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GRADUATE COLLEGE

PERFORMANCE OF ANALOGUE ADHD COLLEGE STUDENTS ON MEASURES OF FOUR FACTORS OF ATTENTION

A Dissertation

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

Doctor of Philosophy

By

SHAWNA LEA LYONFIELDS
Norman, Oklahoma
2001

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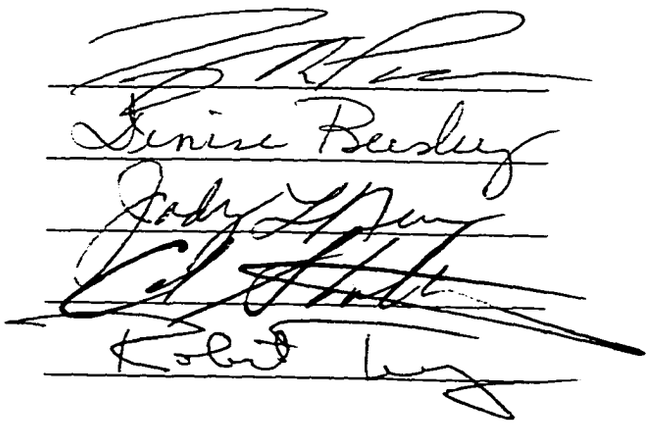
A Dissertation APPROVED FOR THE
DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

BY



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Acknowledgments

This project is dedicated to my husband, Jim, for his tolerance, companionship, and support through a very challenging doctoral process. It is also dedicated to my children, Aja, Jake and Thomas. It is their love of life that puts projects such as this one into perspective.

My respect and thanks go to Dr. Terry Pace whose kind manner and unwavering support guided me through both my doctoral project and served as a role model during my time at the University of Oklahoma.

A heartfelt thanks goes out to my doctoral committee, Drs. Cal Stoltenberg, Jody Newman, Robert Terry and Denise Beesely. Your understanding and encouragement made a tough process pleasant. Thank you for your professionalism and understanding.

To Scott Miller and Lisa Petersen for your effort, patience and commitment to the early phases of this project.

Finally, my thanks to all the college students who donate their time in order that we researchers may better understand the human mind.

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Abstract

The current study examines the discriminate validity of measures of four different components of attention between analogue ADHD college student subjects and control subjects in an attempt to determine which aspects of attentional processes are impaired in ADHD. The components of attention assessed were derived from two neuropsychological models of attention proposed by Allen Mirsky (citation) and Russell Barkley (citation), and include: Focused Attention, Sustained Attention, Response Inhibition and Encoding. Because clients with ADHD have often been seen as having difficulty in all of these areas, it was hypothesized that they would perform more poorly than the controls on all of the assessment measures. Logistic regression equations were used for each of the factors to determine how well they predicted group membership. Only the equations including the measures of focused and sustained attention were statistically significant, correctly classifying 67% and 66% of the subjects, respectively. An equation including measures of all four types of attention correctly classified 82% of the subjects. Subjects were administered the Brief Symptom Inventory as part of the test battery and subjects in the ADHD group scored significantly higher on all subscales. Thus, the GSI score was added to the combined factor equation. The resulting equation perfectly predicted group membership. The results are discussed in terms of the current literature on ADHD as well as their implications for clinical assessment. Limitations of the study and future directions are also discussed.

CHAPTER 1: INTRODUCTION

Historical Background of ADHD Diagnosis

Attention-Deficit/Hyperactivity Disorder (ADHD) is the most common behavior disorder found in children and affects 3 to 5 percent of the school age population. While it was thought that children 'outgrew' ADHD during adolescence, more recent research suggests that up to 50% experience significant sequela as adults (e.g. Nadeau, 1995; Weiss & Hechtmen, 1993). Untreated adult ADHD has been associated with increased risk for depression, anxiety disorders, substance abuse, academic/occupational difficulties, auto accidents, and relationship conflicts (Barkley, 1990).

While the DSM-IV (APA, 1994) recognizes that ADHD can occur in adults, the diagnosis for adults is based upon the same symptoms and criteria used with children. This is problematic given that the DSM-IV field trials did not include any adults in their sample (Lahey et al., 1994). Barkley has also suggested that when 'one size fits all' approaches are used to diagnose ADHD in all age groups, one may over diagnose young children and under diagnose adults. He proposed requiring fewer symptoms to be present for diagnosis of adults in order to compensate for this methodological flaw. Johnson and Lyonfields (1995), however, showed that the magnitude of this reduction in the requisite symptoms varies according to gender and ADHD subtype.

The problem with the DSM-IV diagnostic criteria has been compounded by recent media attention that has greatly heightened public awareness of adult ADHD. Schaffer (1994) has referred to adult ADHD as the 'foremost self-diagnosed condition' in many clinical practices. Jaffe (1995) wrote that its heightened recognition and politicalization places ADHD at risk for becoming a 'diagnosis de joir.' At the University of Oklahoma,

the number of requests for ADHD evaluations has increased 300% in the early 1990's (University of Oklahoma Counseling Clinic records, 1998). These figures appear to be consistent with data collected from colleges nationally (HEALTH, 1993). Given the rapid increase in the number of college students seeking assistance for ADHD, counseling centers, training clinics and private practices, are increasingly likely to encounter clients where ADHD is a possible diagnosis. Given the aforementioned difficulties in applying the DSM-IV criteria to adults, assessment tools that aid in diagnosis of ADHD are clearly needed. Assessment tools that offer specific profiles of attention that correlate strongly with various diagnoses would give clinician an effective tool for diagnosing ADHD as well as other disorders. Such techniques have been successfully employed in the past. For example, the MMPI-II allows clinicians to have an understanding of a client's personality that is not biased by either self-report or the clinician's initial impressions (Greene, 1991). Many well noted psychologist have espoused such techniques as being an effective tool for diagnosing. (i.e. Meehl, 1956).

Assessment based upon validated models of attention might aid in the clinical diagnosis of clients with ADHD. Attention dysfunction is a component of numerous psychological disorders such as schizophrenia, Attention Deficit/Hyperactivity Disorder (ADHD), and dysthymia (American Psychiatric Association, 1994). Yet the type of attentional dysfunction present in each of these disorders may be quite different. Therefore clinicians attempting to determine if a client suffers from actual neurologically based attention problems as opposed to an affective disorder that produces attention problems must do so using an approach tapping all aspects of attention. By approaching assessment

in this manner, clinicians may begin to draw a clearer picture of the specific aspects of attention that are unique to a diagnosis or, more specifically, problematic for a client. As mentioned earlier, attentional difficulties are purported to be a primary characteristic of a wide range of psychiatric disorders, however, recently researchers have begun to pinpoint differing types of attentional deficits in some disorders. For example, Mirsky (1991) has found that patients with absence seizures perform poorly on measures of sustained attention relative to both normal and partial-complex seizures, whereas individuals with partial-complex seizures performed worse than the other two groups on measures of shifting attention and focused attention. Using a similar approach he found that there were differences in attentional deficits between children labeled "abnormally aggressive" and "abnormally shy" (Mirsky, 1996). Specifically, he discovered that children rated as having poor concentration and as being "abnormally shy" were significantly worse than control children on measures of sustained attention, whereas those children with poor concentration labeled "abnormally aggressive" were found to have greater difficulty inhibiting their response. Furthermore, Streissguth et al. (1994) has raised the question as to whether the nature of attention dysfunction within a single patient group may vary at different times in development in his assessment of patients with fetal-alcohol exposure (Mirsky,1996). Such studies reveal that specific disorders may have detectable patterns of attention problems and that these patterns may vary by age of the client. The purpose of this study is to discover which aspects of attention are problematic for ADHD college students. This information is to be obtained utilizing widely available measures of attention validated in neuropsychological models of attention. If ADHD adults exhibit specific

deficits in attention as compared to controls and if such deficits are both statistically and clinically significant, clinicians might find it useful to test for such deficits to aid in proper diagnosis of ADHD.

CHAPTER 2: LITERATURE REVIEW

The Concept of Attention

The concept of attention is a global psychological construct that has been the subject of much scientific investigation over the past hundred years (Douglas, 1983; James, 1898; Mirsky, 1987; Posner, 1988 & Tichner, 1924, Zomeren & Brouwer, 1994). Its rich history is due to the fact that nearly all forms of cognitive functioning involve some aspect of attention.

In 1898 William James defined attention as, "the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatter-brained state which in French is called distraction ...One principle object comes then into focus of consciousness, others are temporarily suppressed" (James, 1898 pp. 261-262). Other researchers have also attempted to define what attention is. Tichener (1924) stated, " Consciousness in attention is patterned or arranged into focus and margin, foreground and background, center and periphery. And the difference between the processes at the focus and the processes in the margin is essentially, a difference of clearness: the central area of consciousness lies clear, the more remote regions are obscure. In this fact we have, indeed, the key to the whole problem of attention" (p. 267). Gibson and Rader (1979) later defined attention as "perceiving in relation to a goal, internally or externally motivated" (p.2).

In whole, one's ability to attend to the environment is ultimately tied to the notion of attention. However, researchers have failed to agree on an operational definition of the

term. In fact, current models of attention have moved away from attempting to define the concept of attention as a unidimensional construct and have instead offered various multidimensional models (Barkley, 1990; Halperin, 1996; Kindlon, 1998; Morris, 1996). This trend has allowed for greater clarification of terms, specification of measurement and empirical validation of each of a host of relevant theoretical models exploring attention. These theories approach the conceptualization of attention from different frameworks that have been subsumed under the areas of information processing, behavioral and neuropsychological (Barkley, 1996). The specific dimensions studied are unique to each model. Informational processing and behavioral theories will be briefly reviewed in the study, as they add dimension to the understanding of the idea of attention as well as offer some direction in the treatment of attention deficits, however, they offer little with regard to clinical assessment. The neuropsychological model will be discussed in depth, as it lays the foundation for this study.

Information Processing Models of Attention

An investigator's basic approach to validating models of attention using the information processing theoretical framework relates to mental chronometry. In other words, the influence of variations in task demands on the reaction times of individuals serves to validate hypotheses regarding how attention is prioritized and allocated (van Zomeren & Brouwer, 1994). Constructs defined in the information processing theories generally include selective, divided and sustained attention. Selection is the ability to focus one's attention at a particular stimulus as opposed to dividing it between different stimuli (Sergeant, 1996). Selective attention may be conceptualized as a general pool of energy that is limited, but can be divided between several simultaneous demands (Gopher &

Navon, 1980; Norman & Bobrow, 1975; Wickens, 1984). Tasks require effort for them to be performed and resources are allocated according to the demands that they place upon the central resource pool. The attention system is designed to assign priority to certain tasks and divide remaining resources between others. Gopher and Navon (1980) refer to this idea as the 'economy of processing.' Because this allocation of resources clearly involves some volitional control, attention itself is intimately tied with executive functioning. In order to study this concept, researchers have designed a multitude of dual tasks paradigms, requiring subjects to process two tasks simultaneously (i.e., Gopher & Navon, 1980; Posner & Boies 1971; van Zomeren & Brouwer, 1994). The concept of 'divided attention' is only one aspect of the broader concept of selective attention.

Sustained attention is the ability to maintain performance over time (Sergeant, 1996). Sustained attention generally focuses on two vigilance measures, namely, perceptual sensitivity (d') and response bias (Beta). These measures, plotted over time, are purported to measure sustained attention. A decline in perceptual sensitivity is the classic index of sustained attention in this model (Warm, 1984). These values are calculated via complex mathematical equations obtained from the time it takes for one to respond to a task.

A critical problem for the application of the above constructs is the lack of good psychometric data for the large number of tasks used by cognitive psychologists to test the subtleties of their theories (Lyon, 1994; Sergeant 1996). Until these become available, clinicians will be required to use more commonly available psychological tests. However, Sergeant (1996) warns against the use of clinical psychometric tests for research on group differences in attention processing. He purports that such tests have both latency and errors that can be the product of a wide variety of processes. He uses the term latency to mean the

delay one has in responding. In addition he uses the term errors to mean the number of times the subjects does not respond correctly. Tests that are purported to be measures attention can be affected by a speed-accuracy trade off and therefore yield an impure measure of attention. Sergeant concedes, however, that better measures of attention developed by cognitive psychologists are not commonly available to the clinician.

Behavioral Models of Attention

Whereas the information processing models of attention focus on the allocation of attentional resources, the behavioral models focus on reinforcement principles. Skinner (1953) defined attention as a functional relationship between stimulus and response rather than a mental function. According to the behavioral models of attention, the way an organism responds has to do with immediate consequences associated with responding as well as the relevant learning history associated with the organism. As might be expected, many behaviorists view the concept of attention with caution. Some perceive that the term 'attention' has been used too broadly and, subsequently, find the term to be superfluous (McIlvane, Dube & Callahan 1996). Many such behaviorists find it more appropriate to discuss the concept of attention in terms such as 'the establishment and maintenance of stimulus control.'

Stimulus control is shown when a stimulus influences some aspect of an organism's behavior (McIlvane, Dube & Callahan, 1996). It is demonstrated when an organism has 'attended' to the stimuli. Many variables may influence stimulus control development. The stimulus itself can vary by complexity or modality, behavior can vary by duration and type. Consequences vary by type and schedule. In addition to this complex system, the modulating aspects of the organism itself can affect the system. Such variables include the

age, gender or genetic make-up of the organism. Finally, behaviorists studying attending behavior consider three types of events: antecedents, behaviors and consequences. Each of these events may influence the other two. The behavioral model of attention differs from the other models in that it assumes that attention is more malleable. Whereas neuropsychologists and cognitive psychologists see attention as being dependent upon a host of intact neural networks, behaviorists see it as being dependent upon the aforementioned event contingencies (McIlvane, Dube & Callahan, 1996). The assumption that dimensions of attention are related to situational variables rather than pervasive response styles, makes this model difficult to adapt to clinical assessment. Such constructs may be of more utility in the treatment of such disorders rather than assessment.

Practically speaking, such variables are usually collected during the interview portion of an assessment rather than through psychometric tests. However, some experiments suggest that some behavioral techniques might eventually offer some diagnostic information to the clinician. For example, behavioral experiments demonstrating the potential for extending stimulus control shaping methods to produce generalized attending behavior on particular tasks (Dube et al., 1992; McIlvane, Dube, Kledaras, Iennaco & Stoddard, 1990) initially appear to offer valuable information in the assessment of individuals with attention deficits. In one such experiment the attending behavior of some of the participants was modified through a procedure referred to as one-trial discriminate learning so that they could more accurately discriminate between stimuli (Dube et al., 1992). Some subgroups exposed to this method did not improve their attending behavior beyond a certain low-lying threshold while others made dramatic improvements and increased formerly poor attending behavior to almost normative levels. Although one can

imagine how such a procedure might eventually aid in differentiating those who could benefit from types of behavioral treatment and those who may not, such assessment procedures would be cumbersome and, to date, no established protocol or normative data is offered. As such, the model chosen to provide structure to this study is the neuropsychological model.

Neuropsychological Constructs of Attention

Neuropsychological models are based largely on an evolutionary-developmental perspective (Halperin, 1996). They highlight the fact that attention to the environment is necessary for survival of all creatures and must therefore be mediated by very primitive subcortical structures. Although the majority of one's attentional systems are hypothetically associated with what is referred to as the reptilian brain or the R-complex, this model posits that additional attentional processes have become differentiated and articulated as the brain has evolved over time, and that parts of the limbic and neocortical structures also play a role in an organism's behavior (MacLean, 1990). The degree of brain differentiation delineated by the various neuropsychological models is directly related to the working definition of attention embraced by each. For instance, the more general the model is in its delineation of the brain, the more general it is in defining attention. A neuropsychological model that is more specific about its conceptualization of the brain can be more specific about investigating the types of attentional processes.

The working definition of attention one uses from the field of neuropsychology depends upon the specific question being posed. In general, however, a distinction can be made between two differing concepts of attention, namely the "capacity" concept and the "mechanistic" concept (van Zomeren & Brouwer, 1994). The capacity concept presumes

that task performance depends upon the use of just one or a few diffuse attentional resources. It emphasizes the mass effect of brain damage on attention. The capacity concept, in general, states that less brain power means fewer neurons which in turn means diminished resources.

In contrast, a mechanistic viewpoint posits that specific types of attention are dictated by specific systems of cerebral hardware and, as such, each aspect of attention should be studied separately (van Zomeren & Brouwer, 1994). These researchers focus upon the effect of specific brain lesions on the different processes of attention. The model embraced to assess for differences between ADHD college students and a controlled population depends upon whether one conceptualizes ADHD as a global deficit or a more specific disorder of attention.

A mechanistic model of attention posits that the functions of attention have become differentiated and articulated in the brain through the course of evolution (Mirsky, 1996). Evidence has shown that mental operations involved in various types of cognitive processing are localized in distinct regions of the brain and that task performance requires coordination of these operations into a system (van Zomeren & Brouwer, 1994). Specifically, attentional processes result from coordination of several elements linked into such a system (Heilman, Watson, Valenstein, Damasio, 1983; Mesulam, 1987; Mirsky, 1987; Posner, 1988). Several integrated theories conceptualize attention as the integrated action of different structures of the brain (Mesulam, 1981; Posner & Petersen, 1990; Struss & Benson, 1986).

A representation of proposed attention systems to specific brain regions was proposed by Mirsky and his colleagues (Mirsky, Anthony, Duncan, Ahearn & Kellam, 1991). They

originally proposed four elements or factors of attention including 'focus/execute,' 'sustain,' 'shift' and 'encode.' Through extensive research and statistical analysis they have confirmed that these elements of attention exist. Further they have shown that it is useful to consider attention as a multifaceted process or capacity, different components of which may be comprised in different disorders (Mirsky, 1996).

Mirsky's model (1996) hypothesizes that these aforementioned components of attention may be supported by different brain regions that have become specialized for this purpose. Mirsky's theory states that the function of short-term focusing on environmental events is shared by the superior temporal and inferior parietal cortices as well as by structures that compromise the corpus striatum. Sustaining focus on some aspect of the environment is the major responsibility of the rostral midbrain structures, including the mesopontine reticular formation and midline and reticular thalamic nuclei. Encoding of stimuli is dependent upon the hippocampus and amygdala. The capacity to shift attention from one aspect of the environment to another is supported by the prefrontal cortex including the anterior cingulate gyrus. Finally, the model speculates that damage in any one of these brain regions can lead to specific deficits in a particular attention function. Mirsky's theory does not imply that specialization is absolute, rather, that some structures may substitute for others in the event of an injury. Although other models examining the components of attention exist, the Mirsky model is unique in that it was stimulated by and validated by neuropsychological tests used in clinical practice. Therefore each component of the model has commonly available neuropsychological tests that are purported to assess the respective brain systems.

ADHD as a Capacity Construct

Initially, global brain damage was proposed to be the chief cause of ADHD symptoms (Barkley, 1990). The damage was purportedly caused by brain infections, trauma, or other injuries or complications that occurred during pregnancy or delivery. Although it is true that brain damage such as hypoxic/anoxic injuries to the brain are associated with increased deficits in attention as well as with increased hyperactivity (Cruikshank, Eliason & Merrifield, 1988) such injuries are not present in the majority of ADHD clients (Barkley, 1990). Less than 5% of ADHD clients have hard neurological findings indicative of actual brain damage (Barkley, 1990). Further, no differences in brain structure have been discovered via computer tomography scan analysis (CT scans) (Denckla, Lemay & Chapman, 1985). Although certain types of trauma may give rise to an ADHD diagnosis, these do not account for the vast majority of ADHD clients' disorders.

In addition to their problems with inattention, impulsivity and overactivity, clients with ADHD may present with a variety of other difficulties. These include an increased likelihood of having other medical, developmental, behavioral, emotional or academic problems. Specifically, ADHD clients are more likely to have a learning disorder, that is a significant discrepancy between one's intellectual capacity and one's academic achievement in areas such as reading, math, handwriting and language. They are likely to lag behind both normal children and their own siblings in their intellectual development, scoring 7 to 15 points below their own siblings on standardized intelligence tests (Barkley & Karlsson, 1985; McGee, Williams Moffitt & Anderson, 1989). However, it is not as yet clear whether these differences represent real intellectual differences or merely differences in test-taking behavior, as inattentiveness to task would naturally produce lower test scores.

Finally, some studies have noted a greater incidence of maternal health and prenatal complications such as toxemia and pre-clampsia, post-maturity and fetal distress for the subjects with ADHD as compared to non-diagnosed individuals (Hartsough & Lambert, 1991). Such findings may suggest that ADHD is a result of a more global brain deficit. However, not all ADHD children display such problems, nor are they diagnostically significant. Their presence is not, in and of itself, diagnostic of ADHD, nor does their absence rule out the diagnosis. The many different definitions of attention, the low correlation between performance on different attention tasks and its correlation with concepts such as problem solving, memory and perception all demonstrate that attention cannot be viewed as single global concept (Parasuraman & Davis, 1984; Van Zomeren & Brouwer, 1994). Such evidence does not legitimize conceptualizing ADHD as resulting from global brain damage.

ADHD as a Mechanistic Construct

Recent findings have pointed to a more specific problem with central nervous system mechanisms in subjects with ADHD (Barkley, 1990). This is most likely in the connections between the prefrontal areas and the limbic system, especially in the striatum (Heilman et al., 1991; Lou et al., 1984, 1989; Zametkin & Rapoport, 1986). These areas of the brain are known to be related to response inhibition, inattention and sensitivity to reinforcement.

Some studies have demonstrated abnormal activity in these regions of the brain in ADHD children. First, Lou and colleagues (1984, 1989) have studied cerebral blood flow to the brain and have found diminished perfusion to the striatum and orbital prefrontal regions of ADHD subjects. Also, a study by James Satterfield, (cited in Barkley, 1990) has shown that ADHD children display less electrical activation in their prefrontal and frontal-

limbic regions. Other studies have shown that such children perform differently on neuropsychological tests assessing frontal lobe functioning (Barkley, 1990). In summary, it is likely that ADHD is related to underactivity of the prefrontal-striatal-limbic regions and their rich interconnections.

Another study by Giedd and colleagues (1994) used the technique of magnetic resonance imaging (MRI) to examine the corpus callosum in samples of ADHD boys. They found that the two anterior regions, the rostrum and the rostral body were significantly smaller in ADHD boys. The authors suggested this was evidence of abnormal frontal lobe development and functioning in ADHD children.

Another line of research investigated the possibility that a genetic abnormality alters catecholaminergic functioning. Wender (1972, 1994) and Wender et al. (1983) and other researchers (Reimherr et al., 1987; Wood et al., 1982, 1983, 1985) have focused on dopamine depletion. Raskin and colleagues examined cerebral spinal fluid in subjects diagnosed with ADHD and those who were undiagnosed. They found decreased brain dopamine in ADHD children (Raskin, Shaywitz, Anderson, & Cohen, 1984). This hypothesis ties in nicely with the previously mentioned studies citing differences between ADHD and controls in the prefrontal and striatum areas, the most dopamine rich areas of the brain (Barkley, 1990).

In spite of these findings there is strong evidence that subjects diagnosed with ADHD are a heterogeneous group. This evidence is primarily based upon the fact that there is considerable variation in drug response. Some patients, clinically indistinguishable from others, do not respond to stimulants (Barkley, 1990). Others respond differently to D-amphetamine than they do to methylphenidate (Barkley, 1990). Others have a robust

response to tricyclic antidepressants (Wender, 1994). The most conservative hypothesis to date is that the syndrome may be caused by several different abnormalities that can be improved to varying degrees by different medications.

Difficulties Studying Mechanisms of Attention in ADHD

A problem arises from the conceptualization of ADHD adults as a homogeneous group. Lumping individuals with similar symptomatology in studies may obscure results that would be obtained if a more homogeneous group, perhaps based upon a common etiology, were used. In truth, researchers are still investigating the contribution of both environmental and genetic factors on the expression of ADHD. According the Wender (1994), researchers have not been able to find a distinct etiology for ADHD, perhaps because to meaningfully examine an etiology one must first have a homogeneous sample. However, having a homogeneous sample requires knowledge of the etiology. This problem is not unique to ADHD. In the medical field there are certain disorders that are produced by one of many genetic abnormalities. This problem, referred to as 'genetic heterogeneity' means that researchers investigating a particular disorder might be studying a group of patients with etiologies from different genetic causes. Similarly, some disorders, such as hemophilia, a disease cause by an X-linked recessive gene, have what is called a phenocopy, or an environmentally produced equivalent. In the case of hemophilia, a vitamin K deficiency will produce similar symptomatology. Identification of such subgroups would be critical when studying the manifestations of these two disorders. A related problem in the assessment of disorders with unclear etiologies is the idea of 'pleiotropism,' in which at least one genetic abnormality produces multiple and different effects. Finally, another etiology complication emerges because in spite of having the same

genetic loading and psychological experience, different individuals may exhibit variable expression or manifestation of symptoms to a greater or lesser degree. Ideally a clearer understanding of ADHD etiology would help researchers to isolate a homogeneous group of subjects.

Although no evidence exists to show that ADHD is the direct result of abnormal chromosomal structures, ample evidence exists to demonstrate that it is a trait which is highly heritable in nature, making heredity one of the most well-substantiated etiologies for ADHD. Studies have shown that the concordance of ADHD in monozygotic twins is as high as it is for other biological conditions (Wender, 1994). In addition, research has shown that if a parent has ADHD the risk of this parent's offspring having ADHD is 57% (Biederman et al., 1995) In spite of the understanding that there is a hereditary basis for the condition, there exists to date no 'test' for ADHD which would aid clinicians in identifying those individuals with the disorder.

Research has also shown that there are some nongenetic phenocopies of ADHD produced by environmental agents. For example, in the 1910's and 1920's there emerged an ADHD-like disorder now referred to as von Economo's Encephalitis that causes behavioral difficulties in children including: irritability, restlessness, disobedience, not being amenable to discipline and emotional instability (Hohman, 1922). In short this viral infection mimicked the syndrome of ADHD. Other environmental causes might include such factors as maternal use of alcohol and smoking during pregnancy (Bennet et al., 1988; Shaywitz et al., 1980; & Streissguth et al., 1984). As mentioned earlier, although the vast majority of ADHD clients endorse no such history, it is impossible to date to verify the

specific etiology of the disorder and, as such, one risks having a heterogeneous sample with a variety of specific brain dysfunctions that produce ADHD symptoms.

Neuropsychological Models of Attention

As mentioned earlier, models developed by researchers such as Allan Mirsky (1996) and Russell Barkley (1996) using a neuropsychological perspective are of interest to clinicians because they operationalize and validate aspects of attention using widely available assessment instruments. Although competing models of attention exist apart form Mirsky's and Barkley's (Cooley & Morris, 1990; Gibson & Rader, 1979; Kahneman, 1973; Mesulam, 1987; Posner, 1988; Shiffrin, 1988), these models are of limited clinical utility at the present time.

Even within the neuropsychological framework there exist many different models of attention. Barkley (1993) summarized the commonly cited aspects of attention as being arousal and alertness, focused attention, sustained attention, divided attention, shifting attention, as well as distractibility, inhibition and span of apprehension. Most models of attention do not address all of these factors. Morris (1996) surveyed articles appearing in six well respected journals that routinely published research relevant to learning disabilities. He discovered that over a five year span these articles discussed over 25 different measures of attention, 15 measures of memory and 20 measures of executive functioning. However, none of these measures were categorically unique. In sum, the majority of these models define attention as a multidimensional construct that includes overlapping dimensions of memory and executive functioning.

There are a staggering array of measures used to assess attention. These developments are driven in part by the explosion of technology and in part by the need for a specific

instrument created for the study of different paradigms of attentional processes. Among the more common measures of attention are continuous performance tests (and a host of associated variables), subsets from intelligence tests, maze completion, direct observations, and many other information processing paradigms (Barkley, 1996). The specific measures used for the following study have been chosen in part for their accessibility to the clinicians and, most importantly, for their empirical validation in the models highlighted in this research.

Mirsky's Model of Attention

One of the more extensively studied models of attention has been developed by Mirsky (1987). He has studied attention extensively and has subsequently provided a clinically useful model for conceptualizing various components of attention. He has proposed four major components of attention including: 'focus-execute,' 'sustain', 'encode' and 'shift' (Mirsky, 1987). These four areas of attention have been used in the investigation of attentional processes with normal and psychologically impaired children and adults (Mirsky, 1987; Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Zubin, 1975). Mirsky's components of attention are used primarily in evaluating which aspects of attention are problematic for certain populations by utilizing common assessment instruments.

Mirsky and his associates provided empirical evidence for their model of attention based upon separate and combined factor analyses of large samples of adults and children using a battery of neuropsychological tests presumed to assess attention (Mirsky, 1988; Mirsky et al., 1991; Mirsky Silberman, Latz & Nagler, 1985; Nagler & Mirsky, 1985). These tests are referred to as the Laboratory of Psychological and Psychopathology-

National Institute of Mental Health (LPP-NIMH) Attention Battery. The data in support of Mirsky's model were initially derived from a factor analysis of two samples, the first consisting of 203 adult neuropsychiatric patients and respective control populations, and the second consisting of a sample of 435 second grade school children ranging in age from 7 to 9. Independent principle component analyses of test scores from these two populations yielded similar results; namely, a set of 4 elements of attention that are measured by different tests (Mirsky 1996). Since its inception the LPP-NIMH Attention Battery has been administered to a spectrum of clinical populations including patients with petit mal and complex partial seizure disorders (Duncan, 1988; Mirsky, 1991), anorexia nervosa and bulimia nervosa (Jones, Duncan, Brouwers, & Mirsky, 1991), affective disorders, and closed head injuries and to normal subjects, including a large sample of public school children (Mirsky et al., 1991). The fact that Mirsky's original findings have been utilized in diverse subject populations makes his factor model clinically useful in assessing attention in the ADHD population.

Presently the adult version of the LPP-NIMH Attention Battery includes eight standard neuropsychological measures tapping different aspects or elements of attention identified by factor analysis (Mirsky, 1987, 1988, 1989; Mirsky et al., 1991). As seen in Table 1, the first factor, "focus-execute," includes loadings from four tests, including Digit Symbol Substitution, Stroop, Letter Cancellation, and Trail Making, Parts A and B. This factor seems to be comprised of two elements, a visual-perceptual ability to scan stimulus material for a preset target rapidly and efficiently as well as an ability to make either verbal (Stroop) or skilled manual responses quickly (Digit Symbol Substitution, Letter

Cancellation, Trail Making). The designation 'focus-execute' for this factor is an effort to encompass both aspects of performance required for these tasks.

The second factor referred to as 'shift' is measured by a single test, the Wisconsin Card Sorting Test. It appears to reflect the abstract capacity to shift from attending to one aspect or stimulus to another in a flexible and adaptive manner. The third factor, known as 'sustained attention' has substantial loading from the performance measures derived from CPT measures. The CPT task, requiring sustained concentration for 5 to 30 minutes of time, yields measures of correct responses, commission errors and reaction times. In addition to the CPT measures, the third factor also has modest loading from the Trail-Making Test, Parts A and B, although this test's loadings on the 'shift' factor is not as high as is it on the first (focus-execute). Thus the attentive effort is also important to some extent in successful performance on the Trails Making Test.

The final factor, labeled 'encode' arises from the Digit Span and Arithmetic subtests of the Wechsler Scales. It is the least understood of the four factors. A reasonable hypothesis about this factor is offered by Mirsky (1996). He hypothesizes that this factor embodies some sort of numerical-mnemonic quality of attention, because both tasks loading on this factor require the serial incorporation, retention, cognitive manipulation and recall of numerical information.

Table 2.1
Instruments recommended for assessing Mirsky's factors of Attention

'focus/execute'	'shift'	'sustain'	'encode'
Digit Cancellation	Wisconsin Card Sorting	CPT **	Digit Span*
Digit Symbol*			Arithmetic*
Stroop			
Trails A & B			
Letter Cancellation			

* Wechsler Scales
** (reaction time, number of correct responses, commission errors)

Barkley's Model of Attention

Barkley (1990) provided a model of attention similar to Mirsky's. Although Barkley's model of attention does not enjoy the extensive empirical validation of Mirsky's, it is based upon the areas of attention considered to be problematic for ADHD clients. Also, it provides an additional aspect of attention not captured by Mirsky's. Barkley's first three factors mirror Mirsky's 'focus-execute,' 'sustained' and 'encode/manipulate,' but to these he adds another factor of attention that he refers to as 'impulsivity.' This factor reflects a lack of attention to the consequences of behavior.

Barkley recommends that each aspect of attention be assessed using common psychological measures available to most clinicians. These assessment measures are similar to the ones utilized by the LPP-NIMH Attention Battery. He recommends that the component of attention that he referred to as 'focused attention' (analogous to Mirsky's focus-execute component) be assessed using the Trails A & B as well as the Wechsler Digit Symbol Subtest. Barkley also recommends that the Wechsler Digit Span and Arithmetic subtest be used for assessing what he refers to as the 'encoding/manipulation' aspect of attention, analogous to Mirsky's 'encode' factor. He also suggests using the CPT as a measure of 'sustained attention.' He explained that analysis of omission errors provided an accurate measure of sustained attention, as it documents the number of times a subject failed to attend to a target. He also recommends use of the aforementioned factor termed d' that, when analyzed over time, can determine a change in a subject's perceptual sensitivity to changes. Warm (1984) explained that a decline in perceptual sensitivity over time is a 'classic' index of failure in sustained attention. Finally, Barkley recommend the use of a CPT for assessing the additional component of impulsivity. He reported that the

number of commission errors from a continuous performance test, or the number of times a subject incorrectly responds to a nontarget, measures one's inability to keep from responding. The degree to which one cannot inhibit responding is conceptualized as impulsivity. A summary of Barkley's recommendations can be found in Table 1.2.

Table 2.2
Instruments recommended for assessing Barkley's factors of Attention

focused attention	encoding/manipulation	sustained attention	impulsivity
Digit Symbol*	Digit Span*	CPT, omission errors	CPT, commission
Trails A & B	Arithmetic*	d'	errors

* Wechsler Scales

Barkley's newest model conceptualizes ADHD as a disorder of self-control (Barkley, 1997). This model posits that ADHD is not a disorder of attention, but rather a problem with the executive neuropsychological function that permits self-control. Barkley's support for his model currently rests in much of the same literature mentioned in this review. However, he reinterprets measures of attention as measures of executive functioning. Barkley has even cited Mirsky's model as an example of how previous models of attention are actually measures of executive functioning. Regarding Mirsky, Barkley writes, "consider the long term programmatic research of Mirsky (1996) on the components of attention. He employs a number of measures that others have frequently interpreted as assessing executive functions, including the Stroop as well as the CPT. Among other things, such confusion reflects deeper problems in reaching a consensus among investigators as to the actual nature of the constructs of attention and executive functions." (Barkley, 1997 p.110)

Barkley argues that executive functioning constitutes a special form of attention (Barkley, 1997). The term attention in Barkley's newest model defines a relationship between an event and the individual's response to it to achieve an immediate outcome. He

defines executive functioning as a form of attention that enables one to control oneself in such a manner as to produce a desired future outcome. He explains that individuals with ADHD respond more readily to immediate needs whereas individuals without ADHD have the ability to be future oriented. There is merit in redefining these terms, and his model more accurately predicts and explains some of the problems with ADHD. However, even Barkley concedes that satisfactory measures of executive functioning in its purest state are currently lacking in most clinical settings. In fact, Barkley admits that even where good measures of executive functioning may exist, they are most likely less useful than other measures, such as those assessing behavioral inhibition, in detecting ADHD (Barkley, 1997). Finally, Barkley's suggestion that Mirsky's model is comprised of tests tapping executive functioning implies that Barkley's newest conceptualization of ADHD would view Mirsky's model as assessing those aspects of functioning that are problematic for individuals with ADHD.

Factors of Attention and Their Relevance to ADHD

Viewed together, Mirsky and Barkley's models provide five factors of attention relevant to the study of attentional processes in ADHD clients. The factors, referred to in this study as 'focused attention', 'sustained attention', 'encoding', 'impulsivity' and 'shift,' have been discussed by many authors and require elaboration not only as concepts in and of themselves, but as clinical issues for the ADHD adult. The two models provide similar conceptualizations of attention and require similar assessment methods. The convergence of the two models may provide some understanding of the attentional difficulties seen in ADHD.

Focused Attention and ADHD

The focus/execute element is tapped by a group of tests that capture the ability to identify important environmental stimuli and perform motor responses under conditions of distraction for short periods of time. In practice, focused attention can be thought of as being either visual or auditory. Because both Mirsky's and Barkley's assessment batteries focus on visual focused attention, the deficits in ADHD client's auditory focused attention will not be explored in this paper. Visual focused attention is usually operationalized as visual search. Target stimuli have to be found in a field of distraction stimuli. The tasks used to assess focused attention are generally self-paced, but subjects are asked to complete them as quickly as possible (von Zomeren & Brouwer, 1994).

ADHD adults are generally thought to have difficulty with focused attention (Wender, 1994). They do poorly in situations that require them to focus on certain stimuli. They also generally lack careful attention to detail. The college ADHD adult may have persistent problems that interfere with their performance. They may have to reread text multiple times or fail to adequately proof read their own work.

Sustained Attention and ADHD

Sustained attention can be operationalized in a variety of ways including time on task, lapses of attention and intraindividal variability (von Zomeren & Brouwer, 1994). Because every test has an attention component to it, it is theoretically possible to extend the length of any test to assess sustained attention. However, because the clinician requires continuous information on performance over time, such an assessment might prove to be laborious. Thankfully commercially available computer software provides specific information on response speed and decrement of performance over time that do not require

the constant attention of a clinician. Vigilance tests of approximately 20-30 minutes appear to be long enough to provide a noticeable decrease in signal detection (Brouwer & Van Wolffelaar, 1985; Sanders, 1983). Such tests, generally referred to as Continuous Performance Tests (CPT), play an important role in present clinical neuropsychology assessment. They are a vast improvement over initial vigilance tests in which clients were placed alone in a cubicle for 2 hours to watch a clock's hand move (N. H. Mackworth, 1950). The idea that such attentional concerns are relevant to study in ADHD adults is not surprising. ADHD adults often report they find it difficult to sit still for any length of time, sometimes finding themselves unable to sit through a TV program or movie. They often begin projects, but quickly lose interest and fail to finish them. They often have difficulty keeping their mind on things that are not of interest to them. (Wender, 1994).

Encoding and ADHD

Memory and attention are integrally woven together. There is overwhelming evidence that the quality of one's memory is largely determined by the amount and type of processing given to the information to be remembered (Baddeley, 1990; Craik & Lockhart, 1972). Events that escape attention cannot be remembered, but when attention is directed towards an event, even if it is not meant to be recalled, parts of that event will be placed in memory. This process is called 'incidental memory.' The amount of information learned is directly proportional to the duration and intensity of the attention given to the material (Russell, 1981). It is therefore not surprising to find individuals with ADHD to have difficulty with short-term memory. The problem of unfocused attention manifests itself in the form of frequently losing or misplacing items, being late or forgetting appointments, etc.

There have been findings that 'impulsivity' is related to aspects of 'working memory' involving encoding and manipulation of information (Bronowski, 1977). Since the concept of working memory is closely related to Mirsky's factor of 'encode' and Barkley's factor called 'encode/manipulation,' it seems likely that this factor would also be useful in the assessment of ADHD and should covary with measures of impulsivity.

Impulsivity and ADHD

Inhibition, or its antithesis, impulsivity, has been found to be linked in ways not fully understood to other important, and uniquely human brain functions, often referred to as executive functions. These include a sense of time, including hindsight and forethought, self-awareness, the internalization of language and its governance over behavior, the regulation of affect and the separation of affect from current responding and its governance over behavior (Barkley, 1996). Clinicians working closely with clients diagnosed with ADHD can often see that their clients struggle with issues related to each of the above areas. ADHD as a disorder related to impulsivity or response inhibition has greater face validity than ADHD as a disorder related to focused and sustained attention, which does not fully capture the breadth of the struggles of the ADHD client. Measures of impulsivity demonstrate a propensity to react before adequate time has been given to processing the information.

Impulsivity is one of the most striking characteristics of ADHD (Wender, 1995). In formal terminology impulsivity may be defined as an inability to delay gratification or as having a low frustration tolerance. ADHD clients are generally seen as being impatient and becoming easily upset when things do not go as expected. They interrupt others, blurt out

answers and may even be considered to be reckless (Barkely, 1990). Even as adults they act on the spur of the moment, and decisions may be made without attention to the consequences.

Shifting Attention

The concept of shifting attention is also referred to as flexibility. Tests assessing shifting attention are meant to determine whether changing between different modes of input has a disproportionate effect on a client. By studying the changes in reaction times between changes in the delivery of stimuli, one can assess such flexibility (Benton, 1962). The study of difficulty shifting attention might prove to be a valuable avenue for further research, however, this aspect of attention was not examined in this study.

Attention Problems and Psychiatric Disorders

It is important when studying ADHD to consider the possibility that comorbid psychological disorders may exist within such a subject pool. Such comorbid disorders may introduce uncontrolled variables that may obscure results. In a related matter, some psychological disorders may resemble ADHD especially when the diagnoses are made on the basis of self-report measures. Differential diagnosis is essential when classifying individuals for research purposes so that one can be sure results obtained are related to the presence of ADHD and not due to a host of other unrelated disorders.

One such diagnosis, elaborated upon by Wender (1995), is Borderline Personality Disorder. Wender explained that on the surface the two diagnoses have similar traits including: impulsivity, angry outbursts, affective instability and feelings of boredom. Subtle differences in the expression of these behaviors may aid in the differential diagnosis. For example, the ADHD client's impulsivity is short lived and situationally

based. It is milder, intermittent and appears to be related to thoughtlessness, rather than compulsively driven. This differs from the BPD client's more severe and sometimes compulsive behaviors such as shoplifting and bingeing. Wender offers other comparisons that further differentiate ADHD from other clinical groups. Such differences are important to keep in mind when attempting to establish a homogeneous sample of ADHD adults.

As a disorder "depression" often refers to a constellation of behaviors including sad affect, loss of interest in activities, feelings of worthlessness and guilt, sleep disturbances, changes in weight, psychomotor retardation or agitation, fatigue and diminished ability to concentrate (Kazdin, 1989). There is considerable conflict as to what degree ADHD clients experience mood disorders more than their undiagnosed counterparts. Szatmari, Offord and Boyle (1989) found in a large epidemiological survey that 17% of girls and 21% of boys under 11 years of age diagnosed with ADD had at least one additional affective disorder. This figure rose to 24% for boys and 50% for girls as they progressed into young adulthood. Comorbidity of affective disorders tends to rise with other risk factors such as learning disabilities, high stress and coercive parenting (Wender, 1995). Other studies have not found a higher incidences of affective disorders in ADHD young adults (Gittelman, Mannuzza, Shenker & Bonagura, 1995). Whether or not ADHD clients are more likely to meet full criteria for affective or mood disorders, they seem more likely to have at least some of the symptoms of such disorders than are normal. Some studies have found that ADHD clients have higher ratings on scales measuring depression, while many other studies do not (Barkley, DuPaul & McMurray, 1992; Biederman, Faraone, Keenan, Knee, & Tsuang, 1989; Biederman et al., 1997). Studies examining specifically young adults and adolescents have been more consistent in showing that affective or depressive disorders are

not more common in ADHD individuals (Barkley et al., 1992; Gittelman, Mannuzza, Shenker, & Bonagura, 1995; Weiss & Hechtman, 1993). In summary, depressive disorders are not necessarily associated with ADHD in young adults. However, "depression" as a symptom may certainly punctuate the life of an ADHD client, particularly considering the population's struggles with self-esteem, peer acceptance and failures in accomplishing tasks (Barkley, 1990).

At present, research suggest that ADHD is not typically associated with anxiety disorders and that individuals with such disorders rarely have ADHD as an associated condition (Barkley, 1990; Wender, 1995). Although individuals with anxiety disorders manifest restlessness and have a diminished ability to concentrate, they do not typically have a pervasive history of behavioral disinhibiton, hyperactivity and poor sustained attention since early childhood. Moreover, those with anxiety disorders are rarely impulsive and "externalizing" whereas such behavior is commonly seen in ADHD. Finally, individuals with ADHD typically have a history of being rejected by their peers whereas individuals with anxiety disorders are typically neglected by their peers (Barkley, 1990). Although the two conditions do not typically occur together, anxiety is often reported by individuals presenting with ADHD, presumably a result of their lifestyle (Barkley, 1990).

Differential diagnosis of ADHD and manic-depression can sometimes be difficult. Nieman and Delong (1997) have shown that these disorders can readily be discriminated from each other by close examination of their symptoms. Manic clients are likely to have a long-standing history of depression, considerable emotional maladjustment and evidence of psychotic symptoms or significant disturbance in their thinking. Such individuals are generally not social and their level of aggression is considerably more deviant than those

characteristic of ADHD. Finally, as always, a clear family history may prove to be invaluable in suggesting what a particular individual is predisposed to experience.

Purpose of the Study

The purpose of this study is to determine which factors of attention as defined and measured by Drs. Barkley and Mirsky are problematic for individuals with ADHD.

Hypotheses

Using selected measures of the aforementioned factors of attention developed by Mirsky and Barkley, the following null hypotheses were developed:

(1) Use of measures of focused attention, specifically the Stroop Color-Word Test, Digit Symbol and Trail A & B, will not improve the classification of analogue ADHD subjects above the level of chance using logistic regression.

(2) Use of measures of sustained attention, specifically, d' and omission errors on the CPT, will not improve the classification of analogue ADHD subjects above the level of chance using logistic regression.

(3) Use of measures of working memory, specifically, Digit Span and Arithmetic Subtests from the Weschler Adult Intelligence Scale, will not improve the classification of analogue ADHD subjects above the level of chance using logistic regression.

(4.) Use of a measure of response inhibition, specifically CPT commission errors, will not improve the classification of analogue ADHD subjects above the level of chance using logistic regression.

(5) Use of a measure of affective symptomatology, specifically the BSI, will not improve the classification of analogue ADHD subjects above the level of chance using logistic regression.

Alternative Hypotheses

Based upon previous research and theory, several alternative hypotheses are predicted.

(1) Use of measures of focused attention, specifically the Stroop Color-Word Test, Digit Symbol and Trail A & B, will improve the classification of analogue ADHD subjects above the level of chance using logistic regression.

(2) Use of measures of sustained attention, specifically, d' and omission errors on the CPT, will improve the classification of analogue ADHD subjects above the level of chance using logistic regression.

(3) Use of measures of working memory, specifically, Digit Span and Arithmetic Subtests from the Weschler Adult Intelligence Scale, will improve the classification of analogue ADHD subjects above the level of chance using logistic regression.

(4.) Use of a measure of response inhibition, specifically CPT commission errors, will improve the classification of analogue ADHD subjects above the level of chance using logistic regression.

(5) Use of a measure of affective symptomology, specifically the BSI, will improve the classification of analogue ADHD subjects above the level of chance using logistic regression.

CHAPTER 3: METHODS

Participants

In order to utilize the criterion group design method, participants from a large southwestern university who were participating in the experiments for class credit were assigned to group membership based upon their responses to the Adult Behavior Checklist (ABC) administered in a large group setting. Individuals endorsing two or fewer DSM-IV symptoms from the ABC were initially assigned to the control group. Students endorsing six or more DSM-IV symptoms from the Adult Behavior Checklist (ABC) (Johnson & Lyonfields, 1995) and who indicated that they had experienced such symptoms throughout their lifetime were initially assigned to the Analogue ADHD group, analogue meaning that subjects were not clinically evaluated and formally diagnosed. These subjects were contacted and asked to participate in further testing. Students agreeing to participate were administered the Wender-Utah Rating Scale (WURS) and readministered the ABC. If a participant consistently met DSM-IV criteria for ADHD utilizing the ABC (Johnson & Lyonfields, 1995) as well as endorsed behavioral criteria from the WURS such that he or she fell within the 'probable ADHD' range, the participant was placed in the Analogue ADHD group. If a participant consistently endorsed two or fewer ADHD DSM-IV criteria and scored in the 'normal' range of the Wender-Utah Rating Scale, she or he was placed in the control group for the study. Of the 179 subjects who were asked to participate in the second part of the study, 29 participants met criteria for being placed in the Analogue ADHD group and 33 participants met criteria for the control group.

The two groups were similar on demographic variables. The Analogue ADHD group had a mean age of 19.39 years and the control group had a mean age of 18.68 years. The

Analogue ADHD group was comprised of 31 % females and 69 % males whereas the control population was comprised of 37 % females and 63 % males. The vast majority of participants were Caucasian. The Analogue ADHD group was comprised of 97% Caucasians, 3 % African Americans. The Control group was 100% Caucasian.

Instruments

Six tests were used to investigate which factors of attention successfully classified Analogue ADHD clients. These tests were the Continuous Performance Test - II (CPT-II), The Stroop Color Word Test, the Arithmetic, Digit Span, and Digit Symbol subtests of the WAIS-R and the Trail Making Test, Parts A and B. In addition, the Brief Symptoms Inventory (BSI) was utilized to investigate what, if any, other psychiatric difficulties might be exacerbating ADHD symptomatolgy.

Adult Behavior Checklist.

One of the tests used to select the subjects was the Adult Behavior Checklist (ABC) (Johnson & Lyonfields, 1995). The ABC is an eighteen item self-report questionnaire that asks individuals to rate the interference of DSM-IV symptoms for ADHD on a 4-point Likert scale (Johnson and Lyonfields, 1995). The questions on the ABC are modeled directly after the DSM-IV criteria for ADHD. Individuals are considered to have endorsed a symptom if they rate the item at one of the two highest levels. The instrument also asks participants to indicate whether or not these symptoms were problematic for them as children. If the subjects endorses enough symptoms to meet DSM-IV criteria for ADHD, and if they indicate that these symptoms were problematic to them as a small child, then the subject is considered to be an analogue ADHD subject. Similar instruments have been used to identify subjects with ADHD in previous studies (Pelhan, Evans, Gnagy &

Greenslade, 1992). The measure has been found to have good test-retest reliability (rxx=0.83 for inattentive items and rxx=0.78 for hyperactive items) as well as good validity (a factor analysis revealed high internal consistency with a three factor model with fit values high (0.90).

Wender Utah Rating Scale. The other test used to distinguish the two subject groups is the WURS (Ward, Wender & Reimherr, 1993). Wender specifically states that use of outside sources, such as a client's mother, is important in establishing an ADHD diagnosis, as a client's memory of their childhood is often 'sketchy,' however, such contact is not always possible or even desirable (Wender, 1995). The WURS, therefore, aids in the diagnosis of adult ADHD by helping account for the two criteria necessary for diagnosis, namely: childhood history and adult symptomology.

Ward, Wender and Reimherr (1993) presented initial data collection and tested the validity of the WURS using 81 outpatient adult ADHD patients, 100 normal adults and 70 psychiatric adult outpatients with unipolar depression. The authors analyzed data from 25 items on a scale that showed the greatest difference between clients with ADHD and the two comparison groups. In addition, the authors compared these scores to the Parent's Rating Scales (PRS). Clients with ADHD had significantly higher mean scores on all 25 items than the two comparison groups. A cut off score of 36 or higher correctly identified 86% of ADHD adults, 99 % of the normals and 81% of the depressed subjects. Correlations between this subset of the WURS and the PRS was moderate, but impressive (.49 for normals and .41 for ADHD adults). The authors concluded that the WURS is useful in recognizing ADHD in clients with ambiguous adult psychopathology (Wender, 1993)

Wechsler Scales. Subtests from the Wechsler scales have been widely utilized to assess various aspects of attention. The Digit Symbol and Coding subtests are believed to measure the focus-execute component of attention (Mirsky et al., 1991). Further corroborating these tests with the focused aspect of attention is Barkley's work examining differential performance on this subtest on ADD children (Barkley, 1990). The Digit Symbol coding tasks have also been found to correlate to a moderate degree (.44 - .61) with teacher ratings of inattention and hyperactivity (Aman & Turbott, 1986; Brown & Wynne, 1982). It should be noted that other studies have found no such relationship (Charles et al., 1979). Other Wechsler subtests that are believed to measure aspects of attention, namely the 'encoding/manipulation' factor are the Arithmetic and Digit Span subtests. The tests confound the attention aspect with short term memory and mathematic skills. Performance on these subtests is sometimes found to be impaired in children with ADHD, but not reliably so (Barkley et al. 1990; Brown & Wynne, 1982b; Milich & Loney, 1979).

Trail Making Test A & B. The Trail Making Test (Parts A and B; Reitan & Wolfson, 1985) from the Halstead Reitan Neuropsychological Test Battery has been described as a measure of the 'focus-execute' factor of attention. It requires motor speed and focused attention while assaying visuomotor coordination and speed of processing in the sequence of both numbers and letters (Reitan & Tarshes, 1959). In Part A the client connects a series of numbered circles distributed randomly about a piece of paper. Part B is comprised of a series of circled numbers and letters. The client is to alternate connecting numbers and then letters in ascending order until all the circles have been connected. The scores are the time taken to complete each part of the test. Mirsky (1991) assigned this test to the 'focus-execute' factor of attention because it correlated highest with this component, but it also

showed a smaller, but still significant correlation with both the 'sustained' and 'shift' dimensions. It has been found that children with ADHD have impairment on the time to complete this task (Barkley et al.,1991). The ecological validity of this measure has yet to be established.

Stroop Color Word Test. There are many versions of the Stroop Test (Stroop, 1935). The LPP-NIMH battery uses stimuli and instructions described by Golden (1978) which include color-word reading, color naming and an interference condition. In addition to assessing lexical response speed to printed words and color, the measure evaluates the ability to focus attention on one aspect of a stimulus, while inhibiting a normally more automatic response. It is often described as a measure of focused attention, however, this is confounded with word recognition, oral reading, speed of reading, color recognition and response inhibition (Mirsky, Anthony, Duncan, Ahearn & Kellam, 1991). An interference score, which is the difference between the obtained score in the interference condition (naming conflicting color-words) and the one predicted given the scores in the first two conditions (i.e., words or colors only) can be derived. The interference score is thought to provide a purer measure of these factors of attention in that it controls for reading and processing speed (Kindlon, 1998).

There are no known studies examining the ecological validity of this variable as a measure of any factor of attention in adults. The reliability of the Stroop scores is highly consistent across the different versions of the test. Golden (1975) found test-retest reliabilities of .86, .82, and .73 (N=30) for the three raw scores for individually administered tests.

Continuous Performance Test. CPT's typically require a subject to sit before a computer screen and observe a sequence of symbols, usually letters or numbers presented individually on a screen at a rapid pace (Barkley, 1990). The subject is required to respond, usually by pressing a button, when the target stimulus appears. The task can last from 5 to 30 minutes, depending upon which version is used. The test produces a number of measures including sustained and focused attention. Low but significant correlations (.25-.41) have been found between CPT scores and direct behavioral observations of sustained attention to academic tasks and measures of impulsiveness (Barkley, 1991; Klee & Garfinkel, 1983; Prinz, Tarnowski & Nay, 1984). Omission errors correlated moderately with teacher's ratings of inattentiveness (Barkley, 1991; Halperin et al., 1988; Klee & Garfinkel, 1983; Pascaulvaca, Wolf, Healey, Tweedy, & Halperin, 1988; Seidel & Joschko, 1991) where commission errors were more likely to be related to teacher and parent's assessment of impulsivity and hyperactivity (.32 - .44) (Barkley, 1991; Halperin et al., 1988; Klee & Garfinkel, 1983). Barkley (1991) posited that these relationships are likely to attenuate considerably with age, but no known measures assessing the ecological validity of CPT variables are available, as such studies have been limited to child populations.

CPT scores have been shown to have good discriminate validity in differentiating between normals and ADHD populations. In addition they are sensitive to medication effects (Barkley, 1997). The CPT-II (Johnson, 1993) was developed as a computerized test of attention and impulsivity. It requires individuals to respond when they see an orange 'H' followed by a blue 'T.' The CPT-II produces two types of error scores. Omission errors occur when the individual does not respond to target stimuli and are presumed to be an index of inattention (Johnson, 1993). Commission errors occur when the subject responds

in the absence of target stimuli and are presumed to be an index of response inhibition or impulsivity. The length of the test varies depending upon the number of incorrect responses given; the more incorrect responses given, the slower the stimuli are presented, however, the number total number of stimuli are presented each time.

The number of omission errors on trial one of the CPT-II is an indicator of focused attention. Subjects are required to attend to the letters and color combinations and respond only when appropriate letter-color combinations are presented. Only the first trial was used because subsequent trials are confounded with sustained attention. The number of omission errors committed on the CPT-II was defined as the indicator of the subject's sustained attention. Reported split half reliability of the CPT-II was 0.86 (Johnson, 1993).

Brief Symptom Inventory. The Brief Symptoms Inventory (Derogatis & Cleary, 1977) is a self-report inventory designed to reflect the psychological profiles of clients. It is essentially a shorter version of the SCL-90-R. Each item of the BSI is rated on a five point scale of distress (0-4) ranging from 'not at all' to 'extremely.' The responses to the BSI items are scored and subsequently plotted on a nine psychological dimensions. These dimensions are: Somatization, Obsessive-Compulsive, Interpersonal Sensitivity, Depression, Anxiety, Hostility, Phobic Anxiety, Paranoid Ideation, and Psychoticism. Finally, there is a measure of overall functioning called the Global Severity Index. The nine primary symptom dimensions of the BSI have evolved through a combination of clinical, rational and empirical procedures (Derogatis & Cleary, 1977). Internal consistency coefficients were established on a sample of 719 psychiatric outpatients using Crombach's coefficient alpha. The alpha coefficients for all nine dimensions were very good ranging from a low of .71 to a high of .85. A study by Derogatis, Rickels and Rock (1976) also

showed impressive convergent validity for the BSI with the MMPI. The results of their analysis showed that the correlation coefficients ranged from a low of 0.30 to a high of 0.67. The measure is meant to be used as an indicator of current psychological functioning rather than a personality profile.

Experimental Design and Procedure

By convention, the methodological approach utilized in this study is criterion-group design, meaning participants were placed in one of two groups, either control or analogue ADHD, based upon their responses to the ABC and the WURS. After being placed in the appropriate group, subjects were then administered a series of tests assessing each of the aforementioned factors of attention as well as their affective symptomatology

CHAPTER 4: RESULTS

Analysis

Because classification of subjects in this study essentially involves the use of a dichotomous variable, logistic regression was utilized. In this manner the utility of each of the four factors of attention in classifying participants can be evaluated. In addition, the utility of all the four factors combined, both with and without the GSI scores, in the classification of participants can be assessed.

Group Characteristics

The groups were established based upon their responses to questions measuring the diagnostic criteria for ADHD from the DSM-IV (APA, 1994), their scores on the Adult Behavior Checklist (Johnson & Lyonfields, 1994) and the Wender Utah Rating Scale (WURS) (Ward, Wender & Reimherr, 1993). During the testing, the subjects completed the Brief Symptom Inventory (BSI) (Derogatis, 1993). Table 3.1 displays the means and standard deviations by group for the WURS and the ABC. It also displays the number of females and males, and ages of the subjects for each group. Independent t-tests were used to compare the means for each of the variables except gender, where a Chi-square was employed. The results of these analyses are displayed in Table 4.1.

Table 4.1
Group Characteristics

Variable	Mean	Standard Deviation	Statistic Value	Level of Significance
Gender	M = 20, F = 9		Chi-sq. = .20	p < .66
	M = 21, F = 12			
Age	ADHD = 19.39	1.91	t(60) = 1.93	p < .06
	Control = 18.68	.75		
WURS	ADHD = 54.17	13.16	t(60) = 20.39	p < .00
	Control = 5.58	3.60		
ABC	ADHD = 11.10	3.22	t(60) = 17.80	p < .00
	Control = 0.64	0.96		

As expected, the groups did not differ significantly in the number of male and female subjects. Given that the groups were chosen on the basis of their scores on the ABC and the WURS, the differences between groups on these scores were expected. The WURS mean for the analogue ADHD subjects (mean = 54.14), however, was lower than that reported for samples of subjects designated as ADHD in other studies (Wender, 1994). This would suggest that the subjects in the ADHD group in this study were reporting lower levels of interference from symptoms than samples of subjects labeled as ADHD in other studies.

In addition, the BSI was administered to all subjects. Independent t-tests were conducted to compare the two groups on each psychological dimension. Table 4.2 displays the means, standard deviations, t-values, and levels of significance for each comparison.

Table 4.2

Brief Symptom Inventory Comparison

Variable	Mean	Standard Deviation	Statistic Value	Level of Significance
Somatization	ADHD = 1.08 Control = 0.30	0.83 0.50	t(60) = 4.55	p < .00
Obsessive-Compulsive	ADHD = 2.50 Control = 0.62	0.64 0.56	t(60) = 12.42	p < .00
Interpersonal Sensitivity	ADHD = 1.87 Control = 0.52	1.02 0.61	t(60) = 6.46	p < .00
Depression	ADHD = 1.76 Control = 0.36	0.97 0.49	t(60) = 7.32	p < .00
Anxiety	ADHD = 1.54 Control = 0.38	0.77 0.40	t(60) = 7.57	p < .00
Hostility	ADHD = 1.74 Control = 0.30	0.99 0.34	t(60) = 7.87	p < .00
Phobia	ADHD = 0.83 Control = 0.19	0.82 0.29	t(60) = 4.23	p < .00
Paranoia	ADHD = 1.66 Control = 0.44	0.89 0.52	t(60) = 6.62	p < .00
Psychosis	ADHD = 1.67 Control = 0.27	0.87 0.43	t(60) = 8.14	p < .00
Global Severity Index	ADHD = 1.62 Control = 0.37	0.62 0.37	t(60) = 9.83	p < .00

Examination of the data reveals that the subjects in the ADHD group endorsed more symptoms on every scale of the BSI. The differences are significant even after applying a Bonferroni adjustment for multiple t-tests. Again, this suggests the subjects in the ADHD

group were experiencing greater numbers of psychological symptoms in a broad range of areas than the subjects in the Control group.

To examine the clinical significance of these differences, the scores for all subjects were reviewed to determine how many were at or above the cut-off of 70 (t-score). Scores at or above this level indicate a clinically significant level of symptoms. Table 4.3 displays the number of subjects that had zero, 1 - 3, 4 - 7, or 7+ scales clinically elevated. Thirty of the subjects in the Control group had no scales on the BSI elevated above 70, compared to only one of the subjects in the ADHD group. Only three subjects in the Control group had one or more scales elevated, while twenty-eight of the subjects in the ADHD group had one or more elevated. Clearly the level of psychological symptoms is much higher for the subjects in the ADHD group and they reach clinical significance.

Table 4.3: Number of BSI Scales Elevated

Number of Scales Elevated Above 70	ADHD	Controls
0	1	30
1 - 3	9	2
4 - 6	10	1
7 - 10	9	0

Factor Comparisons

Focused Attention Factor. The focused attention factor was measured using the Stroop Index (SI), the time to complete the Trails A (TA), the time to complete the Trails B (TB), and the standardized score for the Digit Symbol subtest of the WAIS-R (Dsym). Since this study aims to understand the relationship between a dichotomous dependent variable (Analogue ADHD vs. Control) and several independent variables (tests and questionnaires), a logistic regression was used. The regression aimed at understanding the utility of measures of focused attention in the classification of Analogue ADHD

participants and Controls was performed with SI, TA, TB, and DS entered into the model and without any interaction effects. The regression equation was significant, Model Chi-Square (4) = 11.578, p<.03, suggesting the variables combine to distinguish between the groups. The analysis showed that SI provided the most significant contribution to the equation (see Table 4.4 for group means, standard deviations, and logistic regression statistics). Table 4.5 displays the classification table for the equation. The equation correctly classifies 67.21% of the subjects which, although significantly better than chance, does not help much in clinical diagnosis. The results reveal that the subjects in the ADHD group performed poorer on SI, TB, and DS than the subjects in the control group. Although it was not significant, the subjects in the ADHD group actually performed better on the Trails A test than the subjects in the Control group. This was unexpected. Overall, the model is useful in distinguishing between ADHD and Control subjects in this study.

Table 4.4
Comparisons for Focused Attention

Variable	Mean (SD)	B	SE	Wald	df	Sig	Partial (zero order) R
Stroop Index	ADHD = 50.69 (10.3)	.09	.04	5.99	1	.01	.22
	Control = 57.51 (7.89)						(.23)
Digit Symbol	ADHD = 11.93 (2.55)	.21	.13	2.58	1	.11	.08
	Control = 12.79 (2.30)						(.00)
Trails A	ADHD = 25.50 s (7.7 s)	.02	.04	.43	1	.51	.00
	Control = 26.70 s (10.38 s)						(.00)
Trails B	ADHD = 52.96 s (13.24 s)	-.01	.02	.05	1	.82	.00
	Control = 51.42 s (15.42 s)						(.00)

Table 4.5
Classification Table for Focused Attention

Observed	Predicted ADHD	Controls	Percent Correct
ADHD	18	10	64.29%
Controls	10	23	69.70%
			Overall 67.21%

Table 4.6 displays the correlation matrix for the tests in the Focused Attention factor. As would be expected, the Trails A and Trails B tests are significantly correlated. Also, the Digit Symbol and Trails B test were significantly, but negatively, correlated. This would also be expected. Interestingly, the Stroop Index score was not significantly correlated with the other tests and was the one measure in the Focused Attention factor that seems to best predict group membership. This would suggest that it may be possible to reduce the number of tests measuring this factor.

Table 4.6
Correlation of Tests of Focused Attention

	Trails A	Trails B	Stroop Index
Digit Symbol	-.17	-.22*	.14
Trails A		.33*	.02
Trails B			.09

* $p < .01$

Encoding and Manipulation Factor. The encoding and manipulation factor of attention was measured using the standard score for the Digit Span (DS) and Arithmetic (ARITH) subtests of the WAIS-R. The same logistic regression was performed using these variables. The equation was not significant, Model Chi-Square (2) = 1.91, $p < .39$, suggesting that the model is not useful in distinguishing between the two groups. Further analysis revealed that none of the variables significantly contributed to the equation (please see Table 4.7 for means, standard deviations, and logistic regression statistics). Again, although the differences were not significant, the subjects in the ADHD group out-performed those in

the Control group on both measures. Table 4.6 displays the classification table for the equation. The test measures were significantly correlated (.25, $p < .01$) as would be predicted by the research on the WAIS.

Table 4.7
Comparisons for Encoding and Manipulation

Variable	Mean (SD)	B	SE	Wald	df	Sig.	Partial (zero order) R
Digit Span	ADHD = 11.45 (2.18)	-.14	.13	1.22	1	.27	.00
	Control = 10.69 (2.26)						(.00)
Arithmetic	ADHD = 10.90 (2.12)	-.04	.12	.12	1	.73	.00
	Control = 10.42 (2.48)						(.00)

Table 4.8
Classification Table for Encoding and Manipulation

	Predicted		Percent Correct
Observed	ADHD	Controls	
ADHD	14	15	48.28%
Controls	10	23	69.70%
			Overall 59.68%

Sustained Attention Factor. The sustained attention factor consists of two measures from a Continuous Performance Test (CPT-II) (Barkley, 1990), specifically the Delta change score and the omission error rate from the third trial (OER). A logistic regression was significant, Model Chi-Square (2) = 8.75, $p < .02$, suggesting the variables combine to distinguish between the two groups. Additional analyses revealed that both of the variables contributed significantly to the equation (please see Table 4.9 for means, standard deviations, and logistic regression statistics). Table 4.10 displays the classification table for this equation. Again, the equation correctly classifies subjects better than chance, 66.07%, but, like the focused attention factor, the improvement is modest. The subjects in the ADHD group tended to commit more omission errors on the CPT-II than the subjects in the Control group. In addition, the performance of the subjects in the ADHD group tended to fall off

over time, indicated by the negative value of Delta, in contrast to the Control group who improved over trials. The test measures for this factor were significantly correlated (.44, $p < .01$).

Table 4.9
Comparisons for Sustained Attention

Variable	Mean (SD)	B	SE	Wald	df	Sig.	Partial (zero order) R
Delta	ADHD = -0.46 (8.84)	.13	.06	5.02	1	.02	.20
	Control = 2.04 (5.45)						(.00)
Omission Error Rate	ADHD = 13.31 (4.94)	-.28	.14	4.00	1	.04	-.16
	Control = 11.94 (2.42)						(.00)

Table 4.10
Classification Table for Sustained Attention

Observed	Predicted ADHD	Controls	Percent Correct
ADHD	10	14	41.67%
Controls	5	27	84.38%
			Overall 66.07%

Impulsivity Factor. The impulsivity factor was measured using the commission error rate (CER) from the CPT-II as well. The logistic regression equation with CER was not significant, Model Chi-Square (1) = .43, $p < .52$, suggesting the equation does not significantly distinguish between the two groups (please see Table 4.11 for means, standard deviations, and logistic regression statistics). Table 4.12 displays the classification table for this equation. This suggests no significant difference between the groups on the degree of impulsivity during the CPT-II.

Table 4.11
Comparisons for Impulsivity

Variable	Mean (SD)	B	SE	Wald	df	Sig.	Partial (zero order) R
Commission Error Rate	ADHD = 13.44 (4.90)	-.03	.04	.42	1	.52	.00
	Control = 14.38 (6.48)						(.00)

Table 4.12
Classification Table for Impulsivity

Observed	Predicted ADHD	Controls	Percent Correct
ADHD	9	20	31.03%
Controls	4	28	87.50%
		Overall	60.66%

Combined Equation. A logistic regression was performed entering all of the variables. This equation was significant, Model Chi-Square (9) = 28.77, $p < .001$, suggesting the overall model is effective in distinguishing between the groups. With all of the variables entered into the equation, more of them reached significance (please see Table 4.13 for logistic regression statistics). Table 4.14 displays the classification table for this equation. With all the factors included in the equation, the classification of subjects improves dramatically to 82.14%.

Table 4.13
Combined Equation

Factor	Variable	B	SE	Wald	df	Sig	R
Focused Attention	Digit Symbol	.48	.24	4.21	1	.04	.17
	Trails A	-.01	.05	0.03	1	.87	.00
	Trails B	-.01	.03	0.06	1	.81	.00
	Stroop Index	12	.06	4.61	1	.03	.18
Encoding/ Manipulation	Digit Span	-.54	.27	3.91	1	.05	-.16
	Arithmetic	.08	.21	0.17	1	.68	.00
Sustained Attention	Delta	16	.07	5.06	1	.02	.20
	Omission Error Rate	-.41	.19	4.49	1	.03	-.18
Impulsivity	Commission Error Rate	-.22	.11	4.01	1	.05	-.16

Table 4.14
Classification Table for Combined Equation

Observed	Predicted ADHD	Controls	Percent Correct
ADHD	18	6	75.00%
Controls	4	28	87.50%
		Overall	82.14%

Psychiatric Symptoms. Since the subjects' scores on the BSI were significantly different, the Global Severity Index (GSI) was entered into the combined equation to determine the degree to which this measure contributes to the differences between the groups. With the GSI included, the combined equation perfectly predicted group affiliation (please see Table 4.15). Clearly, the GSI significantly improves the predictions of the equation. This was an unexpected finding.

Table 4.15
Classification of Subjects

Equation	Percentage of correctly classified subjects
Focused Attention	67.21%
Encoding/Manipulation	59.68%
Sustained Attention	66.07%
Impulsivity	60.66%
Combined	82.14%
Combined + GSI	100%

CHAPTER 5: DISCUSSION

Review of Hypotheses

Perhaps one of the most pervasive and least understood behavioral disturbances found in a clinical setting is the symptom of impaired attention (Mirsky, Anthony, Duncan, Ahearn & Kellam, 1991). Attention impairment is recognized as a disorder in and of itself in the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (APA, 1994). However, impairment of attention is also a characteristic of many other disorders including schizophrenia (Mirsky & Duncan, 1986), absence or petit mal epilepsy (Mirsky et al, 1991), cerebral lesions in the posterior brain or in the frontal lobes (Heilman, 1979; Heilman and Valenstein, 1979; Heilman et al 1983), lead intoxication (Needleman et al., 1979), as well as metabolic disturbance such as phenylketonuria (Anderson et. al., 1969). In addition individuals with anxiety disorders, depression or combinations thereof often complain of difficulties with attention or concentration. In fact, this symptom may even be used in the diagnosis of such affective disorders (APA, 1994). It is estimated that 10-15% of the population as a whole suffer at one time or another from some manifestation of impaired attention (Mirsky, Anthony, Duncan, Ahearn & Kellam, 1991). Nevertheless this important symptom is often treated casually, without the theoretical and statistical sophistication seen in research on memory, learning and language (Mirsky, Anthony, Duncan, Ahearn & Kellam, 1991). Thus it seems appropriate to begin applying neuropsychologcial models of attention that purport to identify subsets of this process to the study of psychological disorders.

Evidence is rapidly accumulating to indicate that various mental operations are localized in different elements of the brain. Mirsky (1987) has suggested that attentive

functions result from the coordinated action of these elements linked into a system. He further suggests that there are four such elements of attention and has supported his hypothesis through extensive research and factor analyses. These components include a focus element of attention that represents the ability to select target information from an array for enhanced processing, a sustain component which represents the capacity to maintain alertness over time, an encode and manipulation factor that assesses the mental processes of memory and information manipulation that are associated with attention, and finally, the shift component of attention which assesses the ability to manipulate one's attention between different stimuli. Barkley (1990) proposes a similar model, but adds an additional component of impulsivity, reflecting an inattention to consequences.

For the purposes of this paper and in light of significant evidence, ADHD was assumed to be the result of a mechanistic abnormality rather than a result of global dysfunction. It was unknown which aspect(s) of attention might be disrupted for individuals with ADHD, but behavioral observations suggest they may very well be impaired in all of these areas. This paper compared the performance of analogue ADHD college students to a control population on measures of four of these factors in an attempt to determine if statistical and clinically useful differences could be found that might aid in the diagnosis of ADHD. It was hypothesized that ADHD individuals would be impaired on all such measures.

Review of Methods

The original sample consisted of a subset of 845 individuals recruited from undergraduate psychology subject pool at a large Southwestern campus. Of these initial 845 students, 179 were contacted to participate in subsequent testing, 120 meeting initial criteria for the analogue ADHD group and 59 initially meeting criteria for the control

group. Subsequent testing for these individuals included readminstration of the ABC as well as assessment using the following instruments: WURS, CPT, BSI, Trails A & B, Stroop Color-Word as well as the Digit Span, Digit Symbol and Arithmetic subtests from the WAIS-R. Subjects were included in the final data set if subsequent testing revealed they reliably endorsed ADHD criteria via the ABC and if their WURS scores were consistent with their initial classification. In total, 33 subjects were included in the analogue ADHD group and 29 served as controls.

The Current Findings

The results partially support the predictions in that analogue ADHD subjects perform significantly more poorly on measures of focused and sustained attention as compared to controls. Measures of encoding/manipulation and impulsivity did not significantly differ between groups. When all four factors of attention are considered together, they are much better at distinguishing between the two groups. Interestingly, the BSI scales were significantly higher for the subjects in the ADHD group. Given the differences in scores on the BSI, the GSI score was entered into the equation with the other four factors. With the GSI included, the equation correctly classified all subjects.

Group Differences in Performance on Measures of Focused Attention. As discussed in Chapter 1, individuals with ADHD often have significant difficulty focusing on certain tasks, even for relatively short periods of time (Barkley, 1997). Analogue ADHD subjects performed significantly poorer on measures of focused attention which included the Stroop Index, Digit Symbol and Trails A & B. This supports the idea that individuals with ADHD have more difficulty with tasks requiring focused attention. The analysis showed that the Stroop Index was the most significant contributor to this model and was of such a

magnitude that it may offer the clinician a tool for the assessment of ADHD. In contrast, the Trails data offered no statistical difference between the two groups. In fact, a comparison of the average time to complete Trails A indicated that the analogue ADHD subjects actually performed better than the control group on this particular task.

Group Differences in Performance on Measures of Encoding and Manipulation. As discussed in Chapter 1, individuals with ADHD often have difficulty with encoding information (Barkley, 1997). Although it was predicted that the ADHD group would perform statistically poorer on measures of encoding and manipulation, this was not shown to be true. The analogue ADHD group did not perform statistically differently from the control group on either of the WAIS-R subtests. In fact, although not significant, the ADHD group actually performed better on one of these measures than the control group. Although not substantiated in the literature, it is possible that the subjects in the ADHD group in this study being compromised of college students, represents a subset of individuals with ADHD who are higher functioning than those in the general population. These subjects may have developed coping strategies that allow them to function at a university level. Their scores on the WURS suggest that the severity of subjects is in the range of non-university subjects in other studies. If true, these students might very well prove to be brighter than the people with ADHD in the general population of students found on a college campus. This may be an avenue for further research.

Group Differences in Performance on Measures of Sustained Attention. As previously discussed, ADHD adults often have difficulty with tasks requiring sustained attention and the results of this study substantiate this theory (Barkley, 1997). Both the omission error rate from the CPT and the delta score were individually found to be statistically different

between the groups. The omission error rate analysis showed that the Analogue ADHD subjects committed more errors than the control subjects. This finding supports the idea that individuals with ADHD have more difficulty with tasks requiring sustained attention. Although statistically significant, the group difference between the Analogue ADHD group and their counterparts amounted to less than two errors during the part of the CPT test utilized for this measure. Thus, it is unlikely that this variable will prove to be very useful to the clinician. However, the delta score indicated that the Analogue ADHD subjects showed a decline in performance over time (Delta = -0.46). Whereas the control group improved with practice (Delta = 2.04). Such trends may assist in the assessment of ADHD in a clinical setting.

Group Differences in Performance on Measures of Impulsivity. As previously mentioned, individuals with ADHD are often found to be impulsive. However, the results from this study did not show that the two groups had statistically different commission error rates on the CPT-II. Again, it is possible the lack of difference between groups may be due to the college ADHD population being a particular subset of the general ADHD population, or it may be that commission error rates from the CPT are not ecologically valid indicators of impulsivity. Whatever the explanation, this measure is not useful in distinguishing between the two groups.

Group Differences on the Brief Symptom Inventory. Noteworthy was the findings of differences in BSI scores between the subjects in the ADHD group and the subjects in the control group. Previous research has shown that ADHD clients score higher on some scales of the BSI (Johnson, Lyonfields & Miller, 1999). Barkley (1997) also indicates that ADHD adults can experience a significant degree of affective disturbance. The presence of

elevated BSI scores may support this conclusion. It may also indicate that the screening procedures used to identify individuals with ADHD symptomology actually identified students with comorbid disorders or with other difficulties resembling ADHD. Because the WURS has previously been found to discriminate between individuals with ADHD and individuals with other psychiatric disorders (Wender, 1995), it is likely that these results indicate that this subset of the ADHD population is experiencing more affective difficulties. However, without further information, this conclusion cannot definitively be made.

Combined Models

When the above measures of focused attention, encoding/manipulation, sustained attention and impulsivity are used in a logistic regression model, it predicts group membership at a level well above chance. In fact, several of the variables that did not significantly contribute to the individual factor models were statistically significant in the combined equation. This suggests that the two groups differ significantly on overall functioning of attention. Individual factor models correctly classified between 60 and 67% of the subjects, whereas the combined model without the GSI classified 82% of the subjects. This would argue for inclusion of all the factors in an assessment of ADHD.

When the above measures are combined with the BSI scores, the model is found to perfectly predict group membership. Because the addition of the BSI significantly increases the prediction power of the equation, it is concluded that the BSI score is useful in assessing ADHD. This further supports the earlier findings that individuals with ADHD experience greater psychological symptoms, although they may not be severe enough to warrant additional diagnoses.

Relevance to Clinical Assessment of ADHD

Although the separate factors of encoding/manipulation and impulsivity were not significant, clearly they contributed to the overall model and would be useful in assessing for ADHD. This is clearly demonstrated by the fact that the combined model predicted group membership more accurately and by the fact that these two factors were significant in their contribution to the combined model.

Close inspection of the data reveals that not all of the differences in performance were clinically distinct, in spite of their statistical significance. Although many of the differences may not be large on these tests, the pattern of test scores may be the best approach to diagnosis. This is especially true in light of the fact that the subjects in this sample may have been higher functioning. It is possible that if these tests were used with a broader range of people then they might show greater significance.

Also, the BSI scores are a significant predictor of group membership. This reinforces many research studies that have shown that people with ADHD experience greater psychological symptoms. In fact, if this is a higher functioning group of subjects, their BSI scores may underestimate what would be found in the overall population of people with ADHD. Thus, it will be important to gather information regarding psychological symptoms either through testing or via interview when assessing for ADHD.

Summary of the Findings

In summary, this study found significant group differences between the control and ADHD group on measures of focused and sustained attention. Other measures of attentional components, namely encoding/manipulation and impulsivity, produced no such

differences. When viewed as a whole, the measures produced statistically significant differences between the ADHD and control groups.

The groups also differed on measures of psychological distress. Specifically, the ADHD group significantly elevated all nine of the dimensions of the BSI as well as the Global Severity Indices. Clearly the ADHD group was endorsing significant psychological distress as compared to the control group.

Review of the Current Study

The primary mission of the current study was to identify which aspects of attention are compromised in individuals with ADHD symptomology. Subjects identified as Analogue ADHD subjects using self report measures and others serving as a control group were placed through a battery of tests modeled after Mirsky's and Barkley's recommended protocols. This test battery evaluated four aspects of attention using assessment tools commonly available to clinicians. These aspects included: Focused Attention, Encoding/Manipulation, Sustained Attention and Impulsivity. Previous research using these models has identified specific deficits in attention unique to specific disorders.

The results of this study suggest that Analogue ADHD subjects perform more poorly than controls on measures of Focused and Sustained Attention. Their performance on measures of Impulsivity and Encoding/Manipulation was not statistically distinguishable from the control group. If future research substantiates the current findings, measures used in assessing aspects of Focused and Sustained Attention might prove to be useful tools in evaluating individuals with ADHD symptoms. Results of this study also suggest that all four factors of attention, when placed in a model developed via logistic regression, accurately identify approximately 82% of the subjects in the study. This suggests that using

assessment using individual factors of attention is not as useful as utilizing the combined model, as all four factors of attention significantly contribute to the combined model.

Due to the possibility of comorbid symptoms in the Analogue ADHD population, subjects were administered the BSI assess the level of affective disturbance in the population. The level of such disturbance was significant in the Analogue ADHD population as compared to the control group. When the GSI score from the BSI was added to the four factors of attention, a logistic regression equation was developed that perfectly predicted group membership. Thus assessment of affective symptoms contributes significantly to the assessment of ADHD. The current research supports the theory that individuals with ADHD have difficulty with all aspects of attention and also experience significant affective disturbances.

Limitations of the Study

As mentioned earlier, without a clear understanding of the etiology of ADHD, obtaining a homogeneous sample to assess the specific attentional difficulties present in the disorder is difficult. Research suggests that ADHD itself is likely comprised of many subgroups whose clinical manifestations are similar, but whose disorders originate from a variety of factors. Because it is, to date, impossible to obtain a homogenous sample, the possible presence of multiple subgroups in this study may serve to diminish effects that may be observed if a purer sample could be obtained. Thus, the generalizability of this study to specific clients is called into question.

Another limiting factor may be the analogue nature of the subjects. Although the WURS has been shown to distinguish between those meeting criteria for ADHD and other disorders and the ABC requires endorsement of DSM-IV criteria in order to be included in

the ADHD subject pool, the lack of external verification of symptoms and a clinical interview make this distinction somewhat less accurate than what would be seen in a clinical assessment. Also, these questionnaires do not rule out the presence of those with additional diagnoses as does the more aggressive diagnostic procedures. Thus this study may include subjects whose diagnosis of ADHD is secondary to another syndrome which may affect their response patterns. This may account for the significant role of the BSI scores

Another limitation inherent in this study is the selection of a college based population, which, by definition, represents a skewed sampling of the ADHD population. Although the use of a college sample may limit the number of ADHD subjects with comorbid learning disabilities and comorbid psychiatric difficulties (Heiligenstein, Guenther, Levy, Savino & Fulwiler, 1999), these hypotheses were not verified in the current study.

Despite its usefulness, the BSI does not elucidate the mechanisms underlying the problems it identifies. Therefore it is uncertain as to whether the ADHD subjects in this study were experiencing heightened psychological distress due to psychosocial stressors related to their ADHD symptomolgy, or whether the WURS failed to differentiate between clients with ADHD and clients with attention problems resulting from other psychiatric dysfunction. Although the WURS purports to be able to accurately distinguish between ADHD and other psychological difficulties, other studies of ADHD adults have not produced such significant differences (Heiligenstein et al., 1999). Future studies may benefit from the use of clinical samples that would allow researchers to alleviate the problem of differential diagnosis.

Strengths of the Study

While the shortcomings listed above are significant, it is believed that they do not overshadow the positive aspects of the project. The project contributed to the ongoing study of attention problems in various populations first begun by Mirsky. His work is valued as it contributes to the understanding of various disorders. In addition, his assessment battery has purposely been chosen to include assessment tools that are readily available to the clinician.

While the limitations and methodological flaws existed, the conceptual and empirical findings of the project most certainly advanced the state of research in the area of attention deficits in individuals with ADHD symptomolgy.

Future Considerations

One aspect not addressed in this study is the fact that subjects were essentially 'forced' to focus on various tasks, making them effortful. This effort may be analogous to some difficulties experienced by ADHD clients, but not necessarily to others. For example, ADHD college students may be 'forced' to encode information for an upcoming tests, however, it is difficult to assess other less purposeful aspects of attentional processes experienced by ADHD clients, for example, encoding the placement of one's keys when one walks in the door. The ecological validity of these tasks on companions of attention is unknown and worthy of future study

Future studies may attempt to utilize this same procedure with a clinical sample of ADHD adults in order to further develop a clinically appropriate regression equation. In addition, the current instruments will need to be evaluated in terms of how they relate to Barkley's latest theory. Specifically, since his 1990 theory outlining the type assessment

measures clinicians might find useful in evaluating difficulties with attention; he has since reconceptualized ADHD as being related to difficulties with executive functioning. If proven true, the factors utilized in Mirsky's theory of attention and in Barkley's previous theory will require a fresh look, and may even be renamed in terms of types of executive functioning. No matter what label is eventually given to the factors assessed by this study, it is clear that further research in this area may eventually assist clinicians in the diagnosis of ADHD.

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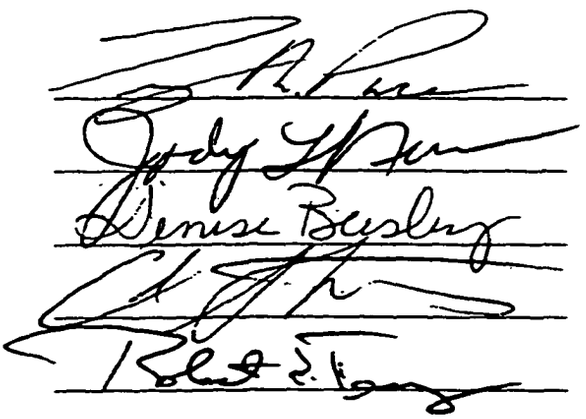
Appendix A

Prospectus

DISCRIMINATE VALIDITY OF MEASURES OF FOUR FACTORS OF ATTENTION ON ANALOGUE ADHD COLLEGE STUDENTS

A Dissertation Proposal APPROVED FOR THE
DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

BY



Chapter 1

Introduction

1.1. Historical Background of ADHD Diagnosis

Attention-Deficit/Hyperactivity Disorder (ADHD) is the most common behavior disorder found in children and affects 3 to 5 percent of the school age population. While it was thought that children 'outgrew' ADHD during adolescence, more recent research suggests that up to 50% experience significant sequela as adults (e.g. Nadeau, 1995; Weiss & Hechtmen, 1993). Untreated adult ADHD has been associated with increased risk for depression, anxiety disorders, substance abuse, academic/occupational difficulties, auto accidents, and relationship conflicts (Barkley, 1990).

While the DSM-IV (APA, 1994) recognizes that ADHD can occur in adults, the diagnosis for adults is based upon the same symptoms and criteria used with children. This is problematic given that the DSM-IV field trials did not include any adults in their sample (Lahey et al., 1994). Barkley has also suggested that when 'one size fits all' approaches are used to diagnose ADHD in all age groups, one may over diagnose young children and under diagnose adults. He proposed requiring fewer symptoms to be present for diagnosis of adults in order to compensate for this methodological flaw. Johnson and Lyonfields (1995), however, showed that the magnitude of this reduction in the requisite symptoms varies according to gender and ADHD subtype.

The problem with the DSM-IV diagnostic criteria has been compounded by recent media attention that has greatly heightened public awareness of adult ADHD. Schaffer

(1994) has referred to adult ADHD as the 'foremost self-diagnosed condition' in many clinical practices. Jaffe (1995) wrote that its heightened recognition and politicalization places ADHD at risk for becoming a 'diagnosis de joir.' At the University of Oklahoma, the number of requests for ADHD evaluations has increased 300% in the early 1990's (University of Oklahoma Counseling Clinic records, 1998). These figures appear to be consistent with data collected from colleges nationally (HEALTH, 1993). Given the rapid increase in the number of college students seeking assistance for ADHD, counseling centers, training clinics and private practices, are increasingly likely to encounter clients where ADHD is a possible diagnosis. Given the aforementioned difficulties in applying the DSM-IV criteria to adults, assessment tools that aid in diagnosis of ADHD are clearly needed.

Assessment based upon validated models of attention might aid in the clinical diagnosis of clients with ADHD. Attention dysfunction is a component of numerous psychological disorders such as schizophrenia, Attention Deficit/Hyperactivity Disorder (ADHD), and dysthymia (American Psychiatric Association, 1994). Yet the type of attentional dysfunction present in each of these disorders may be quite different. Therefore clinicians attempting to determine if a client suffers from actual neurologically based attention problems as opposed to an affective disorder that produces attention problems must do so using an approach tapping all aspects of attention. By approaching assessment in this manner, clinicians may begin to draw a clearer picture of the specific aspects of attention that are unique to a diagnosis or, more specifically, problematic for a client.

As mentioned earlier, attentional difficulties are purported to be a primary characteristic of a wide range of psychiatric disorders, however, recently researchers have begun to pinpoint differing types of attentional deficits in some disorders. For example, Mirsky has found that patients with absence seizures perform poorly on measures of sustained attention relative to both normal and partial-complex seizures, whereas individuals with partial-complex seizures performed worse than the other two groups on measures of shifting attention and focused attention. Using a similar approach he found that there were differences in attentional deficits between children labeled "abnormally aggressive" and "abnormally shy" (Mirsky, 1996). Specifically, he discovered that children rated as having poor concentration and as being "abnormally shy" were significantly worse than control children on measures of sustained attention, whereas those children with poor concentration labeled "abnormally aggressive" were found to have greater difficulty inhibiting their response. Furthermore, Streissguth et al. (1994) have raised the intriguing question as to whether the nature of attention dysfunction within a single patient group may vary at different times in development in his assessment of patients with fetal-alcohol exposure (Mirsky,1996). Such studies reveal that specific disorders may have detectable patterns of attention problems and that these patterns may vary by age of the client. The purpose of this study is to discover which aspects of attention are problematic for ADHD college students. This information is to be obtained utilizing widely available measures of attention validated in neuropsychological models of attention. If ADHD adults exhibit specific deficits in attention as compared to controls and if such deficits are both statistically and clinically significant, clinicians might find it useful to test for such deficits to aid in proper diagnosis of ADHD.

1.2. The Concept of Attention

The concept of attention is a global psychological construct that has been the subject of much scientific investigation over the past hundred years (Douglas, 1983, James, 1898, Mirsky, 1987, Posner, 1988 & Tichner, 1924, Zomeren & Brouwer, 1994). It's rich history is due to the fact that nearly all forms of cognitive functioning involve some aspect of attention.

In 1898 William James defined attention as, "the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatter-brained state which in French is called distraction ...One principle object comes then into focus of consciousness, others are temporarily suppressed (James, 1898 pp. 261-262)." Other researchers have also attempted to define what is attention. Tichener (1924) stated, " Consciousness in attention is patterned or arranged into focus and margin, foreground and background, center and periphery. And the difference between the processes at the focus and the processes in the margin is essentially, a difference of clearness: the central area of consciousness lies clear, the more remote regions are obscure. In this fact we have, indeed, the key to the whole problem of attention." (p. 267) Gibson and Rader (1979) later defined attention as "perceiving in relation to a goal, internally or externally motivated" (p.2).

In whole, one's ability to attend to the environment is ultimately tied to the notion of attention. However, researchers have failed to agree on an operational definition of the term. In fact, current models of attention have moved away from attempting to define the concept of attention as a unidimensional construct and have instead offered various multidimensional models (Barkley, 1990; Halperin, 1996; Kindlon, 1998; Morris, 1996). This trend has allowed for greater clarification of terms, specification of measurement and empirical validation of each of a host of relevant theoretical models exploring attention. These theories approach the conceptualization of attention from different frameworks that have been subsumed under the areas of information processing, behavioral and neuropsychological (Barkley, 1996). The specific dimensions studied are unique to each model. Informational processing and behavioral theories will be briefly reviewed in the study, as they add dimension to the understanding of the idea of attention as well as offer some direction in the treatment of attention deficits, however, they offer little with regard to clinical assessment. The neuropsychological model, will be discussed in depth, as it lays the foundation for this study.

1.3. Information Processing Models of Attention

An investigator's basic approach to validating models of attention using the information processing theoretical framework relates to mental chronometry. In other words, the influence of variations in task demands on the reaction times of individuals serves to validate hypotheses regarding how attention is prioritized and allocated (van Zomeren & Brouwer, 1994). Constructs defined in the information processing theories

generally include selective, divided and sustained attention. Selection is the ability to focus one's attention at a particular stimulus as opposed to dividing it between different stimuli (Sergeant, 1996). Selective attention may be conceptualized as a general pool of energy that is limited, but can be divided between several simultaneous demands (Gopher & Navon, 1980, Norman & Bobrow, 1975; Wickens, 1984). Tasks require effort for them to be performed and resources are allocated according to the demands that they place upon the central resource pool. The attention system is designed to assign priority to certain tasks and divide remaining resources between others. Gopher and Navon (1980) refer to this idea as the 'economy of processing.' Because this allocation of resources clearly involves some volitional control, attention itself is intimately tied with executive functioning. In order to study this concept, researchers have designed a multitude of dual tasks paradigms, requiring subjects to process two tasks simultaneously (i.e., Gopher & Navon, 1980; Posner & Boies 1971; van Zomeren & Brouwer, 1994). The concept of 'divided attention' is only one aspect of the broader concept of selective attention.

Sustained attention is the ability to maintain performance over time (Sergeant, 1996). Sustained attention generally focuses on two vigilance measures, namely, perceptual sensitivity (d') and response bias (Beta). These measures, plotted over time, are purported to measure sustained attention. A decline in perceptual sensitivity is the classic index of sustained attention in this model (Warm, 1984). These values are calculated via complex mathematical equations obtained from the time it takes for one to respond to a task.

A critical problem for the application of the above constructs is the lack of good psychometric data for the large number of tasks used by cognitive psychologists to test the subtleties of their theories (Lyon, 1994, Sergeant 1996). Until these become available, clinicians will be required to use more commonly available psychological tests. However, Sergeant (1996) warns against the use of clinical psychometric tests for research on group differences in attention processing. He purports that such tests have both latency and errors that can be the product of a wide variety of processes. He uses the term latency to mean the delay one has in responding. In addition he uses the term errors to mean the number of times the subjects does not respond correctly. Tests that are purported to measures attention can be effected by a speed-accuracy trade off and therefore yield an impure measure of attention. Sergeant concedes, however, that better measures of attention developed by cognitive psychologists are not commonly available to the clinician.

1.4. Behavioral Models of Attention

Whereas the information processing models of attention focus on the allocation of attentional resources, the behavioral models focus on reinforcement principles. Skinner (1953) defined attention as a functional relationship between stimuli and response rather than a mental function. According to the behavioral models of attention, the way an organism responds has to do with immediate consequences associated with responding as well as the relevant learning history associated with the organism. As might be expected, many behaviorists view the concept of attention with caution. Some perceive that the term 'attention' has been used too broadly and, subsequently, find the term to be superfluous (McIlvane, Dube & Callahan 1996). Many such behaviorists find it more appropriate to

discuss the concept of attention in terms such as 'the establishment and maintenance of stimulus control.'

Stimulus control is shown when a stimulus influences some aspect of an organism's behavior (McIlvane, Dube & Callahan, 1996). It is demonstrated when an organism has 'attended' to the stimuli. Many variables may influence stimulus control development. The stimulus itself can vary by complexity or modality, behavior can vary by duration and type. Consequences vary by type and schedule. In addition to this complex system, the modulating aspects of the organism itself can affect the system. Such variables include the age, gender or genetic make-up of the organism. Finally, behaviorists studying attending behavior consider three types of events: antecedents, behaviors and consequences. Each of these events may influence the other two. The behavioral model of attention differs from the other models in that it assumes that attention is more malleable. Whereas neuropsychologists and cognitive psychologists see attention as being dependent upon a host of intact neural networks, behaviorists see it as being dependent upon the aforementioned event contingencies (McIlvane, Dube & Callahan, 1996). The assumption that dimensions of attention are related to situational variables rather than pervasive response styles, makes this model difficult to adapt to clinical assessment. Such constructs may be of more utility in the treatment of such disorders rather than assessment.

Practically speaking, such variables are usually collected during the interview portion of an assessment rather than through psychometric tests. However, some experiments suggest that some behavioral techniques might eventually offer some diagnostic information to the clinician. For example, behavioral experiments demonstrating the

. potential for extending stimulus control shaping methods to produce generalized attending behavior on particular tasks (Dube et al., 1992; McIlvane, Dube, Kledaras, Iennaco & Stoddard, 1990) initially appear to offer valuable information in the assessment of individuals with attention deficits. In one such experiment the attending behavior of some of the subjects was modified through a procedure referred to as one-trial discriminate learning so that they could more accurately discriminate between stimuli (Dube et al., 1992). Some subgroups exposed to this method did not improve their attending behavior beyond a certain low-lying threshold while others made dramatic improvements and increased formerly poor attending behavior to almost normative levels. Although one can imagine how such a procedure might eventually aid in differentiating those who could benefit from types of behavioral treatment and those who may not, such assessment procedures would be cumbersome and, to date, no established protocol or normative data is offered. As such, the model chosen to provide structure to this study is the neuropsychological model.

1.5. Neuropsychological Constructs of Attention

Neuropsychological models are based largely on a evolutionary-developmental perspective (Halperin, 1996). They highlight the fact that attention to the environment is necessary for survival of all creatures and must therefore be mediated by very primitive subcortical structures. Although the majority of one's attentional systems are hypothetically associated with what is referred to as the reptilian brain or the R-complex, this model posits that additional attentional processes have become differentiated and articulated as the brain has developed over evolution, and that parts of the limbic and

neocortical structures also play a role in an organism's behavior (MacLean, 1990). The degree of brain differentiation delineated by the various neuropsychological models is directly related to the working definition of attention embraced by each. For instance, the more general the model is in its delineation of the brain, the more general it is in defining attention. A neuropsychological model that is more specific about its conceptualization of the brain, the more specific it can be about investigating the types of attentional processes.

The working definition of attention one uses from the field of neuropsychology depends upon the specific question being posed. In general, however, a distinction can be made between two differing concepts of attention, namely the "capacity" concept and the "mechanistic" concept (van Zomeren & Brouwer, 1994). The capacity concept presumes that task performance depends upon the use of just one or a few diffuse attentional resources. It emphasizes the mass effect of brain damage on attention. The capacity concept, in general, states that less brain power means fewer neurons which in turn means diminished resources.

In contrast, a mechanistic viewpoint posits that specific types of attention are dictated by specific systems of cerebral hardware and, as such, each aspect of attention should be studied separately (van Zomeren & Brouwer, 1994). These researchers focus upon the effect of specific brain lesions on the different processes of attention. The model embraced to assess for differences between ADHD college students and a controlled population depends upon whether one conceptualizes ADHD as a global deficit or a more specific disorder of attention.

A mechanistic model of attention posits that the functions of attention have become differentiated and articulated in the brain through the course of evolution. (Mirsky, 1996). Evidence has shown that mental operations involved in various types of cognitive processing are localized in distinct regions of the brain and that task performance requires coordination of these operations into a system (van Zomeren & Brouwer, 1994). Specifically, attentional processes result from coordination of several elements linked into such a system (Heilman, Watson, Valenstein, Damasio, 1983; Mesulam, 1987; Mirsky, 1987; Posner, 1988). Several integrated theories conceptualize attention as the integrated action of different structures of the brain (Mesulam, 1981; Posner & Petersen, 1990; Struss & Benson, 1986).

A representation of proposed attention systems to specific brain regions was proposed by Mirsky and his colleagues (Mirsky, Anthony, Duncan, Ahearn & Kellam, 1991). They originally proposed four elements or factors of attention including 'focus/execute,' 'sustain,' 'shift' and 'encode.' Through extensive research and statistical analysis they have confirmed that these elements of attention exist. Further they have shown that it is useful to consider attention as a multifaceted process or capacity, different components of which may be comprised in different disorders (Mirsky, 1996).

Mirsky's model (1996) hypothesizes that these aforementioned components of attention may be supported by different brain regions that have become specialized for this purpose. Mirsky's theory states that the function of short-term focusing on environmental events is

shared by the superior temporal and inferior parietal cortices as well as by structures that compromise the corpus striatum. Sustaining focus on some aspect of the environment is the major responsibility of the rostral midbrain structures, including the mesopontine reticular formation and midline and reticular thalamic nuclei. Encoding of stimuli is dependent upon the hippocampus and amygdala. The capacity to shift attention from one aspect of the environment to another is supported by the prefrontal cortex including the anterior cingulate gyrus. Finally, the model speculates that damage in any one of these brain regions can lead to specific deficits in a particular attention function. Mirsky's theory does not imply that specialization is absolute, rather, that some structures may substitute for others in the event of an injury. Although other models examining the components of attention exist, the Mirsky model is unique in that it was stimulated by and validated by neuropsychological tests used in clinical practice. Therefore each component of the model has commonly available neuropsychological tests that are purported to assess the respective brain systems.

1.5.1. ADHD as a Capacity Construct

Initially, global brain damage was proposed to be the chief cause of ADHD symptoms (Barkley, 1990). The damage was purportedly caused by brain infections, trauma, or other injuries or complications that occurred during pregnancy or delivery. Although it is true that brain damage such as hypoxic/anoxic injuries to the brain are associated with increased deficits in attention as well as with increased hyperactivity (Cruikshank, Eliason & Merrifield, 1988) such injuries are not present in the majority of ADHD clients (Barkley, 1990). Less than 5% of ADHD clients have hard neurological findings indicative of actual

brain damage (Barkley, 1990). Further, no differences in brain structure has been discovered via computer tomography scan analysis (CT scans) (Denckla, Lemay & Chapman, 1985). Although certain types of trauma may give rise to an ADHD diagnosis these do not account for the vast majority of ADHD client's disorders.

In addition to their problems with inattention, impulsivity and overactivity, clients with ADHD may present with a variety of other difficulties. These include an increased likelihood of having other medical, developmental, behavioral, emotional or academic problems. Specifically, ADHD clients are more likely to have a learning disorder, that is a significant discrepancy between one's intellectual capacity and one's academic achievement such as reading, math, handwriting and language. They are likely to lag behind both normal children and their own siblings in their intellectual development, scoring 7 to 15 points below their own siblings on standardized intelligence tests (Barkley & Karlsson, 1985; McGee, Williams Moffitt & Anderson, 1989). However, it is not as yet clear whether these differences represent real intellectual differences or merely differences in test-taking behavior, as inattentiveness to task would naturally produce lower test scores. Finally, some studies have noted a greater incidence of maternal health and prenatal complications such as toxemia and pre-clampsia, post-maturity and fetal distress for the subjects with ADHD as compared to non-diagnosed individuals (Hartsough & Lambert, 1991). Such findings may suggest that ADHD is a result of a more global brain deficit. However, not all ADHD children display such problems, nor are they diagnostically significant. Their presence is not, in and of itself, diagnostic of ADHD, nor does their absence rule out the diagnosis. The many different definitions of attention, the low

correlation between performance on different attention tasks and its correlation with concepts such as problem solving, memory and perception all demonstrate that attention cannot be viewed as single global concept (Parasuraman & Davis, 1984; Van Zomeren & Brouwer, 1994). Such evidence does not legitimize conceptualizing ADHD as resulting from global brain damage.

1.5.2. ADHD as a Mechanistic Construct

Recent findings have pointed to a more specific problem with central nervous system mechanisms in subjects with ADHD (Barkley, 1990). This is most likely in the connections between the prefrontal areas and the limbic system, especially in the striatum (Heilman et al 1991; Lou et al, 1984, 1989; Zametkin & Rapoport, 1986). These areas of the brain are known to be related to response inhibition, inattention and sensitivity to reinforcement.

Some studies have demonstrated abnormal activity in these regions of the brain in ADHD children. First, Lou and colleagues (1984, 1989) have studied cerebral blood flow to the brain and have found diminished perfusion to the striatum and orbital prefrontal regions of ADHD subjects. Also, a study by James Satterfield, (cited in Barkley, 1990) has shown that ADHD children display less electrical activation in their prefrontal and frontal-limbic regions. Other studies have shown that such children perform differently on neuropsychological tests assessing frontal lobe functioning (Barkley, 1990). In summary, it is likely that ADHD is related to underactivity of the prefrontal-striatal-limbic regions and their rich interconnections.

Another study by Giedd and colleagues (1994) used the technique of magnetic resonance imaging (MRI) to examine the corpus callosum in samples of ADHD boys. They found that the two anterior regions, the rostrum and the rostral body were significantly smaller in ADHD boys. The authors suggested this was evidence of abnormal frontal lobe development and functioning in ADHD children.

Another line of research investigated the possibility that a genetic abnormality alters catecholaminergic functioning. Wender (1972, 1994; Wender et al., 1983) and other researchers (Reimherr et al. 1987; Wood et al 1982, 1983, 1985) have focused on dopamine depletion. Raskin and colleagues examined cerebral spinal fluid in subjects diagnosed with ADHD and those who were undiagnosed. They found decreased brain dopamine in ADHD children (Raskin, Shaywitz, Anderson, & Cohen, 1984). This hypothesis ties in nicely with the previously mentioned studies citing differences between ADHD and controls in the prefrontal and striatum areas, the most dopamine rich areas of the brain (Barkley, 1990).

In spite of these findings there is strong evidence that subjects diagnosed with ADHD are a heterogeneous group. This evidence is primarily based upon the fact that there is considerable variation in drug response. Some patients, clinically indistinguishable from others, do not respond to stimulants (Barkley, 1990). Others respond differently to D-amphetamine than they do to methylphenidate (Barkley, 1990). Others have a robust response to tricyclic antidepressants (Wender, 1994). The most conservative hypothesis to

date is that the syndrome may be caused by several different abnormalities that can be corrected to varying degrees by different medications.

1.5.3. Difficulties Studying Mechanisms of Attention in ADHD

A legitimate problem arises from the conceptualization of ADHD adults as a homogeneous group. Lumping individuals with similar symptomology in studies may obscure results that would be obtained if a more homogeneous group, perhaps based upon a common etiology, were used. In truth, researchers are still investigating the contribution of both environmental and genetic factors on the expression of ADHD. According the Wender (1994), researchers have not been able to find a distinct etiology for ADHD, perhaps because to meaningfully examine an etiology one must first have a homogeneous sample. However, having a homogeneous sample requires knowledge of the etiology. This problem is not unique to ADHD. In the medical field there are certain disorders that are produced by one of many genetic abnormalities. This problem, referred to as 'genetic heterogeneity' means that researchers investigating a particular disorder might be studying a group of patients with etiologies from different genetic causes. Similarly, some disorders, such as hemophilia, a disease cause by an X-linked recessive gene, have what is called a phenocopy, or an environmentally produced equivalent. In the case of hemophilia, a vitamin K deficiency will produce similar symptomology. Identification of such subgroups would be critical when studying the manifestations of these two disorders. A related problem in the assessment of disorders with unclear etiologies is the idea of 'pleiotropism' in which at least one genetic abnormality produces multiple and different effects. Finally, another etiology complication emerges because in spite of having the same genetic loading

and psychological experience, different individuals may exhibit variable expression or manifestation of symptoms to a greater or lesser degree. Ideally a clearer understanding of ADHD etiology would help researchers to isolate a homogeneous group of subjects.

Studies have shown that there are major genetic contribution to ADHD, as the concordance of ADHD in monozygotic twins is as high as it is for other biological conditions (Wender, 1994). In addition there appears to be little environmental contribution to it, as shown by the fact that family factors generally contribute only 10 % of the variance in its expression (Deutsch, 1983). Research has also shown that there are some nongenetic phenocopies of ADHD produced by environmental agents. For example, in the 1910's and 1920's there emerged an ADHD-like disorder now referred to as von Economo's Encephalitis that causes behavioral difficulties in children including: irritability, restlessness, disobedience, not being amenable to discipline and emotional instability (Hohman, 1922). In short this viral infection mimicked the syndrome of ADHD. Other environmental causes might include such factors as maternal use of alcohol and smoking during pregnancy (Bennet et al, 1988; Shaywitz et al, 1980; & Streissguth et al, 1984). As mentioned earlier, although the vast majority of ADHD clients endorse no such history, it is impossible to date to verify the specific etiology of the disorder and, as such, one risks having a heterogeneous sample with a variety of specific brain dysfucntions that produce ADHD symptoms.

1.6. Neuropsychological Models of Attention

As mentioned earlier, models developed by researchers such as Allan Mirsky (1996) and Russel Barkley (1996) using a neuropsychological perspective are of interest to clinicians because they operationalize and validate aspects of attention using widely available assessment instruments. Although competing models of attention exist apart form Mirsky's and Barkley's (Cooley & Morris, 1990, Gibson & Rader, 1979; Kahneman, 1973; Mesulam, 1987, Posner, 1988; Shiffrin, 1988), these models are of limited clinical utility at the present time.

Even within the neuropsychological framework there exists many different models of attention. Barkley (1993) summarized the commonly cited aspects of attention as being: 1.) arousal and alertness 2.) focused attention, 3.) sustained attention, 4.) divided attention, 5.) shifting attention, 6.) distractibility, 7.) inhibition and 8.) span of apprehension, though most models of attention do not address all of these factors. Morris (1996) surveyed articles appearing in six well respected journals that routinely published research relevant to learning disabilities. He discovered that over a five year span these articles discussed over 25 different measures of attention, 15 measures of memory and 20 measures of executive functioning. However, none of these measures were categorically unique. In sum, the majority of these models define attention as a multidimensional construct that includes overlapping dimensions of memory and executive functioning.

There are a staggering array of measures used to assess attention. These developments are driven in part by the explosion of technology and in part by the need for a specific instrument created for the study of different paradigms of attentional processes. Among the more common measures of attention are continuous performance tests (and a host of associated variables), subsets from intelligence tests, maze completion, direct observations, and many other information processing paradigms (Barkley, 1996). The specific measures used for the following study have been chosen in part for their accessibility to the clinicians and, most importantly, for their empirical validation in the models highlighted in this research.

1.6.1. Mirsky's Model of Attention

One of the more extensively studied models of attention has been developed by Mirsky (1987). He has studied attention extensively and has subsequently provided a clinically useful model for conceptualizing various components of attention. He has proposed four major components of attention including: 'focus-execute,' 'sustain', 'encode' and 'shift' (Mirsky, 1987). These four areas of attention have been used in the investigation of attentional processes with normal and psychologically impaired children and adults (Mirsky, 1987; Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Zubin, 1975). Mirsky's components of attention are used primarily in evaluating which aspects of attention are problematic for certain populations by utilizing common assessment instruments.

Mirsky and his associates provided empirical evidence for their model of attention based upon separate and combined factor analyses of large samples of adults and children using a battery of neuropsychological tests presumed to assess attention (Mirsky, 1988; Mirsky et al, 1991; Mirsky Silberman, Latz & Nagler, 1985; Nagler & Mirsky, 1985). These tests are referred to as the Laboratory of Psychological and Psychopathology-National Institute of Mental Health (LPP-NIMH) Attention Battery. The data in support of Mirsky's model were initially derived from a factor analysis of two samples, the first consisting of 203 adult neuropsychiatric patients and respective control populations, and the second consisting of a sample of 435 second grade school children ranging in age from 7 to 9. Independent principle component analyses of test scores from these two populations yielded similar results, namely, a set of 4 elements of attention that are measured by different tests (Mirsky 1996). Since its inception the LPP-NIMH Attention Battery has been administered to a spectrum of clinical populations including patients with petit mal and complex partial seizure disorders (Duncan, 1988; Mirsky, 1991), anorexia nervosa and bulimia nervosa (Jones, Duncan, Brouwers, & Mirsky, 1991), affective disorders, and closed head injuries and to normal subjects, including a large sample of public school children (Mirsky et al., 1991). The fact that Mirsky's original findings have been utilized in diverse subject populations makes his factor model clinically useful in assessing attention in the ADHD population.

Presently the adult version of the LPP-NIMH Attention Battery includes eight standard neuropsychological measures tapping different aspects or elements of attention identified by factor analysis (Mirsky, 1987, 1988, 1989; Mirsky et al , 1991). As seen in Table 1, the

first factor, ''focus-execute,' includes loadings from four tests, including Digit Symbol Substitution, Stroop, Letter Cancellation, and Trail Making, Parts A and B. This factor seems to be comprised of two elements, a visual-perceptual ability to scan stimulus material for a preset target rapidly and efficiently as well as an ability to make either verbal (Stroop) or skilled manual responses quickly (Digit Symbol Substitution, Letter Cancellation, Trail Making). The designation 'focus-execute' for this factor is an effort to encompass both aspects of performance required for these tasks.

The second factor referred to as 'shift' is measured by a single test, the Wisconsin Card Sorting Test. It appears to reflect the abstract capacity to shift from attending to one aspect or stimulus to another in a flexible and adaptive manner. The third factor, known as 'sustained attention' has substantial loading from the performance measures derived from CPT measures. The CPT task, requiring sustained concentration for 5 to 30 minutes of time, yields measures of correct responses, commission errors and reaction times. In addition to the CPT measures, the third factor also has modest loading from the Trail-Making Test, Parts A and B, although this test's loadings on the 'shift' factor is not as high as is it on the first (focus-execute). Thus the attentive effort is also important to some extent in successful performance on the Trails Making Test.

The final factor, labeled 'encode' arises from the Digit Span and Arithmetic subtests of the Wechsler Scales. It is the least understood of the four factors. A reasonable hypothesis about this factor is offered by Mirsky (1996). He hypothesizes that this factor embodies some sort of numerical-mnemonic quality of attention, because both tasks loading on this

factor require the serial incorporation, retention, cognitive manipulation and recall of numerical information.

Table 1.1: Instruments recommended for assessing Mirsky's factors of Attention

'focus/execute'	'shift'	'sustain'	'encode'
Digit Cancellation	Wisconsin Card Sorting	CPT **	Digit Span*
Digit Symbol*			Arithmetic*
Stroop			
Trails A & B			
Letter Cancellation			

* Wechsler Scales

** (reaction time, number of correct responses, commission errors)

1.6.2. Barkley's Model of Attention

Barkley (1990) provided a model of attention similar to Mirsky's. Although Barkley's model of attention does not enjoy the extensive empirical validation of Mirsky's, but is based upon the areas of attention considered to be problematic for ADHD clients. Also, it provides an additional aspect of attention not captured by Mirsky's. Barkley's first three factors mirror Mirsky's 'focus-execute,' 'sustained' and 'encode/manipulate,' but to these he adds another factor of attention that he refers to as 'impulsivity.' This factor reflects a lack of attention to the consequences of behavior.

Barkley recommends that each aspect of attention be assessed using common psychological measures available to most clinicians. These assessment measures are similar to the ones utilized by the LPP-NIMH Attention Battery. He recommends that the component of attention that he referred to as 'focused attention' (analogous to Mirsky's focus-execute component) be assessed using the Trails A & B as well as the Wechsler Digit Symbol Subtest. Barkley also recommends that the Wechsler Digit Span and Arithmetic subtest be used for assessing what he refers to as the 'encoding/manipulation' aspect of attention, analogous to Mirsky's 'encode' factor. He also suggests using the CPT as a measure of 'sustained attention.' He explained that analysis of omission errors provided an accurate measure of sustained attention, as it documents the number of times a subject failed to attend to a target. He also recommends use of a the aforementioned factor termed d' that, when analyzed over time, can determine a change in a subject's perceptual sensitivity to changes. Warm (1984) explained that a decline in perceptual sensitivity over time is a 'classic' index of failure in sustained attention. Finally, Barkley recommend the use of a CPT for assessing the additional component of impulsivity. He reported that the number of commission errors from a continuous performance test assess the number of times a subject incorrectly responded to a nontarget, reflecting an inability to keep from responding, also conceptualized as impulsivity. A summary of Barkley's recommendations can be found in Table 1.2.

Table 1.2: Instruments recommended for assessing Barkley's factors of Attention

focused attention	encoding/manipulation	sustained attention	impulsivity

Digit Symbol*	Digit Span*	CPT , omission errors	CPT, commission
Trails A & B	Arithmetic*	d'	errors

* Wechsler Scales

Barkley's newest model conceptualizes ADHD as a disorder of self-control (Barkley, 1997). This model posits that ADHD is not a disorder of attention, but rather a problem with the executive neuropsychological function that permits self-control. Barkley's support for his model currently rests in much of the same literature mentioned in this review. However, he reinterprets measures of attention as measures of executive functioning. Barkley has even cited Mirsky's model as an example of how previous models of attention are actually measures of executive functioning. Regarding Mirsky, Barkley writes, "consider the long term programmatic research of Mirsky (1996) on the components of attention. He employs a number of measures that others have frequently interpreted as assessing executive functions, including the Stroop as well as the CPT. Among other things, such as such confusion reflects deeper problems in reaching a consensus among investigators as to the actual nature of the constructs as attention and executive functions.' (Barkley, 1997 p.110)

Barkley argues that executive functioning constitutes a special form of attention (Barkley, 1997). The term attention in Barkley's newest model defines a relationship between an event and the individual's response to it to achieve an immediate outcome. He defines executive functioning as a form of attention that enables one to control oneself in such a manner as to produce a desired future outcome. He explains that individuals with ADHD respond more readily to immediate needs whereas individuals without ADHD have

the ability to be future oriented. There is merit in redefining these terms and his model more accurately predicts and explains some of the problems with ADHD. However, even Barkley concedes that satisfactory measures of executive functioning in its purest state are currently lacking in most clinical settings. In fact, Barkley admits that even where good measures of executive functioning may exist, they are most likely less useful than other measures, such as those assessing behavioral inhibition, in detecting ADHD (Barkley, 1997). Finally, Barkley's suggesting that Mirsky's model is comprised of tests tapping executive functioning implies that Barkley's newest conceptualization of ADHD would view Mirsky's model as assessing those aspects of functioning that are problematic for individuals with ADHD.

1.7. Factors of Attention and Their Relevance to ADHD

Viewed together, Mirsky and Barkley's models provide five factors of attention relevant to the study of attentional processes in ADHD clients. The factors, referred to in this study as 'focused attention', 'sustained attention', 'encoding', 'impulsivity' and 'shift,' have been discussed by many authors and require elaboration upon not only as concepts in and of themselves, but as clinical issues for the ADHD adult. The two models provide similar conceptualizations of attention and require similar assessment methods. The convergence of the two models may provide some understanding of the attentional difficulties seen in ADHD.

1.7.1. Focused Attention and ADHD

The focus/execute element is tapped by a group of tests that capture the ability to identify important environmental stimuli and perform motor responses under conditions of

distraction for short periods of time. In practice, focused attention can be thought of as being either visual or auditory. Because both Mirsky's and Barkley's assessment batteries focus on visual focused attention, the deficits in ADHD client's auditory focused attention will not be explored in this paper. Visual focused attention is usually operationalized as visual search. Target stimuli have to be found in a field of distraction stimuli. The tasks used to assess focused attention are generally self-paced, but subjects are asked to complete them as quickly as possible (von Zomeren & Brouwer, 1994).

ADHD adults are generally thought to have difficulty with focused attention (Wender, 1994). They do poorly in situations that require them to focus on certain stimuli. They also generally lack careful attention to detail. The college ADHD adult may have persistent problems that interfere with their performance. They may have to reread text multiple times or fail to adequately proof read their own work.

1.7.2. Sustained Attention and ADHD

Sustained attention can be operationalized in a variety of ways including time on task, lapses of attention and intraindividal variability (von Zomeren & Brouwer, 1994). Because every test has an attention component to it, it is theoretically possible to extend the length of any test to assess sustained attention. However, because the clinician requires continuous information on performance over time such an assessment might prove to be laborious. Thankfully commercially available computer software provide specific information on response speed and decrement of performance over time that do not require the constant attention of a clinician. Vigilance tests of approximately 20-30 minutes

appear to be enough time to provide a noticeable decrease in signal detection (Sanders, 1983; Brouwer & Van Wolffelaar, 1985). Such tests, generally referred to as Continuous Performance Tests (CPT), play an important role in present clinical neuropsychology assessment. They are a vast improvement over initial vigilance tests in which clients were placed alone in a cubicle for 2 hours to watch a clock's hand move (N. H. Mackworth, 1950). The idea that such attentional concerns are relevant to study in ADHD adults is not surprising. ADHD adults often report they find it difficult to sit still for any length of time, sometimes finding themselves unable to sit through a TV program or movie. They often begin projects, but quickly lose interest and fail to finish them. They often have difficulty keeping their mind on things they are not of interest to them. (Wender, 1994).

1.7.3. Encoding and ADHD

Memory and attention are integrally woven together. There is overwhelming evidence that the quality of one's memory is largely determined by the amount and type of processing given to the information to be remembered (Baddeley, 1990; Craik & Lockhart, 1972). Events that escape attention cannot be remembered, but when attention is directed towards an event, even if it is not meant to be recalled, parts of that event will be placed in memory. This process is called 'incidental memory.' The amount of information learned is directly proportional to the duration and intensity of the attention given to the material (Russell, 1981). It is therefore not surprising to find individuals with ADHD to have difficulty with short-term memory. Their problems related to unfocused attention is linked to frequent complaints of losing or misplacing items, being late or forgetting appointments.

There have been findings that 'impulsivity' is related to aspects of 'working memory' involving encoding and manipulation of information (Bronowski, 1977). Since the concept of working memory is closely related to Mirsky's factor of 'encode' and Barkley's factor called 'encode/manipulation' then it seems likely that this factor would also be useful in the assessment of ADHD and should covary with measures of impulsivity.

1.7.4. Impulsivity and ADHD

Inhibition, or its antithesis, impulsivity, has been found to be linked in ways not fully understood to other important, and uniquely human brain functions, often referred to as executive functions. These include: 1.) sense of time, including hindsight and forethought; 2.) self-awareness; 3.) the internalization of language and its governance over behavior; 4.) the regulation of affect; 5.) the separation of affect from current responding and its governance over behavior (Barkley, 1996). Clinicians working closely with clients diagnosed with ADHD can often see that their clients struggle with issues related to each of the above areas. ADHD as a disorder related to impulsivity or response inhibition has greater face validity than ADHD as a disorder related to focused and sustained attention, which does not fully capture the breadth of the struggles of the ADHD client. Measures of impulsivity demonstrate a propensity to react before adequate time has been given to processing the information.

Impulsivity is one of the most striking characteristics of ADHD (Wender, 1995). In formal terminology impulsivity may be defined as an inability to delay gratification or as

having a low frustration tolerance. ADHD clients are generally seen as being impatient and becoming easily upset when things do not go as expected. They interrupt others, blurt out answers and may even be considered to be reckless (Barkely, 1990). Even as adults they act on the spur of the moment and decisions may be made without attention to the consequences.

1.7.5. Shifting Attention

The concept of shifting attention is also referred to as flexibility. Tests assessing shifting attention are meant to determine whether changing between different modes of input has a disproportionate effect on a client. By studying the changes in reaction times between changes in the delivery of stimuli, one can assess such flexibility (Benton, 1962). The study of difficulty shifting attention might prove to be a valuable avenue for further research, however, this aspect of attention was not examined in this study.

1.8. Attention Problems and Psychiatric Disorders

The literature related to adults with ADHD often warns of a host of psychiatric disorders that may be comorbid. In their large epidemiological study, Szatmari, Offord & Boyle (1989) found that 17 % of female children and 21% of male children diagnosed with ADD were found to have at least one additional psychiatric disorder. This figure rose to 24% for male and 50 % for females during the adolescent years. However, this research has shown that the vast majority of these comorbid disorders are learning or behavioral disorders as opposed to affective disorders. Although Breen and Barkley(1983) found that children diagnosed ADD also evidenced more severe symptoms of anxiety, depression, and

low self-esteem, these symptoms are thought to be a product of the struggles of living with ADHD rather than presentation of an actual comorbid disorder. In sum, ADHD children and adolescents often experience comorbid psychiatric disorders that are behavioral or developmental in nature rather than affective in nature.

It is important when studying ADHD to consider the possibility that comorbid psychological disorders may exist within such a subject pool. Such comorbid disorders may introduce uncontrolled variables that may obscure results. In a related matter, some psychological disorders may resemble ADHD especially when the diagnoses are made on the basis of self-report measures. One such diagnosis, elaborated upon by Wender (1995) is Borderline Personality Disorder. Wender explained that on the surface the two diagnoses have similar traits including: impulsivity, angry outbursts, affective instability and feelings of boredom. Subtle differences in the expression of these behaviors may aid in the differential diagnosis. For example, the ADHD client's impulsivity is short lived and situationally based. It is milder, intermittent and appears to be related to thoughtlessness, rather than compulsively driven. This differs from the BPD client's more severe and sometimes compulsive behaviors such as shoplifting and bingeing. Wender offers other comparisons that further differentiate ADHD from other clinical groups. Such differences are important to keep in mind when attempting to establish a homogeneous sample of ADHD adults.

As a disorder "depression" often refers to a constellation of behaviors including sad affect, loss of interest in activities, feelings of worthlessness and guilt, sleep disturbances,

cahnges in weight, psychomotor retardation or agitation, fatigue and diminished ability to concentrate (Kazdin, 1989). There is considerable conflict as to whether ADHD clients experience mood disorders more than their undiagnosed counterparts. Some studies have found that ADHD clients have higher ratings on scales measuring depression, while many other studies do not (Barkley, DuPaul & McMurray, 1992; Biederman, Faraone, Keenan, Knee, & Tsuang, 1989; Biederman, Munir, Knee et al., 1997). Studies examining specifically young adults and adolescents have been more consistent in showing that affective or depressive disorders are not more common in ADHD individuals (Barkley, Fischer et al., 1992; Gittelman, Mannuzza, Shenker, & Bonagura, 1995; Weiss & Hechtman, 1993). In summary, depressive disorders appear to have a low likelihood of association with ADHD. However, "depression" as a symptom may certainly punctuate the life of an ADHD client, particularly considering the populations struggles with self-esteem, peer acceptance and failures in accomplishing tasks (Barkley, 1990).

At present, research suggest that ADHD is not typically associated with anxiety disorders and that individuals with such disorders rarely have ADHD as an associated condition (Wender, 1995). Although individual with anxiety disorders manifest restlessness and have a diminished ability to concentrate, they do not typically have a pervasive pattern of behavioral disinhibiton, hyperactivity and poor sustained attention since early childhood. Moreover, those with anxiety disorders are rarely impulsive and "externalizing" whereas such behavior is commonly seen in ADHD. Finally, individuals with ADHD are typically have a history of being rejected by their peers whereas individuals with anxiety disorders are typically neglected by their peers (Barkley, 1990). Although the two conditions do not

typically occur together, anxiety is often reported by individual presenting with ADHD, presumably a result of their lifestyle (Barkley, 1990).

Differential diagnosis of ADHD and manic-depression can sometimes be difficult, especially if the individual is presenting at the same time of a manic-like episode. Nieman and Delong (1997) have shown that these disorders can readily be discriminated from each other by close examination of their symptoms. Manic clients are likely to have a long-standing history of depression, considerable emotional maladjustment and evidence of psychotic symptoms or significant disturbance in their thinking. Such individuals are generally not social and their level of aggression is considerably more deviant than those characteristic of ADHD. Finally, as always, a clear family history may prove to be invaluable in suggesting what a particular individual is predisposed to experience.

1.9 Purpose of the Study

The purpose of this study if to determine which factors of attention as defined and measured by Drs. Barkley and Mirsky are problematic for individuals with ADHD.

1.10 Hypotheses:

Using selected measures of the aforementioned factors of attention developed by Mirsky and Barkley, the following null hypotheses were developed:

1) Analogue ADHD college students will show no statistical difference in their performance on the following measures of focused attention as compared to controls: Stroop Color-Word Test, Digit Symbol and Trail A & B.

2) Analogue ADHD college students will show no statistical difference in the following measures of sustained attention as compared to controls: d' and omission errors on the CPT.

3) Analogue ADHD college students will show no statistical difference in the following measures of working memory as compared to controls: Digit Span and Arithmetic Subtest from the Weschler Adult Intelligence Scale.

4) Analogue ADHD college students will show no statistical difference in CPT commission errors, a measure of response inhibition, as compared to controls.

5) Analogue ADHD college students will show no statistical difference in BSI measures as compared to controls.

Chapter 2

Methods

2.1. Subjects

In order to utilize the criterion group design method, participants from a large southwestern university who were participating in the experiments for class credit were assigned to group membership based upon their responses to the ABC administered in a large group setting. Individuals endorsing two or fewer DSM-IV symptoms from the ABC were initially assigned to the control group. Students endorsing six or more DSM-IV symptoms from the ABC and who indicated that they had experienced such symptoms throughout their lifetime were initially assigned to the analogue ADHD group. These subjects were contacted and asked to participate in further testing. Students agreeing to participate were administered the Wender-Utah Rating Scale (WURS) and readministered the ABC. If participants consistently met DSM-IV criteria for ADHD utilizing the ABC (Johnson & Lyonfields, 1995) as well as endorsed behavioral criteria from the WURS such that they fell within the 'probable ADHD' range, the participant was placed in the ADHD group. If a participant consistently endorsed two or fewer ADHD DSM-IV criteria and scored in the 'normal' range of the Wender-Utah Rating Scale, they were placed in the control group for the study. Of the 179 subjects who were asked to participate in the second part of the study, 29 participants met criteria for being placed in the ADHD group and 33 participants met criteria for the control group.

The two groups were similar in demographic measures. The ADHD group had a mean age of 19.39 and the control group had a mean age of 18.68. The ADHD group was comprised of 31 % females and 69 % males whereas the control population was comprised

of 37 % females and 63 % males. The vast majority of participants were Caucasian. The ADHD group was comprised of 97% Caucasians, 3 % African Americans. The Control group was !00% Caucasian.

2.2. Experimental Design and Procedure

By convention, the methodological approach utilized in this study is criterion-group design.

2.3. Assessment Tools

Six tests were used to investigate which factors of attention were problematic for ADHD clients. These tests were the Continuous Performance Test - II (CPT-II), The Stroop Color Word Test, the Arithmetic, Digit Span, and Digit Symbol subtests of the WAIS-R and the Trail Making Test, Parts A and B. In addition, the BSI was utilized to investigate what, if any, other psychiatric difficulties might be exacerbating ADHD symptomolgy.

2.3.1. Adult Behavior Checklist

One of the tests used to select the subjects was the Adult Behavior Checklist (ABC). The ABC is an eighteen item self-report questionnaire that asks individuals to rate the interference of DSM-IV symptoms for ADHD on a 4-point Likert scale (Johnson and Lyonfields, 1995). The questions on the ABC are modeled directly after the DSM-IV criteria for ADHD. Individuals are considered to have endorsed a symptom if they rate the item at one of the two highest levels. The instrument also asks participants to indicate as to whether these symptoms were problematic for them as children. If the subjects endorses

enough symptoms such that they meet DSM-IV criteria for ADHD and if they indicate that these symptoms were problematic to them as a small child, then the subject is considered to be an analogue ADHD subject. Similar instruments have been used to identify subjects with ADHD in previous studies (Pelhan, Evans, Gnagy & Greenslade, 1992). The measure has been found to have good reliability (r_{xx}=0.83 for inattentive items and r_{xx}=0.78 for hyperactive items) as well as good validity (a factor analysis revealed high internal consistency with three factor model with fit values high (0.90)).

2.3.2. Wechsler Scales

Subtests from the Wechsler scales have been widely utilized to assess various aspects of attention. The Digit Symbol and Coding subtests are believed to measure the focus-execute component of attention (Mirsky et al., 1991). Further corroborating these tests with the focused aspect of attention is Barkley's work examining differential performance on this subtest on ADD children (Barkley, 1990). The Digit Symbol coding tasks has also been found to correlate to a moderate degree (.44 - .61) with teacher ratings of inattention and hyperactivity (Aman & Turbott, 1986; Brown & Wynne, 1982). It should be noted that other studies have found no such relationship (Charles et al., 1979). Other Wechsler subtests that are believed to measure aspects of attention, namely the 'encoding/manipulation' factor are the Arithmetic and Digit Span subtests. The tests confound the attention aspect with short term memory and mathematic skills. Performance on these subtests is sometimes found to be impaired in children with ADHD, but not reliably so (Barkley et al. 1990; Brown & Wynne, 1982b; Milich & Loney, 1979).

2.3.3. Trail Making Test A & B

The Trail Making Test (Parts A and B; Reitan & Wolfson, 1985) from the Halstead Reitan Neuropsychological Test Battery has been described as a measure of the 'focus-execute' factor of attention. It requires motor speed and focused attention while assaying visuomotor coordination and speed of processing in the sequence of both numbers and letters (Reitan & Tarshes, 1959). In Part A the client connects a series of numbered circles distributed randomly about a piece of paper. Part B is comprised of a series of circled numbers and letters. The client is to alternate connecting numbers and then letters in ascending order until all the circles have been connected. The scores are the time taken to complete each part of the test. Mirsky (1991) assigned this test to the 'focus-execute' factor of attention because it correlated highest with this component, but it also showed a smaller, but still significant correlation with both the 'sustained' and 'shift' dimensions (see Table 1.1). It has been found that children with ADHD have impairment on the time to complete this task (Barkley et al.,1991). The ecological validity of this measure has yet to be established.

2.3.4. Stroop Color Word Test

There are many versions of the Stroop Test (Stroop, 1935). The LPP-NIMH battery uses stimuli and instructions described by Golden (1978) which include color-word reading, color naming and an interference condition. In addition to assessing lexical response speed to printed words and color, the measure evaluates the ability to focus attention on one aspect of a stimulus, while inhibiting a normally more automatic response.

It is often described as a measure of focused attention, however, this is confounded with word recognition, oral reading, speed of reading, color recognition and response inhibition (Mirsky, Anthony, Duncan, Ahearn & Kellam, 1991). An interference score, which is the difference between the obtained score in the interference condition (naming conflicting color-words) and the one predicted given the scores in the first two conditions (i.e. words or colors only) can be derived. The interference score is thought to provide a purer measure of these factors of attention in that it controls for reading and processing speed (Kindlon, 1998).

There are no known studies examining the ecological validity of this variable as a measure of any factor of attention in adults. The reliability of the Stroop scores is highly consistent across the different versions of the test. Golden (1975) found test-retest reliabilities of .86, .82, and .73 (N=30) for the three raw scores for individually administered tests.

2.3.5. Continuous Performance Test

CPT's typically require a subject to sit before a computer screen and observe a sequence of symbols, usually letters or numbers presented individually on a screen at a rapid pace. The subject is required to respond, usually by pressing a button, when the target stimulus appears. The task can last from 5 to 30 minutes, depending upon which version is used. The test produces a number of measures including sustained and focused attention. Low but significant correlations (.25-.41) have been found between CPT scores and direct behavioral observations of sustained attention to academic tasks and measures of

impulsiveness (Barkley, 1991; Klee & Garfinkel, 1983; Prinz, Tarnowski & Nay, 1984). Omission errors correlated moderately with teacher's ratings of inattentiveness (Barkley, 1991; Halperin, et al., 1988; Klee & Garfinkel, 1983; Pascaulvaca, Wolf, Healey, Tweedy, & Halperin, 1988; Seidel & Joschko, 1991) where commission errors were more likely to be related to teacher and parent's assessment of impulsivity and hyperactivity (.32 - .44) (Barkley, 1991; Halperin et al., 1988; Klee & Garfinkel, 1983). Barkley (1991) posited that these relationships are likely to attenuate considerably with age, but no known measures assessing the ecological validity of CPT variables are available, as such studies have been limited to child populations.

CPT's have been shown to have good discriminate validity in differentiating between normals and ADHD populations. In addition they are sensitive to medication effects (Barkley, 1997). The CPT-II (Johnson, 1993) was developed as a computerized test of attention and impulsivity. It requires individuals to respond when they see an orange 'H' followed by a blue 'T.' The CPT-II produces two types of error scores. Omission errors occur when the individual does not respond to target stimuli and are presumed to be an index of inattention (Johnson, 1993). Commission errors occur when the subject responds in the absence of target stimuli and are presumed to be an index of response inhibition or impulsivity. The length of the test varies depending upon the number of incorrect responses given; the more incorrect responses given, the slower the stimuli are presented, however, the number total number of stimuli are presented each time.

The number of omission errors on trial one of the CPT-II is an indicator of focused attention. Subjects are required to attend to the letters and color combinations and respond

only when appropriate letter-color combinations are presented. Only the first trial was used because subsequent trials are confounded with sustained attention. The number of omission errors committed on the CPT-II was defined as the indicator of the subject's sustained attention. Split half reliability of the CPT-II is 0.86 (Johnson, 1993).

2.3.6. Wender Utah Rating Scale

The other test used to distinguish the two subject groups is the WURS (Ward, Wender & Reimherr, 1993). Wender specifically states that use of outside sources, such as a client's mother, is important in establishing an ADHD diagnosis, as a client's memory of their childhood is often 'sketchy,' however, such contact is not always possible or even desirable (Wender, 1995). The WURS, therefore, aids in the diagnosis of adult ADHD by helping account for the two criteria necessary for diagnosis, namely: childhood history and adult symptomology.

Ward, Wender and Reimherr (1993) presented initial data collection and tested the validity of the WURS using 81 outpatient adult ADHD patients, 100 normal adults and 70 psychiatric adult outpatients with unipolar depression. The authors analyzed data from 25 items on a scale that showed the greatest difference between clients with ADHD and the two comparison groups. In addition, the author's compared these scores to the Parent's Rating Scales (PRS). Clients with ADHD had significantly higher mean scores on all 25 items than the two comparison groups. A cut off score of 36 or higher correctly identified 86% of ADHD adults, 99 % of the normals and 81% of the depressed subjects. Correlation between this subset of the WURS and the PRS was moderate, but impressive (.49 for

normals and .41 for ADHD adults). The authors concluded that the WURS is useful in recognizing ADHD in clients with ambiguous adult psychopathology (Wender, 1993)

2.3.7. Brief Symptom Inventory

The BSI is a self-report inventory designed to reflect the psychological profiles of psychiatric and clients. It is essentially a shorter version of the SCL-90-R. Each item of the BSI is rated on a five point scale of distress (0-4) ranging from 'not at all' to 'extremely.' The responses to the BSI items are scored and subsequently plotted on a nine psychological dimensions. These dimensions are: Somatization, Obsessive-Compulsive, Interpersonal Sensitivity, Depression, Anxiety, Hostility, Phobic Anxiety, Paranoid Ideation, and Psychoticism. Finally, there is a measure of overall functioning called the Global Severity Index. The nine primary symptom dimensions of the BSI have evolved through a combination of clinical, rational and empirical procedures (Derogatis & Cleary, 1977). Internal consistency coefficients were established on a sample of 719 psychiatric outpatients using Crombach's coefficient alpha. The alpha coefficients for all nine dimensions were very good ranging from a low of .71 to a high of .85. A study by Derogatis, Rickels and Rock (1976) also showed impressive convergent validity for the BSI with the MMPI. The results of that analysis showed that the correlation coefficients ranged from a low of 0.30 to a high of 0.67. The measure is meant to be used as an indicator of current psychological functioning rather than a personality profile.

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Appendix B

IRB Approval

96-031

The University of Oklahoma

OFFICE OF RESEARCH ADMINISTRATION

October 3, 1995

Dr. Brian D. Johnson
Educational Psychology
University of Oklahoma

Dear Dr. Johnson:

Your research proposal, "The Assessment of Attention Deficits in a College Sample," has been reviewed by Dr. E. Laurette Taylor, Chair of the Institutional Review Board, and found to be exempt from the University of Oklahoma-Norman Campus Policies and Procedures for the Protection of Human Subjects in Research Activities.

The exempt status of your protocol is for a period of 12 months from this date, provided that the research procedures are not changed significantly from those described in your "Application for Approval of the Use of Human Subjects" and attachments. Should you wish to deviate from the described protocol, you must notify me and obtain prior approval from the Board for the changes. If the research is to extend beyond 12 months, you must contact this office, in writing, noting any changes or revisions in the protocol and/or informed consent form, and request an extension.

If you have any questions, please contact me.

Sincerely yours,

Karen M. Petry
Administrative Officer
Institutional Review Board

KMP:sg
96-031

cc: Dr. E. Laurette Taylor, Chair, IRB
Ms. Shawna Lyonfelds, Educational Psychology

Appendix C

Informed Consent Form

INFORMED CONSENT FORM

UNIVERSITY OF OKLAHOMA - NORMAN CAMPUS

AGREEMENT TO PARTICIPATE IN RESEARCH PROJECT

This is to certify that I, _____, hereby voluntarily agree to participate in the research project entitled: **The Assessment of Attention Deficits in a College Sample.** I understand that the person responsible for this project is Brian D. Johnson, Ph.D., Department of Educational Psychology, the University of Oklahoma. Dr. Johnson can be reached at (405) 325-5974.

The purpose of this study is to evaluate various cognitive, emotional, and behavioral characteristics that are associated with attention deficits in adults. I will be asked to complete 4 self-report questionnaires that assess various behaviors and/or thoughts that some people exhibit. I will also be asked to compete a series of tests that will assess aspects of memory, language, attention, concentration, and my ability to shift between demanding tasks. Two of the tests will be administered on a computer. I understand that the information obtained during group testing will be used as part of this study. The entire study will take approximately 1-1 1/2 hours to complete, for which I will be compensated with experimental credit through the department of Psychology.

I understand that I may experience some discomfort as a result of focusing my attention and concentration for a sustained period of time; however, there are no known risks of physical harm associated with this task. I can take as many breaks as I desire between the tests to reduce any physical discomfort. In the unlikely event that I am physically injured, I understand that I will receive no compensation. By participating in this study, I am helping to demonstrate the usefulness of various devices for assessing attention in college students and helping to develop norms for how normal college students perform on these tests.

I understand that I am free to refuse to participate and to withdraw from the experiment at any time without prejudice to me. I also understand that, if I am participating in this experiment to obtain course credit and I decide to withdraw from participating, I might not get the course credit associated with the experiment.

I also understand that all information identifying me will be kept in a locked file cabinet, in a locked office. Once all data are collected, ID numbers will be assigned and all names will be removed from the data, consequently there will be ~~know~~ no way to personally identify me. Furthermore, all findings will be presented as group averages only. If I have any questions about my rights as a participant or any questions/concerns during or following my participation, I can contact Dr. Johnson at the phone number above.

_____	_____	_____
Participant's Signature	University ID Number	Date
_____	_____	
Investigator/Witness	Date	