, N = 67) = 3.06$, $p = .08$.

An Analysis of Variance revealed that the effect of strategy selected on number of words recalled during the computerized tasks was significant, $F(3,63) = .8.61$, $p = .00$. Figure 4 illustrates the effect of selection strategy on mean recall across tasks. Tukey's HSD post-hoc test confirmed significant recall differences between those participants choosing difficult items and choosing easier items ($p = .00$) or choosing randomly ($p = .02$). Does the effect of strategy selection hold for both experimental groups? Subsequent analyses confirmed that this pattern of results was similar for the group with AD/HD, $F(3,29) = 3.69$, $p = .02$, and the comparison group, $F(3,30) = 5.12$, $p = .01$.

Cognitive Failures Questionnaire. The Cognitive Failures Questionnaire was used as an index of cognitive control in everyday life. Adults with AD/HD reported significantly more cognitive errors in everyday life ($M = 139.12$, $SD = 25.73$) than their comparison group counterparts ($M = 77.65$, $SD = 23.41$), $t(67) = 10.30$, $p < .001$, with a very large effect size (Cohen's $d = 2.50$).

Hypothesis 3

The magnitude of differences in cognitive control and recall performance between adults with AD/HD and adults without AD/HD will correspond to the level of externally imposed task structure. The magnitude of between-groups effect sizes will be greatest for an unstructured learning task and least for a task where item presentation is controlled. An intermediary condition (computer presentation with free time allocation) will result in correspondingly intermediary effect sizes.

Hypothesis 3 was addressed in three ways: exploring interactions between task and group in the two computer-administered tasks, comparing group effect sizes for recall between the card task and the computer-administered tasks, and comparing group effect sizes for study time between these tasks. Figure 3 displays mean recall by group, condition, and trial for the computer-administered tasks in the *initial sample only*. A three-way Group x Time Allocation x Recall Trial mixed-factor ANOVA was conducted to examine whether group with AD/HD status was associated with incrementally poorer performance when study time was self-controlled. The three-way interaction was not significant, $F(2,40) = .41$, $p = .67$. Likewise, the planned examination of Group x Time Allocation Condition interaction was not significant, $F(1,48) = .20$, $p = .82$. The main effects for Time Allocation Condition, $F(1,50) = .12$, $p = .74$, and Group, $F(1,50) = 2.04$, $p = .16$, were not significant. Not surprisingly, the main effect for Recall Trial was significant, $F(2,100) = .287.71$, $p = .00$.

Between-group effect sizes for both recall and study time were larger in the unstructured card task than in the more structured computer-administered tasks. For total recall, the Cohen's *d* effect size for between-group recall differences in the card task was .61 (medium) compared to .36 in the computer-controlled and .41 self-controlled conditions (both small). Similarly, Cohen's *d* for between-group differences in study time in the card task was .27 (small) compared to only .03 in the self-controlled task.

Exploratory Analyses

For a subset of participants, data from working memory span tasks and the Conners' Continuous Performance Task – Second Edition (CPT-II) were collected to explore the possible contributions of these cognitive measures in the prediction of AD/HD inattentive and hyperactive/impulsive symptoms. For the operation span version of the working memory task, adults with AD/HD ($M = 53.54$, $SD = 16.78$) did not obtain significantly lower total memory scores than the comparison group ($M = 60.64$, $SD = 12.99$), $t(47) = 1.66$, $p = .10$. This was also the case for reading span total memory scores (AD/HD: $M = 53.56$, $SD = 15.37$; Control: $M = 59.04$, $SD = 13.82$), $t(48) = 1.33$, $p = 19$.

The group with AD/HD did make more reading errors on the reading span task (i.e., incorrectly identifying whether sentences they read made sense) compared to the comparison group (AD/HD: $M = 4.46$, $SD = 5.23$; Control: $M = 1.81$, $SD = 2.04$), $t(48) = 2.18$, $p = .04$). No significant between-group differences in arithmetic errors or "timed-out" speed errors were obtained.

Analysis of data from the CPT-II required creating a reduced matched sample because task data from several subjects in the group with AD/HD were lost due to computer error. The reduced matched sample included 17 comparison participants and 18 participants with AD/HD. These groups did not differ with respect to age, gender, or education. The group with AD/HD made significantly more commission errors ($M = 14.11$, $SD = 6.67$) than the comparison group ($M = 9.41$, $SD = 5.98$), $t\ (33) = 2.19$, $p = .04$. No significant differences were found between groups on number of omission errors, reaction time, and number of perseveration errors.

Planned exploratory analyses were conducted in the reduced matched sample to compare the predictive power of working memory measures (operation span and reading span total memory scores) and CPT-II measures (omission and commission errors). All four variables were entered simultaneously into a series of four multiple regression equations predicting inattentive symptoms (*AD/HD-RS* Total Inattentive Symptoms, *C-DISC-IV* Total Inattentive Symptoms) and hyperactive-impulsive symptoms. Table 7 contains the bivariate correlations among these variables. As a group, the variables did not significantly predict *AD/HD-RS* Total Inattentive Symptoms, *AD/HD-RS* Total Hyperactive-Impulsive Symptoms, or *C-DISC-IV* Total Hyperactive-Impulsive

Symptoms. In Table 8, prediction of inattentive symptoms on the *C-DISC-IV*, $F = 3.02$, $p = .03$ reached significance, with the span and CPT measures accounting for 29.4% of the variance in *C-DISC-IV* inattentive symptoms ($R = .54$). Among the individual predictors, only commission errors on the CPT reached significance ($t = 2.20$, p = .04). Notably, prediction by reading working memory span scores approached significance ($t = -1.66$, p = .11) and the effect was in the hypothesized direction.

CHAPTER IV

DISCUSSION

Adults with AD/HD experience chronic impairment in educational activities (Barkley, et al., 2006; Barkley et al., 2008; Biederman et al., 1993; Biederman et al., 2004; Biederman et al, 2006; Frazier et al., 2007; Murphy et al., 2002; Reaser et al., 2007; Roy-Byrne et al., 1997; Schwanz et al., 2007; Weiss & Hechtman, 1993). Few studies, however, have gone beyond documenting impairment to explore what specific processes contribute to these difficulties and may be amenable to intervention. Some studies suggest that adults with AD/HD have more difficulties in learning tasks that require more effortful processing (Roth et al., 2004; Seidman et al., 1998; Young et al., 2006), but these investigations have not been organized around a common theoretical framework and their applicability to "real world" learning situations is questionable. To begin to form these connections between basic research and intervention, the metacognitive model of self-regulated study (Nelson & Narens, 1990) was used to review the existing literature and to design a series of tasks to empirically investigate the self-regulated study behavior of adults with AD/HD. This model was specifically designed to study and explain the behavior of an adult student studying for an exam and differentiates conceptual targets for intervention—monitoring and control.

The first hypothesis addressed by this study stated that adults with AD/HD would show metacognitive monitoring deficits compared to adults without the disorder. This hypothesis was not supported. Across two types of tasks, adults with AD/HD were just as accurate as those without the disorder at predicting their overall recall proportion (absolute accuracy) as well as which items they would better remember (relative accuracy). The results replicate the findings of Knouse et al. (2006) who failed to find metamemory monitoring deficits in adults with AD/HD for absolute and relative accuracy when JOL were made at a delay. On the card task, this accurate monitoring was found in the presence of performance deficits on the task itself, leading to dissociation of task performance and judgment accuracy concerning that performance. Interestingly, this outcome is very similar to findings in other populations with impairments on memory tasks including patients with traumatic brain injury and the elderly (Dunlosky & Connor, 1997; Kennedy & Yorkston, 2000;). Despite performing more poorly on the task, when prompted, participants can still accurately assess their memory for items. This may be because monitoring depends on basic memory processes such as cue familiarity, retrieval fluency, and subjective ease of processing (Hertzog, Dunlosky, Robinson & Kidder, 2003) that remain intact when other aspects of memory are affected. Thus, results do not support a deficiency in metamemory monitoring in the current study.

The second hypothesis stated that adults with AD/HD would show poorer metacognitive control *and* a weaker relationship between monitoring and control during learning tasks. This was assessed with a range of dependent measures including study time, item selection, verbal reports of strategies and observation. On the card task, participants with AD/HD recalled significantly fewer words. What control processes contributed to this outcome? Adults with AD/HD did not spend less time studying and the efficiency of their study was not significantly different from controls. However, it may be that combining these effects—slightly less study time and slightly less efficient study—influenced between group differences in recall. These measures index somewhat different aspects of metacognitive control—the effectiveness of study and amount of study. Most strikingly, adults with AD/HD were less likely to use a very effective strategy for the task—self-testing—by self-report and observation. More adults in the group with AD/HD used categorization, which is not a normatively effective strategy for the paired-associates task because categorizing words *across* pairs does not aid in associating *between* the words in a pair. On the computer task where items were presented relatively quickly, adults with AD/HD reported less often trying to associate words in the pair—an important strategy for this cued-recall task.

Thus, findings from verbal reports and observation replicated prior findings in both the adult and child AD/HD literatures showing less use of effortful, normatively effective strategies during learning tasks (Holdnack et al., 1995; O'Neill & Douglas, 1991; Seidman et al., 1998). Adults with AD/HD reported less frequent, consistent use of a self-testing strategy during the card task and fewer adults with AD/HD were observed to use this strategy. Analysis revealed that self-testing was an effective strategy for both adults with and adults without AD/HD. These results are similar to those found in the study on which the card task was based. Murphy, Schmitt, Caruso, and Sanders (1987) found that older adults were less likely to self-test during a difficult memory task and their performance improved upon explicit self-testing instructions. Self-testing is an especially important study strategy because memory research demonstrates better learning when the mode of study matches the mode of the later test. In addition, self-testing produces information that can be monitored in the services of additional strategic behavior. Finally, a few members of the group with AD/HD had no strategy whatsoever when selecting items for restudy during computerized tasks. As a group, adults with AD/HD chose and executed less effective strategies and remembered fewer items.

In contrast to findings for control processes, little evidence of a weaker relationship *between* monitoring and control emerged as evidenced by no significant differences in the magnitude of correlations between JOL or test performance and control behaviors of item selection and study time allocation on the computerized tasks. Negative correlations for both groups indicated that they chose to re-study items they judged to be less well-learned and studied less-well-learned items for longer. Participants also monitored their test performance and used this information to control study time during the next study opportunity, studying items they got incorrect at test for longer. One result—the correlation between JOL and items selection on the self-controlled computerized task—was marginally significant, although this appeared to be due to a minority of participants in the group with AD/HD who reported using no strategy to select items whatsoever. This corresponds to other deficits in strategic behavior observed during the learning tasks.

The third hypothesis for this study stated that the relative between-group differences in performance would track the level of task structure across the three tasks administered. This hypothesis addresses the question of whether adults with AD/HD have incrementally more difficulty in unstructured learning situations that a) are more ecologically valid, and, b) place increased demands on executive functioning. The strongest version of this hypothesis—differences across all three tasks—was not supported. No differences were detected between the two computer-administered task versions in the initial sample, despite the fact that one allowed for unlimited re-study time and the other restricted each item to five seconds of restudy. This occurred regardless of group status, indicating that the tasks are of comparable difficulty. Study time data showed that participants in both groups ended up re-studying items at about 10 seconds on average—the same amount of time that was provided in the timed task. Thus, these tasks may not have been functionally different enough in their demands to produce effects with respect to level of structure.

A less strong version of this hypothesis, however, was supported by the data comparing the computer-administered tasks to the card task. Adults with AD/HD did *relatively more poorly* than their non-AD/HD peers on the unstructured card task, where between-group differences reached statistical significance and a medium effect size. Similarly, a small effect size on study time between groups was obtained for the card task in contrast to an essentially equivalent amount of study time between groups for the computer-administered task with unlimited re-study time. Thus, the spread between the performance of adults with and without AD/HD was wider when the task involved less structure, with incrementally poorer performance and less study time for the group with AD/HD. These findings fall in line with prior studies, where children and adolescents with AD/HD are less efficient in organizing their behavior to complete a variety of tasks under time constraints (Clark et al., 2000; Siklos & Kerns, 2004). This finding supports the broad prediction that AD/HD should produce more impairment when executive functioning is required by the task and when performance is less supported by the immediate environment (Barkley, 1997).

In this experimental context, however, the findings pertaining to Hypothesis 3 could be viewed in another way. Aside from highly structured vs. highly unstructured, the two tasks differed in the point at which participants were cued to make monitoring judgments. In the card task, participants made these judgments just before recall when there was no opportunity to use them to change their study behavior. In the computer-administered task, however, judgments were made after the first study trial but *before* item selection and two re-study opportunities. An intriguing way to view the results, then, is that being forced to make monitoring judgments prior to restudy incrementally improved the metacognitive control and thus the memory performance of the group with AD/HD. Indeed, correlations between judgments and control measures of item selection and study time largely did not differ between groups, showing that both groups often made comparably efficient use of their judgments during learning. Further, the computerized tasks incorporated multiple tests and adults with AD/HD also may have monitored the outcomes of these tests and used this as data to control their study. It is possible, then, that the computer administered task essentially represents a memory intervention for the group with AD/HD and this adds credibility to the notion that cued memory monitoring and self-testing might be profitable interventions to improve the study of adults with AD/HD.

Finally, exploratory analysis regarding working memory span tasks and measures of vigilance and impulsivity were conducted. These preliminary analyses suggest that behavioral inhibition, as indexed by CPT-II commission errors, deserves further consideration in models predicting AD/HD symptoms in adults. Although working memory span measures did not significantly predict AD/HD symptoms, investigations in larger samples will be necessary as between-group differences on these measures were in the hypothesized direction.

In review, while no support was found for metamemory monitoring deficits on the tasks, between-group differences in strategy selection and implementation support metacognitive control deficits in the disorder. These findings fit nicely with conclusions drawn from prior literature. Additionally, task structure appears to be differentially associated with improved memory performance for adults with AD/HD compared to their non-affected peers.

Participants appeared to be aware of their performance deficits during the learning tasks. No differences in absolute or relative JOL accuracy were found on any task in the current study, replicating findings from Knouse et al. (2006) and participants were aware of their less frequent use of self-testing, a highly effective strategy in this learning context. Participants with AD/HD may also have been less likely to spontaneously report associating and instead to used an inefficient categorization strategy that did not match the later test. Importantly, self-testing was associated with better memory performance in both groups, suggesting it may be an effective intervention strategy. On the computerized tasks, which did not show significant recall differences, they were less likely to report trying to associate the words—a very efficient strategy.

There was little evidence for weaker monitoring-affects-control relationships with respect to control of study time, but the group with AD/HD had a marginally lower correlation between JOL and selection. This is most likely due to a minority of participants in the group with AD/HD who reported no selection strategy whatsoever. Adults with AD/HD had more difficulties on the card task compared to the computerized tasks (relative to the comparison group) and the largest effect size differences occurred on the measures of cognitive failures in daily life. The structured nature of the computerized tasks, including the incorporation of monitoring judgments and other cues to strategic behavior, may have aided the memory performance of adults with AD/HD. This broadly supports the idea that as task structure relevant to executive functioning increases, the observed deficits for the group with AD/HD decrease.

These results provide new information about the learning deficits exhibited by adults with AD/HD in a learning context and provide clues toward specific targets for academic intervention. If cued, adults with AD/HD can make accurate memory monitoring judgments that serve as input to control behavior and specific, normatively effective strategies were identified as possible intervention targets. These findings were made possible via the novel study design, including multiple methods and measurements used to tap metamemory monitoring, control, and the relationship between them. This is one of the few studies to incorporate the verbal reports of adults with AD/HD during a cognitive task as well as their observed strategy behavior. The tasks were designed with sensitivity to the context being investigated—verbal learning for a later test—while balancing the need for experimental control of outside factors. Participants were fairly representative of adults presenting in a real-world clinical and academic setting and participants expressed a high degree of satisfaction with their involvement in the research. Finally and perhaps most importantly, the research was conceived and carried out with both basic and applied goals in mind. Specific parts of a theory were tested and the results yielded possible targets for academic intervention.

Theoretical Implications

Monitoring and Self-Awareness. The current study has theoretical implications for the application of a metacognitive model to learning in adults with AD/HD. First, AD/HD-related deficits in metacognitive monitoring were not supported using this research design and replicating a prior study. The current study adds some evidence that adults with AD/HD can use monitoring judgments to increase their study efficiency in a structured context. However, it is unknown to what extent adults with AD/HD *spontaneously* monitor in a learning situation compared to their non-affected counterparts. This question might be difficult to answer experimentally, since debate is ongoing as to how these processes play out in normal populations and to what extent uncued monitoring is conscious (Cary & Reder, 2002). However, self-testing could be characterized as a control strategy that *generates* data for participants to monitor, and so adults with AD/HD may be less likely to have access to this type of data in a learning situation. Importantly, the *accuracy* and *effective use* of monitoring judgments appeared to be intact in the structured context in the current study.

These results also have implications for developmental models of AD/HD. Failure to find deficits in monitoring, a form of self-awareness, fits with findings about self-awareness in adult AD/HD in other domains. As discussed in the introduction to this dissertation, several researchers have published on the “positive illusory bias” in children with AD/HD using measures of absolute accuracy in broad domains. However, in adulthood, some recent evidence suggests that self-awareness may become more lucid as people with AD/HD enter adulthood—about the same time that rates of internalizing disorders begin to increase. Barkley and colleagues (2008) found that while self-reported AD/HD symptoms declined although late adolescence, the rate of self-reported symptoms jumped again during the young adult follow-up. Other-rated symptoms, however, remained more consistent. It is as if people with AD/HD, entering adulthood with its multiple demands, begin to realize the severity of their symptoms and impairment more fully.

Golden et al. (2006) found, using methods similar to the child positive illusory studies, that adults with high AD/HD symptoms actually *underestimated* their objectively measured academic abilities. The authors speculate that by adulthood, chronic negative feedback may lead to more awareness of deficits and, in some cases, negative biases about the self. Combined with a lack of deficits in metacognitive monitoring, the few studies that can address the question suggest that self-awareness may not be as impaired in adult AD/HD as in childhood. However, awareness of behavior may exist even when one cannot adequately control that behavior. If this dissociation is experienced by adults with AD/HD, it may contribute to the development of internalizing disorders and selfhandicapping beliefs. In future, it may be possible to incorporate awareness of deficit into a model of the development of internalizing symptoms subsequent to AD/HD onset.

Control Processes and Strategies. Similar to the reviewed literature, a greater weight of evidence was found for deficits in control processes in adult AD/HD. Adults with AD/HD were less likely to engage in effortful, normatively effective strategies. However, these data cannot provide a more fine-grained analysis of the factors leading to this outcome. This is important because, unlike monitoring, which relies on basic memory processes, formation and execution of a control plan involves multiple stages. The point of supposed breakdown in the chain of events is difficult to disentangle empirically. As Burgess (1997) aptly notes, "…the process underlying planning, and those that enable a person to effect a self-generated plan are theoretically separable, [but] they will not be empirically: one cannot fail to succeed in carrying out a plan one has not made." For example, control processes could be affected by whether or not one has learned particular skills prior to the learning situation, beliefs about the relative effectiveness of skills, working memory capacity to hold a complex action plan in mind, motivation to use an effective but effortful skill, and self-efficacy related to the task at hand.

With respect to cognitive capacity, Dunlosky and Kane (2006) provide evidence for the *"strategy-as-effect"* hypothesis, which suggests that greater working memory capacity allows for the production of strategies in tasks that are cognitively demanding. Thus, it is even premature to suggest that the use of strategies alone in the current study can adequately account for between-group differences in recall, since both could result from some third factor associated with AD/HD such as working memory capacity. Differences in this capacity or any of the other aforementioned factors could produce differences in observed control behavior.

Although such a fine-grained analysis is beyond the scope of the data, some explanations may be more plausible than others and should be explored in future research. First, study time and self-reported effort did not differ significantly between experimental groups, which may argue against a purely motivational explanation of the results. Anecdotally, the majority of participants seemed very motivated to do well on the tasks. Second, overall number of strategies used across tasks did not differ between groups, suggesting that knowledge of skills prior to the task may not have produced differences. Although a comparable number of participants in each group *spontaneously* reported self-testing in the interview, the comparison group more frequently and consistently used a testing method that was similar to the later criterion test. This may indicate that the group with AD/HD either had a less systematic plan in mind or was unable to carry it out in a systematic manner as might be predicted by theories of AD/HD as executive dysfunction. Finally, again using anecdotal evidence, several participants in the group with AD/HD spontaneously expressed negative beliefs about their ability to do well on the task or reported approaching the task with anxiety. These observations suggest that future research should specifically investigate deficits in generating and executing a more elaborate plan and the effects of memory self-efficacy on performance (Berry, 1999). It is not difficult to imagine that multiple prior difficulties with learning tasks might produce negative beliefs about one's own memory, but it is less clear whether these beliefs would impact control processes.

Executive Function and Task Structure. Examining the results from a broader scope, the data generally support the self-regulation deficit or executive dysfunction hypothesis of AD/HD (Douglas, 1998; Barkley, 1997), although they do not support *global* deficits in these areas. A less structured context increased the effect size of AD/HD-related memory deficits, supporting the idea that people with AD/HD perform better when feedback is immediate and frequent. Although explicit task feedback was not given during the computer-administered tasks, multiple test and study trials were opportunities for participants to obtain feedback about the state of their learning. The self-generation of an elaborate study plan was not required, likely decreasing the demands placed on participants' planning abilities and working memory capacity. Finally, as mentioned previously, the JOL monitoring trials may have further prompted adults with AD/HD to engage metacognitive control.

On the whole, the results fall in line with the often-observed pattern in this population that a large proportion of group members perform within normal limits on simpler, more structured tests of executive function while still showing impairment in daily life functioning (Anastopoulos & Shelton, 2001). Participants with AD/HD showed a much larger effect size compared to controls in their report of cognitive failures in daily life (CFQ) than on any of the laboratory tasks. The results of this study point to level of task structure vs. the need for self-generated structure as an important variable in this phenomenon. Although tasks used in experimental and clinical assessment contexts must adequately control confounding variables, too much structure may wash out behavioral variance of interest in this population. Thus, more ecologically valid tasks such as the "multiple errands shopping task" developed by Alderman, Knight and Burgess (2003) might be of use as assessment or research tools for adults with AD/HD. Similarly, academic assessments more closely related to unstructured learning situations—such as the card task in the current study—might be more sensitive and potentially useful measures of academic impairment in AD/HD.

Heterogeneity. Finally, the within-group variability in task performance and control strategies within the group with AD/HD supports theories like those of Nigg & Casey (2005) and Castellanos et al. (2006) emphasizing multiple pathways to AD/HD. Presumably, this etiological multiplicity would produce different levels and sources of academic impairment. Research and assessment techniques must be increasingly sensitive to the heterogeneity inherent in this disorder as currently defined by *DSM-IV*.

Clinical Implications

Results from the current study may inform the assessment and treatment of adults with AD/HD and academic impairments. As mentioned above, the heterogeneity of performance and presentation in the group with AD/HD is a critical factor in these considerations. At the individual level, there was a high degree of variability in strategy selection and execution within the group with AD/HD *and* a wide range of task performance from perfect recall to only remembering a few items. While it can be stated that, as a group, adults with AD/HD would benefit from instruction and guidance in the use of normatively effective memory strategies, this may not represent optimal intervention for an individual student—thus, individualized assessment of strengths and weaknesses is critical. Recommending a standard, inflexible "treatment package" for adults with AD/HD would be an inefficient way of providing services. One individual meeting criteria for this disorder and presenting with academic difficulties may vary widely in his or her symptom profile and in the loci of school-related problems. For example, one student may primarily experience problems with inattentive symptoms accompanied by skills deficits, negative beliefs from past learning experiences, and internalizing symptoms. For another student, problems may primarily stem from poor medication adherence, minimal time spent studying, and problems with alcohol use. Obviously, treatment plans for the students would look very different.

Assessment. One prerequisite to an individualized intervention is an assessment that gathers the data relevant to designing that intervention. Even a thorough assessment documenting AD/HD according to all *DSM-IV* criteria may need to be augmented with tools targeting the factors contributing to a particular student's academic impairments. A skilled clinician with experience with this population or with experiences specific to the academic setting may be able to gather this information during an unstructured interview. Input from teachers, parents, and school records may augment this information. However, instruments, such as the self-report, normed Learning and Study Strategies Inventory – Second Edition (LASSI; Weinstein & Palmer, 2002) used by Reaser et al. (2007) would help to pinpoint specific areas of need for particular students from strategy use to attitudes and beliefs. Semi-structured interviews targeting strategies, beliefs, motivation, and patterns of study behavior could also be useful. While intelligence and academic achievement testing are important assessments to determine a student's level of functioning relative to his or her peers, these tests often bear little resemblance to the academic tasks the student faces on a daily basis at the college level[1]. Assessment instruments with more relevant content and form might provide useful objective information. For example, an open-ended learning task such as the card task in the current study might provide useful observations of a students' planning, strategy use, and persistence on a learning task. Student self-monitoring of study times and study behavior, possibly assisted with Personal Digital Assistants, would also supply objective information while serving as a bridge to intervention.

Metacognitive Strategies. Consideration of metacognitive study strategies in the "toolbox" of techniques for adults with AD/HD and academic impairments is warranted for two reasons. First, evidence for intact monitoring suggests a basis for intervention for adults with AD/HD. In the current study, cues to monitor that were built into the computer-administered task may even have contributed to the improved performance of the group with AD/HD relative to the comparison group. Second, two 2-hour small group sessions of training using a self-monitoring plus mnemonic approach was shown to improve the associative learning of older adults by 21%, while mnemonic-only training only produced an 8% gain (Dunlosky, Kubat-Silman & Hertzog, 2003). Like adults with AD/HD, metacognitive research with older adults has shown deficits in memory task performance in the context of intact monitoring. Importantly, however, transfer of effects did not occur on a list-learning task, suggesting that learners need to be specifically trained in the application of monitoring strategies in different contexts. Future applications of metacognitive study techniques could also involve assistive technology whereby a computer algorithm uses learners' JOL or test accuracy to determine future study time or frequency of presentation.

The current study also suggests that instruction in basic strategies based on research on learning and memory might be a straightforward, low-cost way to improve learning efficiency for adults with AD/HD. Training adults to match study to test conditions, use specific normatively effective strategies (self-testing and association strategies), and engage in distributed practice are just a few possible empirically-based strategies that may be relevant.

Intervention. As suggested by clinical heterogeneity, metacognitive interventions will likely need to be one element in a suite of interventions to improve study. Instruction in developing a study plan, mnemonic techniques, self-testing, distributed practice, and matching study to test parameters should be combined with self-motivational strategies. These techniques could be incorporated into a coaching model, whereby a student with AD/HD has frequent meetings with a coach who teaches and helps apply techniques, monitors progress, and aids in motivation (Swartz et al., 2005). Unfortunately, coaching has not been systematically evaluated or its effectiveness empirically established (Goldstein, 2005). A coaching approach does bear some similarity to a recent, empirically-supported cognitive-behavioral intervention for AD/HD that trains skills, addresses motivation and medication adherence, and uses cognitive restructuring to identify and modify maladaptive beliefs (Safren et al., 2005). A similar type of skills training treatment in group format (interestingly, termed "Metacognitive Therapy"!) is also being developed (Solanto, Marks, Mitchell, Wasserstein, & Kofman, 2008). Modules specifically addressing academic impairments and including the aforementioned skills could easily be added to augment these approaches. This study suggests that metacognitive strategies are a reasonable and potentially profitable addition.

Beliefs and Expectations. Many adults with AD/HD in the current study expressed negative performance predictions before, during, and after the memory tasks in this study. Although observations of these statements were not collected in a systematic way, they appeared to be more frequent and more negative in the group with AD/HD. It is not terribly difficult to see why this would be the case. Adults with AD/HD are more likely to experience failures in the academic setting and on “tests” in general, and so past learning experiences lead to anticipation of future failure. Even before the task begins, negative emotions and self-schemas are activated that may affect effort and performance. Memory self-efficacy is a construct that embodies these factors and low memory self-efficacy has been hypothesized to underlie avoidance of challenging tasks and reliance on less efficient strategies (Berry, 1999). In older adults, lower memory self-efficacy has been shown to predict declines in memory performance over time (Valentijn, Hill & Van Hooren, 2006).

Beyond the experimental context, task-related negative automatic thoughts and beliefs may reduce the likelihood that adults with AD/HD will try to learn new strategies or will continue to use them in the absence of immediate feedback on their effectiveness. Conversely, overly *positive* expectations about task performance may also preclude adults with AD/HD from making behavior changes. In either case, cognitive restructuring (examining the evidence, determining the usefulness of a thought) or motivational techniques such as those developed by Miller and Rollnick (2002) may augment skills training. First, however, much more research is needed on the influence of inaccurate or maladaptive cognitions in AD/HD.

Academic achievement is strongly related to socio-economic status and quality of life, and academic impairments for adults with AD/HD are well-documented, chronic, and costly (Barkley et al., 2008). Systematic research programs focused on this problem in this population are rare and are hampered by divisions between specialties (e.g., clinical psychologists vs. educational psychologists vs. counselors in disability services offices). Numerous, potentially profitable approaches remain untested. Assessment tools include open-ended, ecologically valid learning tasks, specialized semi-structured interviews, self-reports focused on academic skills and beliefs (e.g., the LASSI), and technology-assisted self-monitoring. A wide array of candidate intervention strategies has been mentioned, including metacognitive approaches with or without assistive technology. Behavioral approaches such as organizational skills, reducing distractibility, improving medication adherence, scheduling devoted study time, and self-reward would increase the frequency of study. Motivational techniques would support the acquisition and continued use of effective strategies. Finally, cognitive approaches might be useful in addressing the beliefs and expectations that prevent adults with AD/HD from trying new strategies or from continuing to use these strategies in the face of delayed positive consequences. A varied, flexible toolbox of interventions for academic impairments would increase the likelihood of success for adults with this heterogeneous disorder.

Future Research

Three distinct but interrelated lines of research could be carried out to address the range of issues touched upon in this discussion.

Control Processes. A future program of research could more systematically investigate the learning and memory control processes of adults with AD/HD. Results from the current study indicate that formulation and maintenance of an effective study plan may have differentiated performance between the groups and contributed to the effect size on recall in the card task. Several approaches could be used to more fully examine these processes. First, adults could be asked to formulate a study plan without carrying it out to see whether the plans are qualitatively different prior to their execution. Second, more detailed self-report or observational measures could be collected regarding the formulation and execution of a study plan. Third, participants with AD/HD and comparison group participants matched on a standard recall task could be yoked and given the same study plan. Presuming they follow it without intruding other strategies, any differences in performance should be a result of plan execution and not formulation. Fourth, the effect of task structure could be more fully evaluated by testing a condition with structure truly intermediary to the card and computer tasks. This might enable an investigation of which aspects of structure are most important. Finally, the effect of forced monitoring could be compared to a condition with no monitoring and to a condition with cued but optional monitoring. This program of research would clarify which points in the metacognitive process are most vulnerable to the effects of AD/HD and would suggest more fine-grained targets for intervention.

Self-Awareness, Beliefs, and Internalizing Disorders. This line of future research would involve a variety of research questions and methods, but would center around the effects of living with AD/HD on aspects of the self. Some possible studies relate directly to academic and learning situations. First is a more detailed study of monitoring, beliefs, and expectations before, during, and after the learning task. Future investigations should explore the accuracy of other types of monitoring judgments including feeling-of-knowing and further investigation of the accuracy of immediate JOL. Second, standardized instruments designed to measure self-efficacy, or beliefs about one's abilities in a particular domain, could be applied to this context. Although predictions from the child literature would suggest an overly positive view, other evidence cited in the theoretical implications section suggests that self-judgments in this domain may be overly negative. Third, the predictive power of memory self-efficacy could be examined as has been done in samples of older adults (Berry, 1999).

Other studies on this topic would relate to additional domains or even global self-awareness and self-worth. Again, evidence is mixed as to whether assessments would be more or less negative than the general population, and results are very likely to be quite heterogeneous within adults with AD/HD. This variability itself could then be a subject of inquiry. What factors predict the development of overly negative or positive views of the self in AD/HD? How do these views affect behavior? Do they contribute to the development of comorbid anxiety and depression? All of these questions could be addressed in a systematic program of research aimed at developing a model of adult-onset comorbidity in AD/HD. Importantly, this research should directly suggest targets for and modes of intervention.

Academic Assessment and Intervention. As extensively discussed in the clinical implications section, several potentially fruitful assessment and intervention tools have yet to be the subject of applied research in adults with AD/HD. These will not be repeated here. However, this research must rely upon relevant findings from basic research and theories of AD/HD while ensuring that innovation and dissemination of helpful strategies proceeds as quickly as possible to those who treat this population.

Limitations

Although this study generated several implications and future research ideas, these must be tempered by limitations inherent in the study's design and execution. The sample in the current study was intellectually high-functioning compared with the entire population of adults with AD/HD. This likely affects the generalizability of the results to that population as a whole. However, the sample was also quite representative of adult students seeking treatment at our clinic and seeking academic accommodations in higher education. In addition, despite their higher IQs, they still had lower incomes than the comparison group. Anecdotally, many had been trying for several years to complete undergraduate or graduate degrees. In future studies, more information on current academic impairment should be more systematically collected to document these impairments even in the context of overall good functioning as measured by general intelligence.

Higher levels of psychiatric comorbidity in the AD/HD sample affect the interpretability of these results. From the current study's design, the possibility that these differences were associated with higher general levels of psychopathology rather than AD/HD specifically cannot be ruled out. Future studies should employ a non-AD/HD clinical comparison group to determine the specificity of these effects. Still, it should be noted that half of the sample with AD/HD did not report comorbid diagnoses. Further, excluding adults with comorbid psychopathology would likely identify a "hyper-normal" group of adults with AD/HD and limit generalizability. Recent findings on comorbidity in adult AD/HD are also relevant to this discussion. Miller et al. (2007) studied psychiatric comorbidity in a large, mixed community and clinic sample of adults with and without AD/HD. They found that AD/HD Combined Type doubled the lifetime risk for two or more externalizing disorders and conferred a 4.5-fold increase in risk for one or more internalizing disorders. In this study and others, psychiatric comorbidity is the rule rather than the exception and more severe AD/HD was associated with increased risk of comorbidity. Despite high rates of comorbidity, AD/HD symptoms continued to uniquely predict overall impairment. Safren, Sprich, Cooper-Vince, Knouse and Lerner (2008) recently reported that while depression and anxiety symptoms were significantly related to impairment in life satisfaction and relationships in a group of adults with AD/HD, only AD/HD symptoms were significantly related to impairment in work/educational activities.

Additional measures more specific to academic impairment were not included in the current study. As mentioned previously, participants in the group with AD/HD readily provided anecdotal reports of their cognitive and academic impairments. These data should be collected and analyzed more systematically in future studies using both open-ended (interview) methods and standardized measures, such as the Learning and Study Strategies Inventory – 2nd Edition (Weinstein & Palmer, 2002). Other relevant academic constructs to measure may include beliefs about study and learning, learning self-efficacy, and test anxiety.

The lack of functional differences between the two computer-administered tasks limited the ability to fully test the third hypothesis. Subsequent research could use a stronger manipulation of task structure to better test the relationship between structure and task performance for adults with AD/HD. Although the interview following the card task was recorded and coded using multiple raters, the interview following the computer task was not. Differences in the way experimenters coded responses on this interview could not be assessed. During the sessions the experimenter was not blind to participant group status because of limited personnel. Although the use of computerized systems to collect data may have minimized the impact on the memory measures, future research should use blinded experimenters. It should be noted, however, that a blinded coder was used to verify interview and observational data.

Finally, the current study did not provide sufficient data to adequately test exploratory hypotheses about behavioral inhibition and working memory in relation to adult AD/HD. Given some promising findings on a working memory span task, future research should continue to examine such tasks in adults with AD/HD. Theories of working memory as executive attention (Kane & Engle, 2002) represent an important perspective to incorporate into the broader debate on WM in AD/HD that appears to have been largely dominated by neuropsychological perspectives.

Conclusion

Bearing in mind these limitations, the findings from this study yield interesting and useful new insights. This study was one of the first to systematically examine both memory and metamemory factors for adults with AD/HD. It posed questions about both monitoring and control processes during a learning task. While adults with AD/HD monitored their performance accurately and used this information to control study, they were less likely to use effortful strategies. This study begins to bridge the gap between research reliant on self-report in real-world settings—with multiple potential causes of impairment—and pure laboratory studies in which highly structured tasks remove important sources of behavioral variation. The study yielded several possible intervention strategies to improve the self-guided learning of adults with AD/HD, including metacognitive techniques and a host of other potential tools. Ongoing translation of findings into practical clinical application is critical for increasing the number of adults with AD/HD who succeed in academic settings and develop adaptive, realistic, and healthy self-concepts. Finally, a model from outside of clinical psychology was successfully applied to adults with AD/HD, yielding unique findings and suggesting fresh approaches to theory, research, and practice.

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FOOTNOTES

[1]Studies suggest that the *DSM-IV* hyperactive-impulsive symptom list, which was developed using data from children with the disorder may contain less appropriate indicators of hyperactivity-impulsivity for adults. Murphy and Barkley (1996) found that 4 of 9 H/I symptoms represented the same degree of statistical deviance for a general population sample of adults as was represented by 6 of 9 symptoms in the *DSM-IV* field trials with children.

[2]We used symptom counts to first establish the presence of a significant number of *DSM-IV* symptoms on both dimensions in the group with AD/HD, reducing the likelihood of including participants who were purely of the Predominantly Inattentive Type. Developmental deviance of symptoms is not frequently used as an additional inclusion criterion in studies of adults with AD/HD, as this is often simply inferred from symptom counts. However, as an additional check on the severity of symptoms in both groups, we placed restrictions on symptom severity as measured continuously by this well-normed scale.

[3]Testing results were spoiled for one participant with AD/HD because she was allowed to look back at the cards after the study period but before the test. Thus, recall and words/minute data for this participant were not included in the analyses.

[4]Video recording data from one participant with AD/HD was lost and so observational data were not available for that participant.

[5]Note that sample size of the group with AD/HD is reduced from 34 to 32 in this analysis, due to aforementioned unavailability of observational data for one participant and the spoiling of card task recall data for another participant.

[6]Interview results for the computer tasks were not collected from one participant with AD/HD and thus are missing from the analyses.

APPENDIX A

TABLES

Table 1

Demographics

	Group								
	Comparison (*n*=34)			AD/HD (*n*=34)			All Participants (*n*=68)		
Measure	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
Age	26.44	6.51	18-38	27.27	6.34	18-39	26.85	6.39	18-39
Education (years)	15.53	2.21	12-20	14.76	2.18	10-18	15.15	2.21	10-20
	Comparison (*n*=34)			AD/HD (*n*=34)			All Participants (*n*=68)		
	Count	%	Cum %	Count	%	Cum %	Count	%	Cum %
Race/Ethnicity									
African Am.	8	24		4	12		12	18	
Hispanic/Latino	2	6		0	0		2	3	
White	27	79		30	88		57	84	
Native Am.	2	6		0	0		2	3	
Job Status									
Employed	21	62		19	56		40	60	
Student	12	35		13	38		25	37	
Unemployed	1	3		2	6		3	4	
Income									
0-$10,000	12	35	35	17	50	50	29	43	43
10,000-$25,000	2	6	41	10	29	79	12	18	61
25,000-	8	24	65	3	9	88	11	16	77

$35,000									
35,000-$45,000	4	12	77	1	3	91	5	7	84
45,000-$65,000	6	18	95	2	6	97	8	12	96
$65,000+	2	6	100	1	3	100	3	4	100

Table 2

AD/HD Symptoms Measures

	Group							
	Comparison			AD/HD				
Measure	*M*	*SD*	Min-Max	*M*	*SD*	Min-Max	*t*	*p*
ADHD-RS Current								
IA	3.24	2.97	0-10	18.38	4.85	9-27		
HY/IM	3.18	2.84	0-11	16.71	5.13	8-27		
ADHD-RS Age 7								
IA	4.73	3.83	0-14	21.27	5.58	9-27	14.05	.00
HY/IM	5.06	4.06	0-14	19.76	5.44	11-27	12.43	.00
ADHD-RS Age 7-12								
IA	4.33	3.65	0-13	21.39	4.87	9-27	16.09	.00
HY/IM	4.12	3.43	0-13	18.82	5.37	9-27	13.24	.00
CAARS								
DSM-IV t scores								
IA	42.40	7.79	34-62	80.16	9.10	59-96		
HY/IM	38.27	5.53	30-50	68.71	10.97	47-95		

C-DISC-IV: Diagnostic Interview Schedule for Children*; ADHD-RS*: ADHD Rating Scale: IA: Inattentive; HY/IM: Hyperactive/Impulsive; *CAARS*: Conners Adults ADHD Rating Scale.

Table 3

Group Characteristics

	Group							
	Comparison			AD/HD				
Measure	*M*	*SD*	Min-Max	*M*	*SD*	Min-Max	*t*	*p*
WAIS-III IQ								
Verbal	12.91	2.35	9-17	12.56	2.23	8-17	0.64	.53
Non-Verbal	12.85	2.60	6-16	12.82	2.68	6-18	0.05	.96
Est. Full Scale	116	13.07	91-134	115	11.63	89-137	0.36	.72
SCL-90-R GSI t-score	46.76	10.61	30-67	65.71	8.56	49-80	8.10	.00
**BDI-II*	0.57	0.37	---	1.01	0.35	---	5.10	.00
**BAI*	0.45	0.47	---	1.01	0.40	---	5.32	.00

*Original variables severely skewed. Values in table are transformations according to log (x + 1). See text for means of non-transformed variables; *WAIS-III*: Wechsler Adult Intelligence Scale-III; *SCL-90-R*: Symptom Checklist 90 Revised; *GSI*: Global Symptoms Index; *BDI-II*: Beck Depression Inventory-II; *BAI*: Beck Anxiety Inventory

Table 4

Measures of Metacognitive Monitoring

	Group							
	Comparison			AD/HD				
	M	*SD*	Min/Max	*M*	*SD*	Min/Max	*Test*	*Sig.*
Card Task								
JOL Magnitude	73.58	22.33	16-100	56.09	27.02	3.5-99.25	2.91	.01
Absolute Accuracy	-.01	0.14	-.47-.45	.00	0.16	-.53-.31	0.22	.83
*Relative Accuracy	.71	0.60	-1 – 1	.93	0.13	.49-1	485.00*	.32*
Self-Controlled								
JOL Magnitude	45.56	20.91	5.00-83.38	38.21	25.55	0-84.55	1.30	.20
Absolute Accuracy	.07	0.17	-.38-.59	.09	0.17	-.22-.46	0.42	.68
*[a]Relative Accuracy	.93	0.10	.55-1	.87	0.26	-.28-1	457.50*	.91*
Computer-Controlled								
JOL Magnitude	47.66	25.98	5-100	40.16	27.00	.00-84.88	1.02	.31
Absolute Accuracy	.04	0.19	-.37-.61	.07	0.13	-.19-.41	0.73	.47
*[b]Relative	.95	0.07	.76-1	.90	0.14	.45-1	238.50*	.42*

Accuracy			

*Variables severely skewed. Test statistics reported are Mann-Whitney *U* Statistics. All other test statistics are independent samples *t*-statistics; [a]Comparison $n = 31$, AD/HD $n = 30$; [b] Comparison $n = 24$, AD/HD $n = 23$; CFQ: Cognitive Failures Questionnaire. JOL: Judgment of Learning; Absolute Accuracy is difference score; Relative Accuracy is Goodman-Kruskall Gamma Correlation.

Table 5

Card Task: Continuous Measures of Control

	Group							
	Comparison			AD/HD				
	M	*SD*	Min/Max	*M*	*SD*	Min/Max	*t*	*p*
Total Study Time (s)	753.94	155.65	287-900	700.15	237.86	253-900	1.10	.27
Words Correct at Test	29.94	10.89	3-40	22.48	13.06	0-40	2.54	.01
*Words Learned / Min	0.52	0.14	---	0.45	0.23	---	1.44	.16
Self-Report Difficulty	3.35	0.77	2-5	3.74	0.96	2-5	1.80	.08
Self-Report Effort	4.15	0.78	3-5	4.25	0.70	3-5	0.57	.57
Number of Strategies	2.94	1.01	1-6	2.94	1.32	1-7	0.00	1.00
Self-Test	2.50	0.90	0-3	1.76	1.30	0-3	2.71	.01

* Original variable severely skewed. Value in table is transformation according to log (x + 1).

Table 6

Task and Calculated Measures for Computer-Administered Tasks

	Group							
	Comparison			AD/HD				
	M	*SD*	Min/Max	*M*	*SD*	Min/Max	*t*	*p*
Computer-Controlled								
Recall on Test 1	17.46	11.51	0-40	13.12	11.66	0-35	1.35	.18
Recall on Test 2	26.38	10.03	9-40	21.81	13.99	2-40	1.36	.18
Recall on Test 3	28.92	9.09	10-40	25.00	12.36	3-40	1.30	.20
*[a]JOL x Selection	0.77	0.28	---	0.72	0.26	---	0.74	.47
Self-Controlled								
Recall on Test 1	15.31	10.86	0-40	11.79	10.40	0-38	1.37	.18
Recall on Test 2	26.71	10.04	7-40	22.24	12.37	0-40	1.64	.11
Recall on Test 3	29.21	8.37	10-40	25.26	10.83	0-40	1.68	.10
**Time / Word RS1	3.78	0.26	---	3.75	0.29	---	0.32	.75
**Time / Word RS2	3.33	0.32	---	3.34	0.40	---	0.16	.87
*[b]JOL x Selection	0.85	0.22	---	0.72	0.27	---	2.05	.05
[c]JOL x Time RS1	-.20	0.34	-.92-.60	-.14	0.27	-.72-.43	0.72	.48

[d]JOL x Time RS2	-.05	0.26	-.77-.55	-.11	0.27	-.53-.53	0.81	.42
*[e]Test1 x Time RS1	0.85	0.18	---	0.84	0.21	---	0.22	.83
*[f]Test2 x Time RS2	0.86	0.15	---	0.81	0.19	---	1.15	.26

* Original variables severely skewed. Values in table are transformations according to 1 / (x + 2). See text for means of non-transformed variables; ** Values in table are transformations according to log (x + 1). See text for means of non-transformed variables; [a]Comparison *n* = 25, AD/HD *n* = 25; [b]Comparison *n* = 33, AD/HD *n* = 31; [c]Comparison *n* = 30, AD/HD *n* = 28; [d]Comparison *n* = 30, AD/HD *n* = 28; [e]Comparison *n* = 18, AD/HD *n* = 23; [f]Comparison *n* = 26, AD/HD *n* = 28; JOL: Judgment of Learning; RS1: first re-study; RS2: second re-study.

Table 7

Bivariate Correlations for Variables in Regression Analyses Predicting AD/HD Symptoms

	OSPAN Total	*RSPAN* Total	*CPT* Omissions	*CPT* Commissions
OSPAN	---			
RSPAN	.71**	---		
Omissions	.17	.21	---	
Commissions	.18	.13	.48**	---
ADHD-RS IA	-.21	-.29	.15	.27
ADHD-RS HY	-.17	-.13	.18	.30
C-DISC-IV IA	-.18	-.30	.22	.40*
C-DISC-IV HY	-.10	-.08	.25	.38*

$^*p < .05$, $^{**}p < .001$; *OSPAN*: operation span total working memory score; *RSPAN*: reading span total working memory score; *CPT*: Conners' Continuous Performance Test; *ADHD-RS*: ADHD Rating Scale: IA: Inattentive; HY: Hyperactive/Impulsive; *C-DISC-IV:* Diagnostic Interview Schedule for Children.

Table 8

Regression Results for Prediction of C-DISC-IV Inattentive Symptoms

	ß	*t*	*p*
OSPAN score	-.00	-0.01	.99
RSPAN score	-.37	-1.66	.11
CPT omission errors	.11	0.60	.55
CPT commission errors	.40	2.20	.04

OSPAN: operation span total working memory score; *RSPAN*: reading span total working memory score; *CPT*: Conners' Continuous Performance Test.

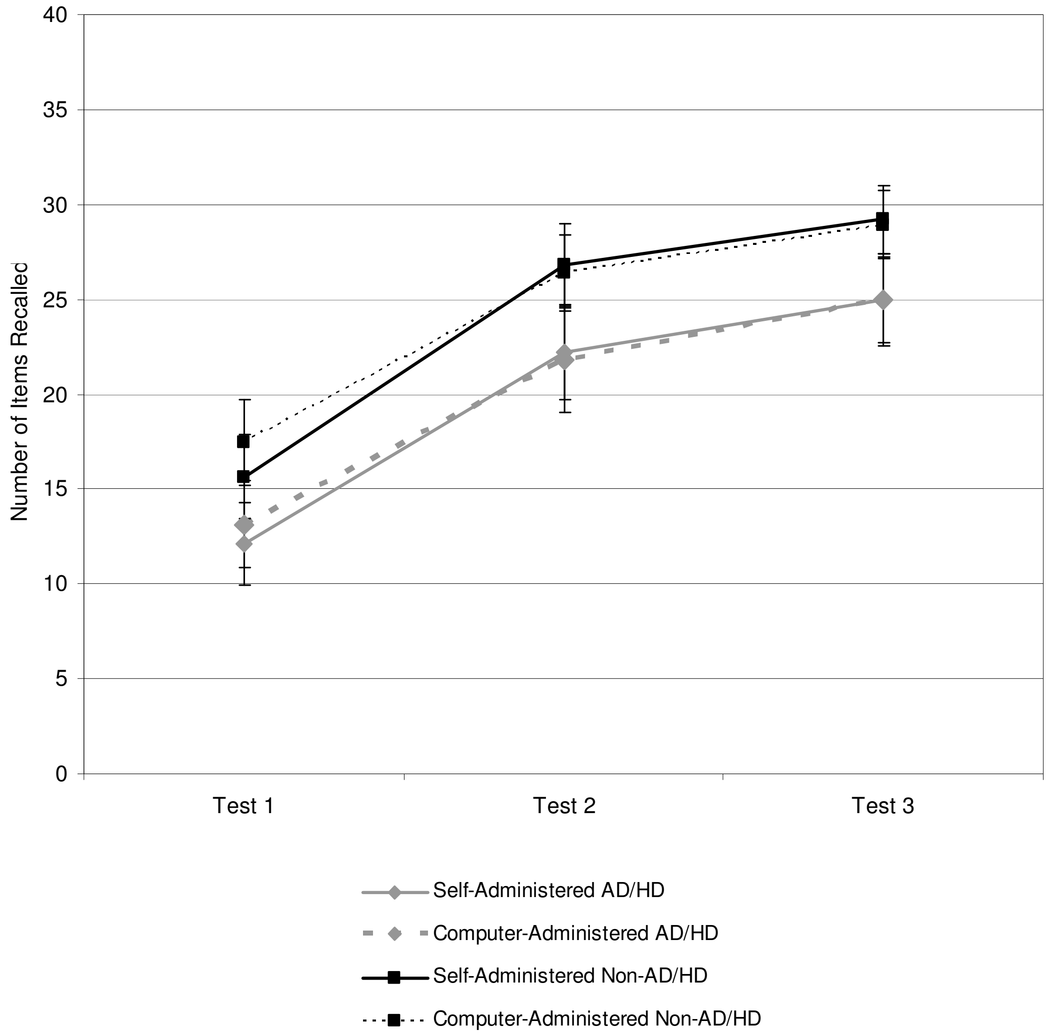
APPENDIX B

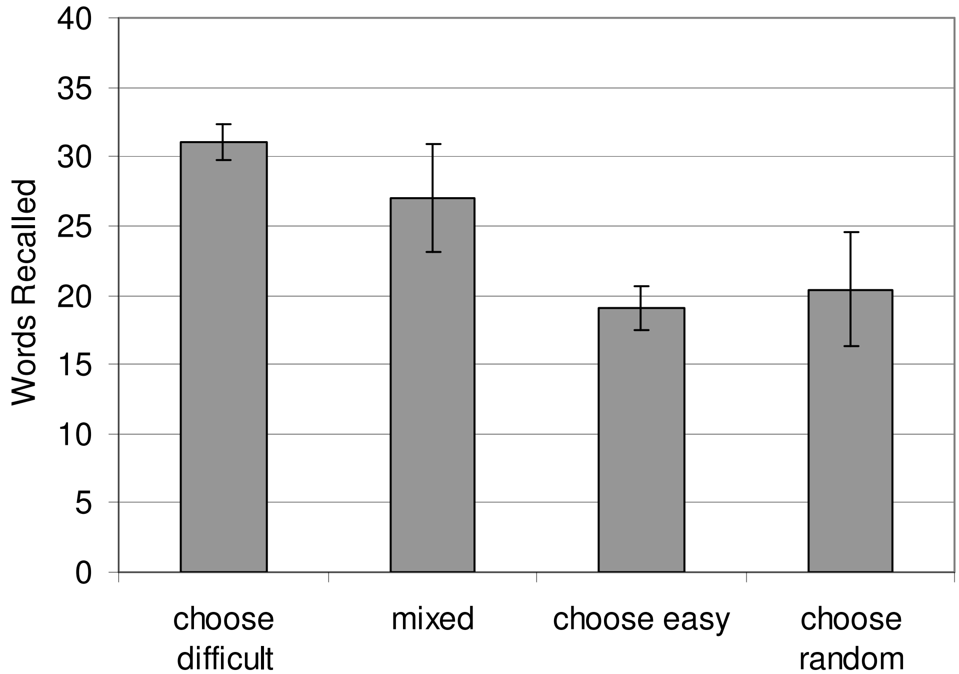
FIGURES

Figure Captions

Figure 1. Mean recall by group, condition and trial for computer-administered tasks in initial sample.

Figure 2. Mean recall for computer-administered tasks by selection strategy.


40
35
30
25
20
15
10
5
0
Number of Items Recalled
Test 1
Test 2
Test 3
Self-Administered AD/HD
Computer-Administered AD/HD
Self-Administered Non-AD/HD
Computer-Administered Non-AD/HD


40
35
30
25
20
15
10
5
0
Words Recalled
choose difficult
mixed
choose easy
choose random

APPENDIX C

SCREENING QUESTIONNAIRE

ID Number:__________

Please answer the following questions to the best of your knowledge:

1) Have you ever been diagnosed with traumatic brain injury or severe closed head injury?

____Yes ____No

2) Have you ever suffered from any other neurological condition?

____Yes ____No

3) Have you ever been diagnosed with reading disorder (learning disability in reading)?

____Yes ____No

4) Have you ever been diagnosed with psychosis (e.g., as part of schizophrenia, delusional disorder, etc.)?

____Yes ____No

5) Have you ever received a diagnosis of Attention-Deficit Hyperactivity Disorder (AD/HD) or Attention Deficit Disorder (ADD) from a health or mental health care professional?

____Yes ____No

6) Are you CURRENTLY suffering from any mental health problems as diagnosed by a health or mental healthcare professional? (please list):

7) IN THE PAST, have you been diagnosed with any mental health problems by a health or mental health care professional (other than AD/HD or ADD)? (please list):

8) Are you CURRENTLY taking prescription medication for a mental health problem? If so, please list medications and dosages, if known.

APPENDIX D

DIAGNOSTIC INTERVIEW

This adult AD/HD diagnostic interview was modified from the *Computerized Diagnostic Interview Schedule for Children for DSM-IV (C-DISC-IV).*

C-DISC-IV AD/HD Module — Revised

Inattention

Everybody has times when they have trouble concentrating or keeping their mind on what they are doing. What we want to know is whether you have had difficulty concentrating or keeping your mind on what you are doing most of the time.

In the past year, have you often made a lot of mistakes because it's hard for you to do things carefully?	(a) YES NO
In the past year, did you often have trouble keeping your mind on what you were doing for more than a short time?	(b) YES NO
In the past year, did you often not listen when people were speaking to you?	(c) YES NO
In the past year, did you often have trouble finishing things you were supposed to do?	(d) YES NO
Some people are often disorganized. They can't remember where they put things. They try to do too many things at the same time so they're often late, or don't go where they're supposed to go, or never have time to do things properly. In the past year, were you disorganized?	(e) YES NO
In the past year, did you often try not to do things where you would have needed to pay attention for along time?	(f) YES NO
In the past year, did you often dislike doing things where you had to pay attention for a long time?	YES NO
In the past year, did you often lose things that you needed?	(g) YES NO
In the past year, did you often find it hard to keep your mind on what you were doing when other things were going on?	(h) YES NO
In the past year, did you often forget what you were supposed to do or what you had planned to do?	(i) YES NO

Symptoms present for at least six months: YES NO
Onset of Symptoms: _______________
Consistent since then: YES NO
Worst at age: _______________
Do these symptoms result in difficulties…
At school (if applicable): YES NO

At home or with family: YES NO

With friends: YES NO

At work: YES NO

Do these symptoms make you feel bad, frustrated, or upset: YES NO

Hyperactivity/Impulsivity

I would now like to ask you some questions about being hyperactive, restless, or impulsive. Everybody has times when they are like that. What we want to know is whether you are like that most of the time.

In the past year, were you often fidgety or restless, fiddling with your hands or feet or moving around in your seat?	(a) YES NO
In the past year, have you often left your seat when you weren't supposed to?	(b) YES NO
In the past year, when you had to sit still, for say more than ten minutes, did you nearly always feel restless, as if you wanted to kick your feet or get up and move around?	(c) YES NO
In the past year, did you often climb on things or run around when you weren't supposed to?	YES NO
In the past year, did you often make much more noise than other people?	(d) YES NO
In the past year, were you often "on the go" or did you move around as if you were "driven by a motor"?	(e) YES NO
In the past year, did you often talk a lot more than other people?	(f) YES NO
In the past year, did you often blurt out answers before someone could finish asking the question?	(g) YES NO
In the past year, have you often had trouble waiting for your turn, like when you were standing in a line?	(h) YES NO
In the past year, did you often interrupt people when they were talking or when they were busy?	(i) YES NO
In the past year, did you often butt in on what other people were doing?	YES NO

Symptoms present for at least six months: YES NO
Onset of Symptoms: ________________
Consistent since then: YES NO
Worst at age: ________________
Do these symptoms result in difficulties…
At school (if applicable): YES NO

At home or with family: YES NO

With friends: YES NO

At work: YES NO

Do these symptoms make you feel bad, frustrated, or upset: YES NO

APPENDIX E

FUNCTIONAL IMPAIRMENT SCALE

ID Number: __________

Please indicate the extent to which the problems you may have reported on the previous page *interfere with your ability to function* in each of the following area of life activities. Indicate your response by checking the appropriate box below.

	Never or Rarely	Sometimes	Often	Very Often
1. In my home life with my immediate family	☐ N/R	☐ S	☐ O	☐ VO
2. In my work or occupation	☐ N/R	☐ S	☐ O	☐ VO
3. In my social interactions with others	☐ N/R	☐ S	☐ O	☐ VO
4. In my activities or dealings in the community	☐ N/R	☐ S	☐ O	☐ VO
5. In my educational activities	☐ N/R	☐ S	☐ O	☐ VO
6. In dating or marital relationships	☐ N/R	☐ S	☐ O	☐ VO
7. In my management of money	☐ N/R	☐ S	☐ O	☐ VO
8. In my driving of a motor vehicle	☐ N/R	☐ S	☐ O	☐ VO
9. In my leisure or recreational activities	☐ N/R	☐ S	☐ O	☐ VO
10. In my management of daily responsibilities	☐ N/R	☐ S	☐ O	☐ VO

Please indicate the following by writing the appropriate number in the boxes provided (one digit per box, please):	
How long have you had a driver's license (in years)?	☐☐
How many times have you been involved in a motor vehicle accident while driving?	☐☐
How many times have you been found to be at fault in a motor vehicle accident?	☐☐
How many times have you received a speeding ticket?	☐☐
What is the total number of driving citations (tickets) you have ever received? (do not include parking tickets)	☐☐

APPENDIX F

COGNITIVE TASK FACTORS QUESTIONNAIRE

CTFQ

ID Number: __________

Sleep, substances, and other factors can affect how people perform on memory tests. We would like to know about your recent use of substances and sleep habits. **Remember that all information you provide will remian completely confidential.**

How many hours of sleep did you get last night?
Write number of hours here: ☐☐

How many hours have passed between the time you woke up and when you came here today? Write number of hours here: ☐☐

NOTE:
Round to nearest hour.

How many alcoholic beverages (drinks) have you consumed...
...since you woke up this morning? ☐☐
...in the past 24 hours? ☐☐

How many cigarettes have you smoked...
...since you woke up this morning? ☐☐
...in the past 24 hours? ☐☐

How many caffinated beverages have you consumed...
...since you woke up this morning? ☐☐

Have you used any illegal drugs...

...since you woke up this morning?	☐ Yes	☐ No
...in the past 24 hours?	☐ Yes	☐ No
...in the past week?	☐ Yes	☐ No
...in the past two weeks?	☐ Yes	☐ No

If you answered "yes" to any of the questions in this box, please print the names of the drugs you used:

Have you used any "over-the-counter" (non-prescription) drugs...

...since you woke up this morning?	☐ Yes	☐ No
...in the past 24 hours?	☐ Yes	☐ No

If you answered "yes" to any of the questions in this box, please print the names of the drugs you used:

Have you used any prescription drugs...

...since you woke up this morning?	☐ Yes	☐ No
...in the past 24 hours?	☐ Yes	☐ No
...in the past week?	☐ Yes	☐ No
...in the past two weeks?	☐ Yes	☐ No

If you answered "yes" to any of the questions in this box, please print the names of the drugs you used:

APPENDIX G

METAMEMORY INTERVIEW

AD/HD and Metamemory Study
Interview Form – Version 2

Card Task:

Study Time: ______minutes; ________seconds (in seconds (max 900):_______)

What did you do to learn items? (code response by checking all that apply; give queries):

____ ROTE REHEARSAL (Q: Did you repeat them aloud, to yourself, or both?)

____REPEAT ALOUD

____SORT BY CATEGORIES

____ASSOCIATE (Q: Tell me more about how you (associated, connected, linked) the words.)

____SENTENCE

____STORY

____PERSONAL REFERENCE

____VISUAL IMAGERY

____CHUNKING

____SELF-TEST

____MONITORING AFFECTS CONTROL

____OTHER (Describe):

Did you test yourself while studying to see if you knew the items? (read prompts)

__Never __A few times __Several times __For every item

How did you know to stop studying items? (record response)

How hard was this task? (read prompts)

__Very Easy __Pretty Easy __In the middle __A bit hard __Very Hard

How hard did you try on this task? (read prompts)

__Hardly at all __A little bit __A medium amount __A bit hard __Very Hard

Comments:

Computer-Administered Task

Stimulus Set (circle one): A B

What did you do to learn items? (code response by checking all that apply; give queries):

____ ROTE REHEARSAL (Q: Did you repeat them aloud or to yourself?)

____REPEAT ALOUD

____ASSOCIATE (Q: Tell me more about how you (associated, connected, linked) the words.)

____SENTENCE

____STORY

____PERSONAL REFERENCE

____VISUAL IMAGERY

____SELF-TEST

____OTHER (Describe):

Did you test yourself while studying to see if you knew the items? (read prompts)

__Never __A few times __Several times __For every item

How did you choose items to study again at the beginning of the task? (record response)

How did you know to stop studying an item and move on to the next one? (record response)

How hard was this task? (read prompts)

__Very Easy __Pretty Easy __In the middle __A bit hard __Very Hard

How hard did you try on this task? (read prompts)

__Hardly at all __A little bit __A medium amount __A bit hard __Very Hard

Comments:

APPENDIX H

MODIFIED COGNITIVE FAILURES QUESTIONNAIRE

CFQ

ID Number: _________

This is a questionnaire about minor cognitive lapses. You will answer 40 questions that try to record how often different kinds of memory lapses happen to you.

The following questions refer to minor lapses, which happen to all of us from time to time. Some of these occur more frequently than others. Please indicate how often you notice such incidents in your own behavior by specifying how often such they happened to you during the last twelve months.

Please mark only one answer per row

1	2	3	4	5
never	rarely	once in a while	often	very often

	never	rarely	once in a while	often	very often
1. Do you read something and find you haven't been thinking about it, so you have to read it again?	○	○	○	○	○
2. Do you find you forget why you went from one part of the house to the other?	○	○	○	○	○
3. Do you find that you forget that you've turned off a light or the stove or locked the door?	○	○	○	○	○
4. Do you find it difficult to stay focused on what's happening in the present?	○	○	○	○	○
5. Do you forget where you put something like a newspaper, set of keys, or book?	○	○	○	○	○
6. Do you find you accidentally throw away the thing you want, and keep what you meant to throw away – as in the example of throwing away the matchbook and putting the used match in your pocket?	○	○	○	○	○
7. Do you daydream when you ought to be listening to something?	○	○	○	○	○
8. Do you start doing one thing at home and get distracted into doing something else (unintentionally)?	○	○	○	○	○
9. At the end of a conversation, do you realize that you forget to mention something you wanted to say?	○	○	○	○	○
10. Do you have to return to your home or apartment to pick up something you forgot?	○	○	○	○	○
11. Do you forget to give a message to somebody as you were requested to do?	○	○	○	○	○
12. Do you not notice feelings of physical tension or discomfort until they really grab your attention?	○	○	○	○	○
13. Are you unable to find something that you put away only a couple of days ago?	○	○	○	○	○
14. Do you drive places on "automatic pilot" and then wonder how or why you went there?	○	○	○	○	○
15. Do you forget a person's name almost as soon as you've been told it for the first time?	○	○	○	○	○
16. Do you forget a change in your daily routine, such as a change in the place where something is kept, or a change in the time something happens?	○	○	○	○	○

MORE ITEMS ON NEXT PAGE.

ID Number: ___________

	never	rarely	once in a while	often	very often
17. Do you have to go back to check whether you have done something that you meant to do?	○	○	○	○	○
18. Do you find your mind wandering when you're doing something that needs your concentration?	○	○	○	○	○
19. Do you completely forget to take things with you, or leave things behind and have to go back and get them?	○	○	○	○	○
20. Do you decide to do something and then find yourself side-tracked into doing something different?	○	○	○	○	○
21. Do you start to read something (a book or an article in a magazine) without realizing you have read it before?	○	○	○	○	○
22. Do you completely forget to do things you said you would do, and things you planned to do?	○	○	○	○	○
23. Do you find you are not sure whether you have told someone a particular story or joke already?	○	○	○	○	○
24. Does it seem you are "running on automatic" without much awareness of what you're doing?	○	○	○	○	○
25. Do you find it hard to keep your mind on a task or job?	○	○	○	○	○
26. Do you do some routine thing more than once by mistake? For example, going to brush your teeth when you have just done so?	○	○	○	○	○
27. Do you begin to do something and then forget what you were supposed to be doing?	○	○	○	○	○
28. Do you lose your train of thought in conversation?	○	○	○	○	○
29. Do you have the feeling that you should be doing something, either now or later, but you can't remember what?	○	○	○	○	○
30. Do you leave some necessary step out of a task? For example, forgetting to put tea in the teapot.	○	○	○	○	○
31. Do you do jobs or tasks automatically without being aware of what you're doing?	○	○	○	○	○
32. Do you think you're paying attention to something when you're actually not (such as when reading a book or having a conversation)?	○	○	○	○	○
33. Do you forget to keep appointments that you don't write down?	○	○	○	○	○
34. Do you find you forget which way to turn on a road that you're quite familiar with but rarely use?	○	○	○	○	○
35. Are you unable to remember something that you had been told some time ago?	○	○	○	○	○
36. Do you have the 'what-am-I-here-for" feeling when you find you've forgotten what you went somewhere to do?	○	○	○	○	○
37. Do you do something automatically, or by habit, that you really wouldn't have done if you had thought more about it?	○	○	○	○	○
38. Do you find yourself *not* having done something you intended after having been interrupted unexpectedly?	○	○	○	○	○
39. Do you find yourself searching for something that you are actually carrying around with you?	○	○	○	○	○
40. Do you "lose your place" in the course of carrying out some fairly routine activity?	○	○	○	○	○

APPENDIX I

CONSENT FORM

Contains study consent form for a participant with AD/HD.

Consent to Participate in Research

Project Title: AD/HD, Learning, and Memory
Project Director: Laura E. Knouse, M.A.
Faculty Supervisor: Arthur Anastopoulos, Ph.D.

Description:

The goal of this study is to examine how people with and without Attention Deficit Hyperactivity Disorder (ADHD) study material and perform on memory tests. The study will also examine how well people can make predictions about their memory. You will be asked to complete one testing session lasting approximately 2 hours. You will be trying to learn different kinds of materials and remember them. These memory tests will be presented on a computer. You will also try to predict how well you will remember items. Other memory tasks will require you to perform tasks while trying to remember certain information. You will also complete paper-and-pencil forms telling about your memory, emotions, and thoughts.

Because of the nature of the computerized tests, it is necessary that you are free of any stimulant medication for AD/HD on the day that you take the test (if applicable). To ensure that you would do this testing while not taking medication, you were asked to schedule your session at a time when you would not be taking medication OR to obtain written permission from your prescribing physician. When you complete the procedures, you may resume your medication schedule as prescribed by your physician.

Your testing session will be recorded for purposes of the study using a digital video recorder (DVR). Any recorded material will remain strictly confidential along with your other written records.

As part of participation, you will also be asked to provide consent for your records from your evaluation in <NAME OF CLINIC/PROJECT> to be used as data in the study. You will do this by signing a “Release for Disclosure” authorization form specifically permitting <NAME OF CLINIC/PROJECT> to release specified information from your evaluation for research purposes only. This procedure is in compliance with the federal Health Information Portability and Accountability Act.

Risks and Discomforts:

Participation in this study carries minimal risks associated with completing psychological tests.
If, at any time, you are uncomfortable answering any question posed to you by the experimenter orally or in written form, you may decline to answer that item without penalty. All written records, video recordings, and data stored on the computers will remain strictly confidential. In data files, all identifying information will be removed and

you will only be identified with a participant number. Written records and recordings will be kept in a locked file cabinet and destroyed after no more than five years. Any information obtained from your evaluation at <NAME OF CLINIC> will have its identifying information removed before being included in the study. All results from this study will be reported at the group level only.

Some items on the questionnaires ask about the possibility of harm toward one's self or others. Should you disclose serious risk of harm to yourself or others, you will receive a referral for appropriate mental health services. In the unlikely event that these risks are imminent and you are unwilling or unable to ensure your own safety or others' safety, you will be identified to emergency personnel.

You may experience a temporary return of your ADHD symptoms if you are not taking your medication. Resuming medication immediately after the experiment will minimize these risks. If at any time you feel the discomfort associated with being medication-free is too great, you may withdraw from the study without penalty.

Potential Benefits:

Individuals participating in this study will receive compensation of $50.00. You will also receive feedback on your performance today as well as tips for more effective study. The findings from this study will help us to learn more about ADHD and may aid in developing treatment strategies to improve memory performance and study for those with the disorder.

Consent:

By signing this consent form, you agree that you understand the procedures and any risks and benefits involved in this research. You are free to refuse to participate or to withdraw your consent to participate in this research at any time without penalty or prejudice; your participation is entirely voluntary. Your privacy will be protected because you will not be identified by name as a participant of this project.

The research and this consent from have been approved by the University of North Carolina at Greensboro Institutional Review Board, which insures that research involving people follows federal regulations. Questions regarding your rights as a participant in this project can be answered by calling Mr. Eric Allen at (336) 256-1482. Questions regarding the research itself will be answered by Laura Knouse at (336) 420-2764 or leknouse@uncg.edu or by Arthur Anastopoulos at (336) 346-3196 Ext. 303. Any new information that develops during the project will be provided to you if the information might affect your willingness to continue participation in this project.

By signing this form, you are agreeing to participate in the project as described to you by the experimenter.

___________________________________ ______________________________

Participant's Signature Date

___________________________________ ______________________________

Witness to Signature Date

APPENDIX J

FEEDBACK LETTERS

Contains two versions of feedback letters for participants for initial and additional data collection.

<DATE>

Dear NAME,

Thank you so much for your interest in the AD/HD and Memory Project and for your participation. This letter contains feedback on your performance on several of the tasks, important study tips based on research studies like this one, and further information about the study itself. I hope you will find the information interesting and useful.

Computerized Word Memory Task

You completed two different computerized tasks where you learned pairs of words to remember them later. You could select some of these words to study again. In one task, you controlled how long you saw each word, while in the other task the computer controlled study time.

At the end of the task, you remembered ______ of the 40 words when you were able to control your study time. When the computer controlled study time, you remembered ____ of 40 words. Therefore, your memory for the words was better when _______ controlled how long you saw each item.

Different people may do better with different types of study. On one hand, people may have a better idea of what they do and do not know than a computer. On the other hand, having words presented on the computer may help people pay attention to each one longer. This study will help to determine which kind of studying is better for people with attention difficulties.

Working Memory Task

Many researchers who study memory are interested in what is called "working memory." Working memory describes a person's ability to hold items "in mind" and remember them while they are doing other types of tasks. Many researchers believe that attention plays a key role in working memory.

During the testing, you completed two working memory tasks requiring you to remember letters—one while you solved math problems and another while you read sentences. Your score for the task involving math problems was ____ and fell at the ______ percentile among a group of college students who took these tests. That means you performed as well or better than _____ percent of those students. Your score for the task involving sentence reading was _____ and fell at the ______ percentile among a group of college students who took these tests. That means you performed as well or better than ______ percent of those students.

Your performance on the task was better when you were asked to ___________. This may indicate which types of activities require more mental effort and attention for you.

Study Tips based on Memory Research

Listed below are a number of strategies that have been shown to be effective in memory research. These strategies are designed to help people who are trying to learn and retain information.

- **Study and review in small chunks over a long period of time**. Students tend to "cram" before exams, but memory research shows that studying and reviewing in small chunks over a longer period of time results in better memory.
- **Quiz yourself.** There's no better way to determine whether or not you've learned something than to quiz yourself and find out for sure. Many students use flashcards. You can also write questions on one half of a sheet of paper and answers on the other half. By folding over the paper and covering the answers, you can easily quiz yourself.
- **Study unlearned material until it is learned**. This may seem obvious, but quizzing yourself won't lead to better memory unless you spend more time studying information that you find you haven't learned yet. After quizzing yourself, mark the items with a 0, 1, or 2. Study 0's most, 1's next, and 2's after you've learned the other material.
- **Quiz yourself again…later!** It's important to quiz yourself repeatedly on an item to see if you've learned it. However, if you quiz yourself right after seeing the answer you can't be sure you've actually learned it. To make quizzing most effective, wait or study other material before quizzing yourself again.
- **Learn in different modes.** The greater the number of times you see information, the more likely you'll be to remember it. In addition, the number of ways you can process information also makes a difference—that is, reading, writing, hearing, speaking. Try writing to-be-learned material, reading it out loud, having someone else read it to you, posting it on your refrigerator, etc. You could also try speaking the information out loud into a tape recorder or digital voice recorder and playing it back when you study.

<u>Research Study Information</u>

The goal of this study is to learn more about the relationship between attention, memory, people's awareness of their memory, and the strategies they choose when learning items. Does AD/HD impact memory because of attention deficits or because it impairs the ability to engage in effective studying behavior? What kind of supports might promote more effective studying? The ultimate goal of this program of research is to develop interventions that will help adults and children with AD/HD to learn more effectively and to achieve academic success.

Thanks again for your time and interest. Data collection for this study will be continuing through Spring of 2007. If you know of anyone who may be interested in this research, have them call 346-3196 Ext. 306 for more information.

Sincerely,

Laura E. Knouse, M.A.
Principal Investigator: AD/HD and Memory Project
AD/HD Clinic and Research Team
Department of Psychology
University of North Carolina at Greensboro

<Date>

Dear NAME,

Thank you so much for your interest in the AD/HD and Memory Project and for your participation. This letter contains feedback on your performance on several of the tasks, important study tips based on research studies like this one, and further information about the study itself. I hope you will find the information interesting and useful.

Card Memory Task

You first completed a task that asked you to learn pairs of words for a later test. In this task, you were able to choose how you studied and (to an extent) how long you studied. We measured both how many words you remembered *and* how accurately you could predict which items you would and wouldn't remember. These predictions are referred to in cognitive psychology as *judgments of learning* (JOL) and they are an aspect of *metamemory*—or a person's ability to take stock of and control their own memory and learning processes.

On the task, you recalled ________ words correctly while your JOL indicated you thought you would remember ___________ words.

<u>Computerized Word Memory Task</u>

You completed a computerized task where you learned pairs of words to remember them later. You could select some of these words to study again. During the task, you were able to control how long you saw each word. You also took the test 3 times total.

At the first test, you remembered ________ of the 40 words, while you predicted you would remember about «jolself» according to your JOL. By the third test, you had remembered ______ of 40 words. In this task, we also examined how your JOL related to which items you selected and how long you studied items. One of these measures was a correlation (a Goodman-Kruskall gamma correlation, to be precise!) between your JOL and whether or not you selected an item. Negative correlations would indicate you chose to study harder items but positive correlations indicate you chose to study easier items. The correlation between your JOL and item selection on this task was _________.

<u>Study Tips based on Memory Research</u>

Listed below are a number of strategies that have been shown to be effective in memory research. These strategies are designed to help people who are trying to learn and retain information.

- **Study and review in small chunks over a long period of time**. Students tend to "cram" before exams, but memory research shows that studying and reviewing in small chunks over a longer period of time results in better memory.

- **Quiz yourself.** There's no better way to determine whether or not you've learned something than to quiz yourself and find out for sure. Many students use flashcards. You can also write questions on one half of a sheet of paper and answers on the other half. By folding over the paper and covering the answers, you can easily quiz yourself.
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- **Learn in different modes.** The greater the number of times you see information, the more likely you'll be to remember it. In addition, the number of ways you can process information also makes a difference—that is, reading, writing, hearing, speaking. Try writing to-be-learned material, reading it out loud, having someone else read it to you, posting it on your refrigerator, etc. You could also try speaking the information out loud into a tape recorder or digital voice recorder and playing it back when you study.

<u>Research Study Information</u>

The goal of this study is to learn more about the relationship between memory, people's awareness of their memory, and the strategies they choose when learning items. Does AD/HD impact memory because of attention deficits or because it impairs the ability to engage in effective studying behavior? What kind of supports might promote more effective studying? The ultimate goal of this program of research is to develop interventions that will help adults and children with AD/HD to learn more effectively and to achieve academic success.

Thanks again for your time and interest!!!
Sincerely,

Laura E. Knouse, M.A.
AD/HD and Memory Project
AD/HD Clinic and Research Team
Department of Psychology
University of North Carolina at Greensboro

APPENDIX K

INTERVIEW CODING SCHEME

Coding Scheme – AD/HD & Metamemory Interview

→ Codes pertain to participant's response to the question: "What were you doing to learn items?" (Note: Codes are NOT mutually exclusive!)

Code	Description	Examples
Rote Rehearsal	Reports study of items by simple repetition, silently or aloud. (If repeated aloud, also code Aloud)	"I just went through them all three times." "I said them to myself in my head while I looked at them until I felt like I knew them." "I started out by going through the pile once and just reading them."
Repeat Aloud	Reports study of items by saying them out loud.	"I read the pairs out loud and the looked away and repeated them." "I repeated the sentence I made up out loud."
Sort by Categories	Reports sorting pairs by categories based on either word of the pair (ACROSS CARDS).	"I put all the ones that had to do with food in one pile and all the ones that were people in another pile." "I studied all the ones that started with "B" together."
Associate	Reports any attempt to connect the words semantically (i.e., based on meaning) even if the method is not further specified. If applicable, also code more detailed association strategies as described below.	"I just tried to find a connection between the two words." "I thought of some funny way to put them together. Like a redneck is a 'Dirt Queen'"
Sentence	Reports making up a sentence that uses/associates both words in a pair (WITHIN PAIRS ONLY). Also code if participant reports Associate and verbally gives examples of sentences.	"I tried to think of them together in a sentence, like 'I skinned my <u>knee</u> coming down the <u>mountain</u>.'"
Story	Reports making up a story that linearly connects pairs to one another (ACROSS PAIRS)	"I started at the beginning and made up a story linking all of the words. Like I'm a hero and first I

		had to go on a quest to find the Blood Daffodil and then I needed to eat the magic Fox Pudding to restore my strength."
Personal Reference	Reports relating at least one pair to a personal experience.	"I'll definitely remember museum-truck because my brother works on the loading dock at an art museum."
Visual Imagery	Reports relating items by mentally visualizing them together or interacting in some way.	"I visualized the pairs put together somehow." "I made a picture…like a prince with a ruffled collar at his throat."
Self-Test	Reports testing on items by looking at first word of the pair and trying to remember second word. **CODE ONLY IF REPORTED BEFORE PROMPT**	"I covered up one half of the card and tried to remember the other word."
Chunk	Reports breaking entire list of items down and studying in smaller sets WITH NO RULE TO DETERMINE SETS. (DO NOT code if sets are determined by categories, perceived difficulty, etc.)	"I split them into four piles and studied each set, then tested myself on each one." "I studied five at a time."
Monitoring Affects Control	Reports BOTH: 1) judging items based on difficulty (ease of association, whether they got it right when self-testing) AND 2) treating items differently based on this (studying or self-testing one group of items more frequently)	"I went through and sorted them into ones I thought I'd remember better and ones that would be harder. I studied the hard pile first and tested myself, then studied the easy pile and tested, pulling out any I got wrong when I tested." "I set aside the ones I couldn't get an association for right away. I saved those for last and studied them a couple extra times."