

SELF-REPORTED INATTENTION AND HYPERACTIVITY-IMPULSIVITY AS
PREDICTORS OF ATTENTION NETWORK EFFICIENCY

by

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Under the Direction of Mary K. Morris

ABSTRACT

Previous research has shown that individuals endorsing inattention and hyperactivity-impulsivity have deficient performance on tasks tapping different aspects of attention. Although there is empirical evidence suggesting that the behavioral domains of inattention and hyperactivity-impulsivity are linked to functioning of independent and separate brain areas and neurotransmitter systems, cognitive characterization of adults presenting with problems within these domains is not complete. The aim for this study was to identify the cognitive correlates of the core behavioral domains that define the diagnosis of AD/HD (i.e., inattention and hyperactivity-impulsivity) in a sample of college students, utilizing a computerized attention task, the Attention Network Test (ANT). Different ANT task components have been found to activate separate brain areas linked to the functioning of alerting, orienting and executive attention, and have the potential to provide an indication of the efficiency of these brain networks. In addition to completing the ANT, the participants filled out questionnaires covering common symptoms of adult AD/HD, anxiety and depression. Hierarchical regression analyses revealed that there were no reliable relationships between self-reported

symptoms of current inattention and hyperactivity-impulsivity and ANT performance. Further, self-reported depression and/or anxiety did not seem to impact the efficiency of attention networks to a significant degree in this study sample. Gender proved to be the most consistent predictor of ANT performance. Female gender was related to poorer executive attention efficiency. An exploratory ANCOVA revealed that individuals reporting high levels of impulsivity and emotional lability had poorer executive attention efficiency in comparison to those reporting these behaviors and problems to a lesser extent. Future research is needed in order to further explore the relationship between ANT performance and behavioral expressions of adult AD/HD and other neurological and psychiatric conditions.

INDEX WORDS: Inattention, Hyperactivity-Impulsivity, Attention Network Efficiency, Attention Network Test

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LIST OF ABBREVIATIONS

ACC	Anterior Cingulate Cortex
Ach	Acetylcholine
AD/HD	Attention-Deficit Hyperactivity Disorder
AD	Alzheimer's Disease
ANT	Attention Network Test
APA	American Psychological Association
BAI	Beck Anxiety Inventory
BDI-II	Beck Depression Inventory, 2 nd Edition
BPD	Borderline Personality Disorder
CAARS	Conners Adult AD/HD Rating Scale
CAARS-S-L	Conners Adult AD/HD Rating Scale, Self-report, Long Form
CPT	Continuous Performance Test
DA	Dopamine
DSM-IV	Diagnostic and Statistical Manual for Mental Disorders, 4 th Ed.
fMRI	Functional Magnetic Resonance Imaging
GMV	Grey Matter Volume
MRI	Magnetic Resonance Imaging
NE	Norepinephrine
RT	Reaction Time
SPSS	Statistical Package for Social Sciences

TBI	Traumatic Brain Injury
WCST	Wisconsin Card Sorting Test
WM	Working Memory
WMV	White Matter Volume

CHAPTER 1

INTRODUCTION

Frontal lobes and subcortical areas connected to the frontal brain areas are essential in higher level behavioral regulation in humans (Stuss & Knight, 2002). Lesion studies and brain imaging research have shown that dysfunction of the frontal and subcortical areas often results in decreased behavioral inhibition, increased hyperactivity, and difficulties with attention, among other cognitive and behavioral problems (Stuss & Knight, 2002). Among the most common developmental neuropsychiatric disorders impacting the frontal –subcortical loop is Attention-Deficit/Hyperactivity Disorder (AD/HD).

According to the APA Diagnostic and Statistical Manual for Mental Disorders, 4th Edition (DSM-IV; APA, 1994) classification, three separate AD/HD diagnostic subtypes exist: Predominantly Inattentive, Predominantly Hyperactive-Impulsive, and a Combined Type. The Inattentive subtype diagnosis requires that the individual have at least six symptoms of inattention for at least six consecutive months (starting before age 7 years) to a degree that is maladaptive and inconsistent with developmental level, and that are present in at least two different settings (e.g., school, work, home). DSM-IV lists the following as symptoms of inattention: difficulty paying attention to details or making careless errors in a variety of activities, pervasive difficulty in sustaining attention, not appearing to listen when spoken to directly, difficulty following through instructions and failing to finish assignments/responsibilities, difficulty organizing tasks/activities,

avoiding/disliking tasks requiring prolonged mental effort, losing things that are necessary for tasks/activities, and being easily distracted and/or forgetful in daily activities. For a diagnosis of Hyperactive-Impulsive Type, the individual needs to have had at least six of the following symptoms for at least six months (starting before age 7 years): fidgeting with hands/feet or squirming in seat, leaving classroom or other setting in which seating is required, running or climbing in situations where this is inappropriate, having difficulty engaging in activities quietly, feeling “on the go” or “driven by a motor,” often talking excessively, often having difficulty awaiting turn/blurting out answers, and interrupting/intruding others. Combined subtype diagnosis requires the individual to meet both the Inattentive and Hyperactive/Impulsive criteria (APA, 1994.)

The symptoms of AD/HD should start before school age, but the AD/HD diagnosis is not usually confirmed before the age of nine (APA, 1994). It has been suggested that some signs of the disorder may become apparent in infancy in children who will later develop AD/HD. These infants may be over-active, cry a lot, be irritable, or show abnormal sleeping patterns. The prevalence of AD/HD among school aged children has been estimated to be somewhere between three to five percent (Barkley, 1997).

Inattention and Hyperactivity-Impulsivity in Adults

Previously it was thought that the symptoms of AD/HD resolve as the brain matures, especially the prefrontal cortex. It has been recently acknowledged that in a significant proportion of children diagnosed with this disorder, the symptoms

will continue in adulthood. That is, in 30 - 60% of the cases, symptoms of inattentiveness and/or hyperactivity-impulsiveness will persist (Barkley, 1997; Wender, Wolf, & Wasserstein, 2001). Due to the complex demands of our society, individuals exhibiting these kinds of behaviors and symptoms are likely to experience problems in school and work, as well as in home and social settings, and society in general. It has been reported that adults with AD/HD have considerable difficulty with reaching higher educational levels, and that they often experience difficulties at work as well as in their marriages and relationships. In addition, conflicts with authorities and law are more common in the AD/HD population compared to control populations, and they are more likely to get into traffic accidents and have substance abuse problems (Barkley, Fischer, Edelbrock, & Smallish, 1990; Johnston, 2002; Mannuzza, Klein, Bessler, Malloy, & LaPadula, 1993).

Some researchers have proposed that adult AD/HD is best characterized by a variety of neurocognitive deficits; overt behavioral symptoms, such as motoric hyperactivity, are not necessarily as prevalent in adults as they are in children (Wolf & Wasserstein, 2001, Wender et al., 2001). This would mean that the current diagnostic classification, which emphasizes overt behavioral aspects of the disorder, may not be applicable as such to adults (McGough & Barkley, 2004). Thus, more empirical studies seeking to explore adult AD/HD, especially those addressing subtype characteristics are needed. Some studies so far have documented that individuals with AD/HD tend to score lower compared to normal

controls especially on neurocognitive tasks tapping executive functions and attention (Lovejoy et al., 1999). In existing literature, similar to child AD/HD, the most commonly identified neuropsychological features related to this disorder in adults are impairments in planning, cognitive flexibility, concept formation, working memory and attention, as well as impulse control, and response inhibition (Johnson et al. 2001; Quay, 1997; Rapport, VanVoorhis, Tzelepis, & Friedman, 2001; Shallice et al., 2002; Stevens, Quittner, Zuckerman, & Moore, 2002; Wodushak & Neumann, 2003; Woods, Lovejoy, & Ball, 2002).

Ward, Wender, & Reimherr (1993) suggested alternative diagnostic criteria for adult AD/HD: The Wender criteria (Wender Utah Rating Scale, WURS) for Adult AD/HD take into account both past childhood and current adulthood characteristics of AD/HD. The criteria include symptoms of hyperactivity, attention deficits, behavior problems in school, impulsivity, overexcitability, and temper outbursts in childhood. Additionally, persistent hyperactivity, attentional difficulties, affective lability, disorganization, hot temper/explosive outbursts, emotional overreactivity and impulsivity in adulthood are included (Ward et al., 1993). However, the criteria have been criticized for having several considerable limitations: The scales lack empirical data, the criteria are based on the outdated DSM-III criteria, there is lack of normative data for the cut-off points used, and symptoms included have significant overlap with other psychiatric disorders (Conners, Wells, Parker, Sitarenios, & Diamond, 1997).

Despite a relatively large amount of research data published, there is no clear consensus about the core deficits in adult AD/HD, especially with regard to the specific behavioral dimensions and cognitive characteristics defining the different subtypes of the disorder. Some of the confusion results from methodological issues, such as the inconsistent selection of measures across studies, selection of participants without regard for comorbid disorders, as well as potential insensitivity of conventional neuropsychological measures to detect the kinds of subtle deficits in attention and/or executive functions that adults with AD/HD may exhibit. In addition, in most studies conducted so far, a between-groups design has been utilized, in which a group diagnosed with AD/HD has been compared to a contrast group. However, in adult populations the defining symptoms have not been agreed upon completely, thus making it difficult to classify individuals accurately (i.e., within group heterogeneity has been considerable). More studies are needed with adults exhibiting AD/HD behaviors to determine whether there are some core impairments in cognitive functioning, and if subgroups differ on any dimensions of cognitive deficit.

Currently, Barkley's (1997) descriptive clinical model of childhood AD/HD is widely supported. His theory proposes that the "cardinal symptom" of AD/HD (particularly the Hyperactive/Impulsive and Combined subtypes), underlying symptoms listed in the DSM-IV, is impaired behavioral inhibition, that is, deficient self-regulatory processes. The main idea of Barkley's model of self-regulation or inhibition is that: "...circumstances or tasks that involve temporal delays, conflicts

in temporally related consequences, or the generation of novel responses most heavily tax the type of behavioral inhibition and self-regulation described here...” (Barkley, 1997, p. 68). He stated that “...inhibition is assessed by performance on cognitive and behavioral tasks that require withholding of responding, delayed responding, cessation of ongoing responses, and resisting distraction or disruption by competing events” (Barkley, 1997, p. 68)

One commonly reported task with these characteristics is the Continuous Performance Test (CPT), during which errors of commission to stimuli that should not be responded to are thought to indicate inhibition difficulty (Armstrong, Hayes, & Martin, 2001). Barkley argued that dysfunctional behavioral inhibition leads to problems in four executive function areas: working memory, internalization of speech, self-regulation of emotions, and behavior analysis and synthesis, that is, reconstitution. Problems in these four areas, in turn, lead to impaired behavioral control. In other words, inhibition is seen as a function that allows the executive functions to take place, and impairment in this domain leads to pervasive deficits in various aspects of executive functions (Barkley, 1997).

Currently, the DSM-IV diagnostic system that is commonly used in the United States classifies all three subgroups as part of the same diagnostic category, even though there have been suggestions about the distinctive nature of the behavioral and cognitive features of inattentive versus hyperactive/impulsive individuals (Geurts, Verté, Oosterlaan, Roeyers, & Sergeant, 2005; Swanson et al., 1998). Among some other researchers, Barkley (1997) has noted that

subtypes may differ with regard to core cognitive deficits. He suggests that in the Combined subtype, inattentive symptoms do not appear to be related to problems in attention per se, but to behavioral inhibition, whereas attention seems to be the primary area of impairment in the Inattentive subtype of the disorder (Barkley, 1997). More specifically, he argued that individuals with Inattentive Type of AD/HD seem to have problems mainly with processing speed, specifically in focused-selective attention. Individuals with Hyperactive/Impulsive and Combined Type of AD/HD have impaired performance in tasks requiring sustained attention and perseverance, and they are more likely to be distractible. In these subtypes, distractibility reflects the individuals' inability to inhibit competing external or internal stimuli from interfering with the current task performance (Barkley, 1997).

Very few studies investigating sub-group differences in cognitive functioning in adult AD/HD have been reported to date. One study by Gansler et al. (1998) found that hyperactive-impulsive adults with AD/HD demonstrated impairment on a planning and problem solving measure, Wisconsin Card Sorting Test (WCST), whereas inattentive adults had poorer performance on a working memory measure (Brown-Peterson Auditory Consonant Trigrams Test).

Some researchers have published data that do not support Barkley's view about inhibition as the underlying cognitive processing deficit in AD/HD. In a study comparing children diagnosed with the three AD/HD subtypes on several cognitive measures, Chhabildas, Pennington, & Willcutt, (2001) found that only symptoms of inattention seemed to be predictive of performance on measures of vigilance,

inhibition and processing speed. That is, the expected link between hyperactive-impulsive AD/HD symptoms, deficits in behavioral inhibition, and predicted cognitive differences among subtypes could not be verified. Armstrong et al. (2001) reported results similar to Chhabildas study; they found that the only area of pervasive cognitive impairment in adults with AD/HD was in selective attention, measured with a negative priming task, requiring the participants to select a relevant semantic memory representation among irrelevant ones. This study also did not find evidence for general behavioral inhibition deficits in adults with AD/HD (Armstrong, 2001).

There is inconsistency with regard to study results looking to validate Barkley's model, especially with adult AD/HD. Thus, it has been suggested that adult AD/HD may need to be conceptualized differently from Barkley's childhood AD/HD model, because the disorder may express itself differently due to brain maturation effects as well as the use of compensatory strategies in order to manage unwanted behaviors (e.g., overt motor hyperactivity, disorganization, motor impulsivity; Armstrong, 2001). This disagreement about core symptoms suggests that more research in the area of adult AD/HD sub-typing is needed, in order to differentiate the core cognitive symptoms of each of the diagnostic sub-groups, and to construct a more comprehensive theory and precise classification system of adult AD/HD in the future. These subgroups seem to exhibit behaviors and cognitive deficits that stem from completely different sources, suggesting that anatomical or functional characteristics and/or functioning of the neurotransmitter

systems in subgroups may be differentially impacted (Booth et al., 2001; Posner & Petersen, 1990; Swanson et al. 1998). More specifically, it has been suggested that inattention may be due to dysfunction in the norepinephrine (NE) transmitter system, whereas hyperactivity and impulsivity may stem from lowered dopamine transmitter system activity (Booth, Carlson, & Tucker, 2001; Posner & Petersen, 1990; Swanson et al. 1998). Studies focused on separating the subgroups based on differential cognitive functioning profiles that could be reliably linked to brain functioning are needed in order to make appropriate adjustments to the current diagnostic criteria of AD/HD.

Neuroanatomical and Neurofunctional Aspects of AD/HD

Regardless of the inconsistent findings in the search for core cognitive deficits in AD/HD, both anatomical and functional studies have indicated that the frontal-subcortical areas and pathways do not seem to function in the same way in individuals with AD/HD as in normal controls. Most of these studies have been conducted with children diagnosed with AD/HD, although a handful of imaging studies have been conducted with adults. The findings with adult participants have been generally similar to those obtained from child studies (Castellanos et al., 2002; Makris et al., 2007; Seidman et al., 2006; Valera et al., 2005).

Satterfield and Dawson (1971) were the first researchers to propose that AD/HD may be caused by dysfunctional neural connections between frontal cortex and the limbic system (Faraone & Biederman, 1998). It was later noted that there were certain behavioral similarities between individuals with frontal lobe damage

and individuals with AD/HD (Faraone & Biederman, 1998), with problems in executive functions and attention characterizing both groups. The abovementioned notion led the researchers to explore the neuroanatomy of AD/HD.

The majority of structural imaging studies conducted to date have supported fronto-striatal involvement in AD/HD. Castellanos et al. (1996; 2003) reported in their magnetic resonance imaging (MRI) studies that AD/HD participants had a smaller total cerebral volume and reduced size of the right anterior frontal region, right caudate nucleus and globus pallidus of the basal ganglia. In their review, Hale, Hariri, & Cracken (2000) report several studies in which volume reduction in AD/HD participants has been found in the right anterior-superior frontal gray and white matter, bilateral anterior-inferior frontal regions, and bilateral retrocallosal white matter, as well as cerebellum. Additionally, parietal lobe abnormalities have been reported in children diagnosed with AD/HD (Tamm, Menon, & Reiss, 2006). More recent MRI studies by Seidman et al. (2006) and Makris et al. (2007) reported overall grey matter volume reduction and frontal cortex thinning in adults diagnosed with AD/HD when compared to healthy controls. More specifically, these studies reported structural abnormalities particularly in the right inferior parietal lobule, the dorsolateral prefrontal cortex, and the anterior cingulate cortex (ACC) area. In their review of structural abnormalities in adult AD/HD, Schneider, Retz, Coogan, Thome, & Rösler (2006) concluded that the most common brain areas impacted are basal ganglia, dorsal

anterior cingulate cortex and cerebellum. The majority of the MRI studies have not differentiated between AD/HD subtypes; instead, the inclusion criteria have for example stated that the participants were to have a history of hyperactive, inattentive, and impulsive behaviors that were impairing in at least two settings and an AD/HD symptom questionnaire score higher than two standard deviations above the age mean (Hale et al., 2000).

Some studies have correlated structural abnormalities with executive functions deficits. Casey, Castellanos, & Giedd (1997) found that volume reduction in the right prefrontal cortex was related to impairments in attentional shifting and problems in inhibiting responses to irrelevant stimuli, whereas striatal abnormalities were closely related to impaired execution of responses (Casey et al., 1997).

Functional imaging has provided more sophisticated insight into brain dysfunction in AD/HD. Abnormalities in frontal-striatal activation have been consistently reported in functional imaging studies utilizing response inhibition tasks, and support the notion that fronto-striatal dysfunction in AD/HD may be the key component of the executive functions deficits in this disorder (Hale, 2000). However, other neural areas have also been implicated. In an fMRI study using a counting Stroop paradigm (a conflict resolution/response inhibition task, a type of Stroop task that requires the examinee to press a button indicating how many words appear on the screen. During neutral conditions, the stimuli consist of a single category of words, whereas trials in the interference condition include number words incongruent with the

correct response). Bush et al. (1999) found that there was decreased anterior cingulate cortex (ACC) activation in adults with AD/HD in comparison to a matched control group. Again, these studies did not address the issue of differences among diagnostic subgroups of AD/HD.

Neurochemistry of AD/HD

In a review of neurochemical factors in AD/HD, Faraone and Biederman (1998) conclude that the majority of studies have found a relationship between hyperactivity-impulsivity and inattentiveness and dysfunction of the catecholamine system. In particular, dopamine (DA) is one of the primary neurotransmitters in the basal ganglia and the frontal lobe regions, and has been found to be involved in voluntary motor performance and sustained alertness (Nieoullon, 2002).

Norepinephrine (NE) has also been implicated in the behavioral expression of AD/HD, particularly attention regulation/sustained attention (Arnsten & Li, 2005; Arnsten, 2006; Biederman, & Spencer, 1999; Beane & Marrocco, 2004). NE does not only seem to be involved in attention regulation, but behavioral inhibition and impulse control are dependent on stimulation of various NE receptor sites (Beane & Marrocco, 2004). Furthermore, individuals with AD/HD usually respond well to drugs such as methylphenidate and D- amphetamine that are designed to stimulate catecholamine pathways, and this implies that the frontal-basal ganglia pathways using DA and NE as the primary transmitters may be dysfunctional in AD/HD (Nieoullon, 2002; Pliszka, 2005; Beane & Marrocco, 2004).

Research has clearly shown that cholinergic involvement is essential in learning and memory performance (Beane & Marrocco, 2004). However, several studies have suggested that it also has a significant role in the functioning of reflexive attention, such as orienting (Beane & Marrocco, 2004; Potter, Newhouse, & Bucci, 2006; Rowe & Hermens, 2006). Acetylcholine (Ach) may have direct influence on the attention system, or its impact may be through interactions with the catecholamine system (Potter et al., 2006). Support for Ach involvement in attention regulation comes in part from studies investigating attentional functioning in patients diagnosed with probable Alzheimer's disease (AD). Patients with AD have reduced levels of Ach neurotransmitter, due to defective basal forebrain functioning, and it has been documented that these individuals exhibit difficulty with tasks requiring visual orientation (i.e., their responses are slow and inaccurate) (Beane & Marrocco, 2004; Parasuraman, 1992). Beane and Marrocco (2004) theorized that individuals with AD/HD may have deficiencies in both the Ach and catecholamine neurotransmitter systems, which is why they exhibit behavioral impairments in multiple domains of attention.

Attention Network Model

One possible approach to study attention and executive attention problems in individuals endorsing hyperactivity-impulsivity and inattention may be offered by Michael Posner and his colleagues. Posner and Raichle (1994), Posner and Petersen (1990), and more recently, Fernandez-Duque & Posner (2001) presented a model of attention that hypothesized a set of functionally and

anatomically distinct but interconnected networks. In this model, multiple brain regions interact to function as a whole network during complex cognitive functions and behaviors. That is, there are specific brain areas and neurotransmitters responsible for specific aspects of attention. These brain areas in turn are connected and communicate with each other during cognitive functions. Three “domain general” aspects of attention were identified by Posner and Petersen (1990) and Fernandez-Duque and Posner (2001): orienting, alerting and executive control. More specifically, the three-domain model proposed the following:

a) *Orienting* (visual domain) refers to a network that is activated in preparation for an action to an expected, spatially determined input. Orienting occurs when an individual momentarily shifts attention to a given stimulus in a specific location in space. Frontal involvement has been documented in voluntary orienting, and parietal brain areas seem to be associated with automatic/involuntary visual orienting. The cholinergic transmitter system has been proposed to be associated with the functioning of the orienting network (Fernandez-Duque & Posner, 2001; Posner & Petersen, 1990). Orienting can be measured with cuing paradigms, such as Posner’s response time paradigm (Posner, 1980), which requires examinees to respond to visual stimuli after having seen either valid cues (indicating the correct spatial location of an upcoming target stimulus) or invalid cues (indicating a different spatial location than the upcoming target).

b) *Alerting* refers to processes during which irrelevant ongoing neural activity is ceased and mental effort is put forth to create a readiness to react to stimuli. That is, alerting refers to a process where state of alertness is either being initiated or sustained. Alertness can be increased both through internal signals (frontal lobe), as well as external stimuli (through ascending thalamic pathways). Two tasks have been used to test this network: continuous performance tasks (i.e., how vigilant and able to disregard irrelevant stimuli the person is) and warning signal tasks (i.e., how fast a person can reach an alert state). In functional imaging studies, right frontal and parietal areas have been found to become activated during vigilance and warning tasks; that is, they overlap with the same brain areas which are involved in orienting. Clinical data also support the involvement of right frontal and parietal areas in sustained attention. For example, right frontal damaged patients perform worse than left frontal patients in vigilance tasks (Fernandez-Duque & Posner, 2001; Posner & Petersen, 1990). There are data supporting noradrenergic involvement in alertness, dissociated from cholinergic functioning which is related to orienting (Beane & Marrocco, 2004).

c) *Executive control* refers to processes during which multiple cognitive activities are coordinated simultaneously (e.g., target detection, beginning and ending mental processes, coordinating several responses) to allow goal directed behavior. Executive attention is needed in task switching, inhibitory control or inhibiting habitual responses, conflict resolution, and allocation of attentional resources (Fernandez-Duque & Posner, 2001). Brain areas commonly found to be activated during executive

attention tasks are anterior cingulate cortex, supplementary motor area, orbitofrontal cortex, dorsolateral prefrontal cortex, and some basal ganglia areas (caudate), and thalamus. In many studies, dorsal anterior cingulate cortex has been found to be involved in conflict resolution; that is, it is activated during tasks such as the Stroop paradigm, which require inhibition of a prepotent response. (Fernandez-Duque & Posner, 2001; Posner & Petersen, 1990).

The basal ganglia may be important in mediating the pathways between the executive attention network and the other attentional networks. Some studies suggest that lateral frontal cortex is also involved with executive attention, though these areas seem to be specialized to process verbal, spatial or form information, rather than general attentional functions (Berger & Posner, 2000). Thus, medial frontal brain areas seem to be the most important in governing executive attention processes. Further, dopaminergic activity is most likely involved in the functioning of this network, given the neuroanatomical and functional findings.

The Attention Network Test

It has been hypothesized that the efficiency of the previously described three attention functions – alerting, orienting, and executive attention- can be assessed based on performance across different cognitive tasks. The Attention Network Test (ANT), “which is a combination of a cued reaction time task and the flanker task” (Fan, McCandliss, Sommer, Raz, & Posner, 2002, p. 342), tests these separable networks through one task with three conditions, by measuring how response times change when alerting cues, spatial cues, and flankers are presented.

The design of the ANT is factorial, with two within-subject factors: cue type (no-cue, center-cue, double-cue, or spatial-cue) and flanker type (congruent or incongruent flanker conditions or no-flanker condition). The cue presentations alert the participants to the target that will appear soon. For the cued trials, either one (spatial or center condition) or two (double condition) asterisks are presented for 200ms preceding the onset of the target. The double cue condition presumably activates the alerting attention network by not providing any specific spatial information of the stimulus location, but by generally activating the arousal system to anticipate the occurrence of a stimulus at some location; that is, the appearance of the center cue and double cue does not predict target location. Spatial cues accurately tell the participant where on the screen the target will appear, either slightly above or below a central fixation point. Presence of the spatial cue is expected to activate the voluntary spatial orienting network. Flanked trials are presented in congruent and incongruent formats, where incongruent flankers are expected to tap error detection and conflict resolution processes, in other words, the executive attention network. The test-retest reliability values for efficiency measures for ANT are as follows: $r=0.77$ for executive, $r=0.52$ for alerting, and $r=0.61$ for orienting network efficiency (Fan et al. 2002). No statistically significant relationships between the efficiency scores have been detected (Fan, 2002), suggesting independence of the three networks. A recent fMRI study by Fan et al. (2005) suggests that the three different ANT task components also reliably activate three separable anatomical networks believed to govern orienting, alerting and executive aspects of attention.

Cognitive and Behavioral Manifestations of AD/HD and Attention Network Model

The functioning of the three attention networks can be linked to other models of attention, as suggested by Swanson et al. (1998). Right frontal areas and the activity of the alerting network are required for sustained attention (e.g., sustaining mental readiness in the face of repetitive stimuli) and posterior parietal/orienting network activation is needed for selective attention (e.g., attending to stimuli that are relevant, and disengaging when needed). Finally, the anterior cingulate gyrus/executive attention network needs to be active to support divided attention (e.g., conflict resolution among competing mental activities; coordination of goal oriented behaviors).

Based on the attention network model, Swanson et al. (1998) attempted to link the DSM-IV diagnostic criteria of AD/HD (i.e., Inattention and Hyperactivity-Impulsivity) to three independent areas of attention as described by Posner (orienting, alerting, executive attention), and to the anatomically corresponding brain areas that are linked to these domains of attention. These researchers suggested that AD/HD be viewed as a neuropathological condition of these networks. They propose that inattentiveness reflects poor sustained and selective attention, secondary to dysfunction of the right frontal/posterior parietal areas which underly the alerting and orienting networks. Further, hyperactivity-impulsivity reflects poor divided attention, secondary to dysfunction of the anterior cingulate gyrus which underlies the executive attention network.

A recent study conducted by Booth, Carlson and Tucker (2001) suggests that children with primarily inattentive symptoms exhibited poorer performance on the alerting aspect of attention as measured by the ANT task when compared to a group with both inattentive and hyperactive-impulsive symptoms. No group differences were found on task components measuring executive attention or orienting. This study suggests that it may be informative to compare groups endorsing different clusters of AD/HD symptoms on an experimental task that focuses on subtle aspects of attentional functioning, in addition to utilizing measures primarily designed for clinical decision making. Since it is unclear which components of attention might be impacted in adults who endorse differing levels of inattention or hyperactivity-impulsivity, studies exploring various aspects of attention in a nonclinical sample could be beneficial. No published empirical data investigating the relationship between inattention and hyperactivity-impulsivity and ANT performance in adults exist to date.

Objectives of the Study

The prevalence of AD/HD in the adult population is relatively large (1-6% of the general population), and the societal and individual consequences are considerable. It is essential to further study the cognitive characteristics of adult AD/HD, given that there are several issues regarding the core symptoms of adult AD/HD that have not been clarified in the literature in this area. More studies are needed in order to better characterize the disorder, as well as to aid with future diagnostic decision making and treatment decisions.

Posner's model of attention provides a well-documented theoretical basis

for the proposed study. It was expected that his approach might help clarify a possible relationship between attentional network functioning and behaviorally expressed dimensions of inattention and hyperactivity/impulsivity. This study investigated the relation between ANT performance and the behavioral domains of inattention and hyperactivity-impulsivity in adults. Empirical evidence supports the notion that AD/HD symptoms are best described as a continuum, where individuals with the disorder represent the tail of a behavioral distribution, rather than a discrete diagnostic group (Levy, Hay, McStephen, Wood, & Waldman, 1997). Thus, a between-groups design (i.e., AD/HD group vs. Control group) may be problematic if the belief that the behavioral dimensions of this disorder, like many other neurological and psychiatric diagnoses, are actually expressed on a continuum (Lilienfeld & Marino, 1995). By using categorically defined diagnostic groups, valuable information about the relationship between the continuous independent variables and dependent variables may be lost. Further, using the current DSM-IV criteria for assignment of a clinical diagnosis to define group membership also may have limitations due to concerns about the applicability of the criteria to adults with AD/HD symptoms (McGough & Barkley, 2004).

I proposed that the efficiency of distinct attentional systems, as measured by a computerized ANT, would be related to self-reported Inattention and Hyperactivity-Impulsivity. The following specific hypotheses were tested:

1) The efficiency of the executive attention network will be predicted by self-reported hyperactive/impulsive behaviors; that is, the lower the total Hyperactivity-Impulsivity score on self-report questionnaires, the higher the executive efficiency on the ANT.

2) Hyperactive-Impulsive behaviors will account for more variance than Inattentive behaviors in predicting the efficiency of the executive attention network.

3) The efficiency of the alerting network will be predicted by Inattentive behaviors; that is, the lower the total Inattention score on self-report questionnaires, the higher the alerting efficiency on the ANT.

4) Inattentive behaviors will account for more variance than Hyperactive-Impulsive behaviors in predicting the efficiency of the alerting network.

5) The efficiency of the orienting network will be predicted by Inattentive behaviors; that is, the lower the total Inattention score on self-report questionnaires, the higher the orienting efficiency on the ANT.

6) Inattentive behaviors will account for more variance than Hyperactive-Impulsive behaviors in predicting the efficiency of the orienting network.

7) The number of errors on all cue and flanker conditions will be predicted by Hyperactive-Impulsive behaviors; that is, the higher the total Hyperactivity-Impulsivity score, the more errors will be committed on the ANT.

CHAPTER 2

METHOD

Participants

The participants were 102 college students, enrolled in Psychology classes at Georgia State University (GSU) in which participation in a psychological experiment could be used to fulfill a course requirement. The contact with students in the Psychology class was made by the principal investigator through the GSU SONA participant recruitment system and they were compensated for their participation with course credit. In order to avoid the confounding impact of age on reaction time performance, male and female participants younger than 18 and older than 40 years of age were excluded (Cerella and Hale, 1994). Participants were excluded if they reported a history of moderate to severe traumatic brain injury (TBI) with post-traumatic amnesia longer than one hour, and/or significant motor or sensory disabilities. Participants needed to report having normal vision, or vision corrected to normal.

Statistical analyses were based on a final sample of 99 participants meeting the inclusion criteria. Data for three individuals were excluded from the final analyses: Two individuals reported history of a concussion with greater than 5 minutes loss of consciousness and with greater than 1 hour of estimated post-traumatic amnesia. One participant's data proved to be invalid due to lack of responses or errors on over 30% of the trials. No participants needed to be excluded based on a sensory or motor disability.

The descriptive statistics for the demographic variables are presented in Table 1. The sample mean age was 21 years, 57% of the participants were female, and the majority of the sample was right handed (94%). The sample consisted of 46% Caucasian, and 54% non-Caucasian individuals. Based on the demographic/medical information interview, the majority of the sample (93%) denied history of neurological or psychiatric problems, 4% had been diagnosed with depression at some point in time in their lives, two participants (2%) reported previous diagnosis of AD/HD, and one (1%) reported having been diagnosed with an anxiety disorder.

Table 1.
Demographic characteristics of the sample (n=99).

Variable	Mean / %	sd (range)
Age	20.9	4.1 (18-38)
Females %	56.6	
Right Handed %	93.9	
Ethnicity %		
Caucasian	45.5	
Non-Caucasian	54.5	
Neurological/Psychiatric Dx %		
None	92.8	
Depression	4	
Anxiety	1	
AD/HD	2	

With regard to medications, 4% had taken an SSRI, 13% had taken oral contraceptives, 7% had taken allergy pills, and approximately 10% had taken

some other type of medication (e.g., robitussin, an antibiotic, naproxen/ ibuprofen or similar) in the 24 hours prior to completing the experiment.

Measures and Procedure

After showing interest in participating in the study, the participants were invited in to complete the study. Informed consent was obtained and participants signed a consent form approved by the Institutional Review Board of GSU prior to beginning the experiment. First, a brief interview pertaining to demographic characteristics and medical information (e.g., age, gender, types of medications with information about dosage, history of TBI, estimated length of post-traumatic amnesia) was completed. After the initial interview, participants were asked to complete three questionnaires. The following measures were administered:

1. *Beck Depression Inventory-II* (Beck, 1996), is a 21-item questionnaire that assesses the number and severity of depressive symptoms experienced during the past two weeks on a 0 to 3 scale. This questionnaire was used to characterize the sample to explore if depressive symptoms may impact ANT performance. BDI-II's reliability and validity have been well supported (Beck, 1996). In a predominantly Caucasian outpatient sample consisting of 500 individuals from rural and urban settings, the mean score on the BDI-II was 21.89 ($sd = 12.69$) (Beck, 1996). However, a study conducted with 414 non-patient undergraduate college students from a Southern US university reported a mean of 11.03 ($sd = 8.17$, range = 0 - 40) for the BDI-II (Storch, Roberti, & Roth., 2004).

2. *Beck Anxiety Inventory* (Beck, 1993), is a 21-item questionnaire covering common symptoms of a variety of anxiety disorders on a 4-point scale rating symptoms from bothering not at all (0) to severely (3) during the past week. Similar to the depression inventory, this questionnaire was used to characterize the sample to explore if symptoms of anxiety may impact ANT performance. The BAI scale has been validated as reliable and valid measure of anxiety symptoms (Beck & Steer, 1993). The normative mean for clinically anxious individuals in Beck, Epstein, Brown, & Steer (1988) study was 25.8, and the median was 24. A study investigating the psychometric properties of BAI in 293 undergraduate college students (75% female) revealed a mean of 10.75 ($sd = 9.12$) for the total sample, with females scoring significantly higher than males (females $m = 12$, $sd = 9.35$, males $m = 7.09$, $sd = 6.94$) (Borden, Peterson, & Jackson, 1991).

3. *Conners' Adult AD/HD Rating Scales Self-Report, Long Form (CAARS – S-L; Conners et al., 1999)* was used to determine the extent to which behavioral dimensions of inattention and hyperactivity/impulsivity were endorsed as present during the past 6 months. The measure was developed through a systematic exploration of clinical observations of professionals working with AD/HD populations, and numerous empirical studies investigating the characteristics of adult form of the disorder. Conners' team initially created a pool of 190 items, after which the relevant ones were selected through an exploratory factor analysis. The long version of the measure contains 66 questions covering behavioral, emotional, social and cognitive characteristics specifically related to adult AD/HD, from which

4 factor–derived subscales may be obtained: a 12-item Inattention/Memory Problems scale, a 12-item Hyperactivity/Restlessness scale, a 12-item Impulsivity/Emotional Lability scale, and a 6-item Problems with Self-Concept scale. There are also two separate 9-item subscales that directly assess the DSM-IV AD/HD Inattentive and Hyperactive/Impulsive subtype criteria. Relevant subscales (Inattention and Hyperactivity/Impulsivity DSM-IV scales) were entered as predictor variables in the model. The remaining scales were analyzed in an exploratory manner, to determine if other symptom groups are related to the dependent variables.

Information regarding the questionnaire characteristics, including validity, reliability and standardization sample is described in detail in the CAARS manual (Conners et al., 1999). The standardization sample included 466 healthy males and 560 healthy females between ages 18 to over 50 years. No data on ethnicity were provided in the manual.

CAARS-S-L has test-retest reliability scores ranging from $r=0.88 - 0.91$. Analyses conducted on the CAARS standardization sample (Conners et al., 1999), indicated that a new administration of the scale reliably produced similar patterns when compared to an administration conducted one month earlier. Internal consistency as indicated by Cronbach's alpha, varied between .49 and .91, depending on the scale, gender and age group in the standardization sample. Inter-item correlations in the standardization sample were between $r=.14$ and $r=.63$, depending on the scale, and age/gender group. Correlations among

CAARS-S-L scales generally range from $r=.40$ to $r=.70$, with some variability by gender.

Conners et al. (1999) also addressed the question of whether self-reported childhood symptoms of AD/HD as measured with Wender Utah Rating Scale (WURS) correlate with current symptoms as measured with CAARS-S-L. Based on the correlations between WURS and four CAARS-S-L subscales, construct validity for Inattention/Memory Problems was determined to be $r=.37$, $p<.01$, Hyperactivity-Impulsivity $r=0.67$, $p<.01$, Impulsivity/Emotional Lability $r=.67$, $p<.01$, and Problems with Self-Concept $r=.37$, $p<.01$.

A discriminant function analysis conducted by Erhardt et al. as reported in the CAARS manual (Conners et al., 1999) revealed that the CAARS-S-L (utilizing the Inattention/Memory Problems, Impulsivity/Emotional Lability, and Problems with Self-Concept subscales) distinguished matched controls from adults diagnosed with AD/HD with 85% accuracy. A cross-validation study conducted by Conners et al. (1999) to validate Erhardt et al. results revealed a diagnostic accuracy of 73%, when data from the normative sample was utilized.

Conners et al. (1999) gathered data from 188 adults and their significant others to investigate how strongly others' reports of AD/HD symptoms on four CAARS subscales are associated with self-reported symptoms. The correlations between significant other and self-reports on CAARS-L varied between $r=.42$ (Problems with Self-Concept scale) and $r=.61$ (Impulsivity/Emotional Lability scale) in 98 males, and between $r=.45$ (Impulsivity/Emotional Lability scale) and

$r=.67$ (Problems with Self-Concept) in 90 females. Murphy and Schachar (2000) found correlations of similar magnitudes (ranging from $r=.59$ to $r=.79$) between significant other reports and self-reports of AD/HD Inattentive, Hyperactivity-Impulsivity and Total (is this the right name) symptom scores in their sample consisting of parents of children undergoing AD/HD assessment. They concluded that “adults can give a true account of their current symptoms of AD/HD” (p. 1158). Thus, only self-report measures were used in the current study.

4. *Attention Network Task (ANT)*. After questionnaires were completed, the ANT computerized task was administered (Fan, 2002). The ANT, developed by Jin Fan et al. (2002), is a modification of Posner’s original cuing paradigm task for spatial orientation (Posner, 1980) and the Eriksen flanker task (Eriksen & Eriksen, 1974). The stimuli were presented via E-Prime, a commercial experiment application, using Windows XP operating system on a Dell Laptop computer with monitor size of 15.4”. The participants were shown an arrow on the computer screen pointing either to the left or to the right, for example \rightarrow or \leftarrow . On some trials, the arrow was flanked by two arrows to the left and two arrows to the right, for example: $\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow$ or $\rightarrow\rightarrow\leftarrow\rightarrow\rightarrow$. The participants’ task was to respond to the direction of the central arrow. The participants were instructed to press the left mouse button with the left thumb if the central arrow points to the left, or press the right mouse button with the right thumb if the central arrow points to the right. The participants were encouraged to make their responses as quickly and accurately as possible, because reaction time and accuracy were recorded. There was a

fixation point ("+") in the center of the screen and the arrows appeared either above or below this cross, and the participants were instructed to fixate on the cross throughout the experiment.

The ANT contained four blocks. The first block was for practice and lasted about two minutes. It contained 24 trials with feedback about accuracy and reaction time. The other three blocks were experimental blocks and each took about five minutes. These trials did not contain feedback. After each block there was a message "take a break" and the participant had the opportunity to take a short rest. Each block contained 96 trials (4 cue conditions; spatial cue, no cue, double cue and center cue x 2 target locations; above or below fixation x 2 target directions; left or right x 3 flanker conditions; neutral, congruent and incongruent x 2 repetitions). The trials were presented in a random order. Each trial consisted of five components: a) a fixation period lasting 400 to 1600 ms, b) cue presentation for 100 ms, c) fixation period of 400ms, d) target and flanker presentation, and e) after response the stimulus disappeared and there was a post-target fixation period lasting 3500ms minus reaction time. The stimulus stayed on the screen until the participant responded, however, for a maximum duration of 1700 ms. Each trial lasted for 4000 ms (please see Appendix 1. for experiment description). The whole experiment took about 20 minutes.

Calculating Attention Network Efficiency Measures

The computer-based task ANT allows for the calculation of measures that indicate the efficiency of the alerting, orienting and executive attention networks.

Orienting attention efficiency is established by presenting stimuli at a location outside the fixation point, predicting the location of the upcoming target, requiring the participants to shift visual attention in space. To calculate the orienting effect, the mean RT of the spatial-cue (predictive) trials is subtracted from the mean RT of the center-cue (non-predictive) trials. Spatial cues always correctly predicted the location of the target. *Alerting attention efficiency* is a measure of how efficiently the individual responds to stimuli that have been preceded by cues without information about the location of the upcoming targets. This effect is calculated by subtracting the mean RT of double-cue trials from the mean RT of no-cue trials. However, the interpretation of this difference may be influenced by the level of performance on the no-cue trial. If no-cue RTs are within ± 1 sd from the sample mean and there is a large benefit to the alert cue, the interpretation is that participants can make use of warning stimuli, and the network is working efficiently. But if the no-cue RTs are longer than expected (i.e., one standard deviation above the mean), the very same difference score may suggest that the network is functioning inefficiently (Personal Communication between Drs. Washburn and Posner.) *Executive attention efficiency* is a measure of how efficiently the individual responds to conflicting information displayed in the incongruent flanker condition. This effect is calculated by subtracting the mean RT of congruent flanker trials, summed across cue types, from the mean RT of incongruent flanking trials. For executive attention network, the more inefficient the network is, the greater the subtracted difference between mean RTs.

CHAPTER 3

RESULTS

Statistical Analysis Overview

All the statistical analyses were carried out by using the Statistical Package for Social Sciences 11.0 (SPSS) statistics software. Before any of the analyses were carried out, the raw data were inspected in order to detect outliers, skewness/kurtosis, and other characteristics of data that may impact the statistical analyses. Data were inspected to confirm that outliers were not due to data entry error or non-declared missing data points.

The following reaction time data points were not included in the calculation of mean RTs: 1) Outlier RT's (any RT > 3 sd from the sample condition mean); 2) trials where no response was detected during the stimulus presentation; 3) error trials. On average, 4.7% of the trials per participant were excluded from the analyses. Further, outlier data points on the questionnaire variables and attention network efficiency variables of interest (i.e., data that were identified to be outside +/- 3 standard deviations from the mean), were re-coded with a value 3 sd's above the sample mean prior to the analyses to minimize loss of data. Outlier data were re-coded for two participants on the BAI questionnaire (> 31.54 points), one participant on the CAARS-S-L Inattention/Memory Problems scale (> 21.5 points), one participant on the alerting effect variable, two participants on total errors, errors on congruent trials and incongruent trials, and two participants on errors on ANT neutral trials.

Dependent and independent variables that were found to be significantly non-normal as measured with Kolmogorov-Smirnov analysis were transformed using e (2.7182818) as the base for the logarithmic transformation. This was done to achieve data more closely approximating a normal distribution. Data were analyzed with both nontransformed and transformed data. In general, the results of these analyses did not differ substantially. Thus, the reported results are based on analyses conducted with nontransformed data.

Pearson correlation coefficients between the CAARS-S-L scale scores, BDI-II, BAI, ANT reaction times, ANT error rates, the attention network efficiency scores, and demographic variables were then calculated. Hierarchical regression was utilized to analyze the relationship between the Inattention and Hyperactivity/Impulsivity scales, and the three attention network efficiency measures. Based on the results of the correlation analysis, possible covariates were identified for entry into the hierarchical regression model, to account for any variance in DV caused by these variables. Possible covariates included age, gender, depression score on the BDI-II, and anxiety score on the BAI.

In the first multiple regression analysis, the Hyperactivity-Impulsivity and Inattention scale scores from the CAARS-S-L were entered as predictor variables and the measure of executive attention efficiency was entered as the dependent variable. In another multiple regression analysis, the self-reported Inattention and Hyperactivity-Impulsivity total scores on the CAARS-S-L were entered as predictor variables and the measure of alerting efficiency was entered as the dependent

variable. In the third multiple regression analysis, the self-reported Inattentive and Hyperactivity-Impulsivity total scores on the CAARS-S-L were entered as predictor variables and the measure of orienting efficiency was entered as the dependent variable. Further regression analysis explored whether CAARS-S-L Hyperactivity-Impulsivity score would be predictive of number of errors on the ANT.

Additional exploratory analyses were conducted with samples scoring high or low on the CAARS-S-L Total AD/HD scale, in order to investigate whether these groups would present with different performance patterns on the ANT variables. Further, based on previous studies finding a relationship between emotion regulation difficulties and poor executive attention (Posner et al., 2002; Rogosh and Cicchetti, 2005), a between groups exploratory analysis was carried out with samples scoring high and low on the CAARS-S-L Impulsivity/Emotional Lability scale, with executive effect as the dependent variable.

Attention Network Test (ANT): Descriptive and Correlational Data

The attention network efficiency scores and reaction times obtained by this sample were consistent with the data reported in a previous study by Fan et al. (2002). Descriptive data for the RTs and attention network efficiency variables are presented in Table 2.

Correlations among ANT variables are presented in Table 3. Strong positive correlations were found among all the reaction time variables. In addition, executive effect was significantly related to all of the RT variables, with greater inefficiency of this network associated with slower RTs. Alerting effect correlated

with the RT variables, except with the double cue and spatial cue RTs, with greater efficiency of the alerting network associated with slower RTs under no cue and center cue conditions. Orienting effect was only related to the spatial cue RT, with greater efficiency of the orienting network associated with faster RTs in this cue condition. Measures of the alerting and orienting effects were significantly correlated, contrary to data reported by Fan et al. (2002); however, the executive effect was not correlated with the other ANT efficiency variables.

Correlations among demographic variables and ANT RTs by condition are presented in Table 4. Gender correlated with every RT measure, with the exception of the spatial cue and neutral flanker conditions, with females having slower RTs. Ethnicity correlated with all the RTs, with non-Caucasians performing more slowly across all ANT conditions. CAARS-S-L, BDI-II and BAI variables did not correlate significantly with ANT reaction times.

Table 2.
Means, sd's, and ranges for attention network efficiency scores and RTs by condition

	Mean (sd)	Range
Alerting Effect	40.4 (21.4)	-7.7 – 107.3
Orienting Effect	43.5 (22.6)	-10.2 – 110.13
Executive Effect	104.9 (44.3)	20.0 – 232.0
No-cue RT	555.4 (76.8)	440.4 – 810.3
Center-cue RT	528.2 (74.7)	406.5 – 792.5
Double-cue RT	514.8 (70.2)	395.0 – 734.0
Spatial-cue RT	484.7 (77.9)	357.4 – 773.5
Congruent RT	488.0 (68.9)	381.0 – 713.2
Incongruent RT	592.9 (93.8)	441.9 – 871.8
Neutral RT	480.7 (64.9)	379.4 – 744.1
Number of Errors		
Total	7.9 (7.0)	0 – 31
Congruent	.69 (1.1)	0 – 6
Incongruent	5.9 (5.3)	0 – 23
Neutral	1.3 (2.1)	0 – 11

Table 3.
Correlations among the ANT variables, n=99

	1	2	3	4	5	6	7	8	9	10	11
1. No-cue RT	--										
2. Center-cue RT	.97**	--									
3. Double-cue RT	.96**	.98**	--								
4. Spatial-cue RT	.94**	.96**	.97**	--							
5. Congruent RT	.96**	.97**	.96**	.95**	--						
6. Incongruent RT	.95**	.96**	.96**	.95**	.90**	--					
7. Neutral RT	.96**	.97**	.97**	.95**	.96**	.90**	--				
8. Alerting Effect	.42**	.25*	.15	.18	.29**	.23*	.23*	--			
9. Orienting Effect	-.02	.01	-.09	-.28**	-.07	-.13	-.07	.22*	--		
10. Executive Effect	.50**	.52**	.54**	.55**	.34**	.72**	.41**	.04	-.16	--	
11. Total Number of Errors	.10	.07	.09	.10	.08	.12	.06	.03	-.10	.13	--

*) p < .05; **) p < .01

Table 4.
Correlations among demographic and ANT RT variables, n=99

	Age	Gender	Ethnicity
1. Age	--		
2. Gender	.18	--	
3. Ethnicity	-.13	-.14	--
4. No-cue RT	-.02	-.26**	.25**
5. Center-cue RT	.03	-.25*	.27**
7. Double-cue RT	.02	-.26**	.27**
8. Spatial-cue RT	.04	-.19	.25**
9. Congruent RT	.04	-.23*	.25*
10. Incongruent RT	.01	-.28**	.25*
11. Neutral RT	.01	-.19	.26**

*) $p < .05$; **) $p < .01$

Self Report Questionnaires: Descriptive Data

Table 5 presents the descriptive statistics for the CAARS-S-L. Twenty-three percent of the sample reported problems with inattention on the CAARS-S-L DSM-IV Inattention scale at a level that fell at least one standard deviation above the mean for the CAARS-S-L standardization sample, and 13 percent reported hyperactivity/impulsivity at this same level on the CAARS DSM-IV Hyperactivity-Impulsivity scale.

Table 5.

Descriptive information for the CAARS-S-L, and number of participants falling in the clinically significant T-score ranges (n=99). Females (F) and males (M) have different cut-scores, thus, the scores are reported separately, as well as together (Tot) (Conners et al., 1999).

Variable	Mean	sd	Range	Above Average (n) T=61-65			Well Above Average (n) T=>65		
				F	M	Tot	F	M	Tot
CAARS-S-L									
Inattention/Memory Problems	11.4	5.9	3-28	6	2	8	7	2	9
Hyperactivity/Restlessness	13.5	5.2	4-26	4	1	5	1	0	1
Impulsivity/Emotional Lability	8.8	5.0	0-23	3	1	4	3	0	3
Problems with Self-Concept	5.9	4.1	0-16	4	2	6	3	2	5
DSM-IV Inattention	7.9	4.4	0-17	3	6	9	9	5	14
DSM-IV Hyperactivity-Impulsivity	7.3	3.9	1-19	3	4	7	4	2	6
DSM-IV AD/HD Symptoms Total	15.1	7.3	3-37	5	3	8	5	5	10

Table 6 presents the descriptive statistics for the BDI-II and BAI. Eighty-six percent of the sample reported symptoms of depression in the minimal to mild range as measured with the BDI-II. Fourteen percent endorsed moderate to severe level of symptoms of depression. Fifty-seven percent of the sample reported no anxiety to mild level of anxiety on the BAI, while forty-three percent reported moderate to severe levels of symptoms of anxiety on the BAI. Self-reported symptoms of depression and anxiety in this sample are comparable to data reported for these measures in undergraduate college student samples (Borden et al., 1991; Storch, Roberti, & Roth, 2004).

Table 6.
BDI-II and BAI scores (n=99).

Variable	Mean / %	sd (range)
BDI-II total		
Mean	10.2	7.7 (0-32)
%:		
Minimal/None (0-13)	71	
Mild (14-19)	15	
Moderate (20-28)	11	
Severe (29-63)	3	
BAI total		
Mean	8.4	7.1 (0-30)
%:		
None-Mild (0-21)	56.6	
Moderate-Severe (>21)	43.4	

Relationships Among Criterion and Potential Predictor Variables

Table 7 contains correlation coefficients among demographic, questionnaire, and the primary ANT variables of interest. Significant positive correlations were present between all of the CAARS-S-L scales, ranging from .27 to .85, consistent with data reported for the normative sample. Similarly, CAARS-S-L scales were positively correlated with both self-reported depression and anxiety on the BDI-II and the BAI, respectively.

Gender was found to be correlated with the CAARS-S-L Impulsivity/Emotional Lability scale, with females endorsing significantly more problems. Ethnicity correlated with the anxiety rating on the BAI, as well as several CAARS-S-L scales. Caucasians reported a significantly higher level of anxiety and higher scores on the CAARS-S-L Inattention-Memory Problems scale, Problems with Self-Concept scale, DSM-IV Inattention scale and DSM-IV

Hyperactivity-Impulsivity scale. There were no other significant correlations detected among questionnaire and demographic variables.

In general, ANT efficiency variables were not related to demographic or questionnaire variables, with the exception of a significant correlation between gender and the executive effect, with females performing more poorly than males.

Table 7.
Correlations among demographic, questionnaire, and main ANT variables, n=99

	1	2	3	4	5	6 A	6 B	6 C	6 D	6 E	6 F	6 G	7	8	9	10
1. Age	--															
2. Gender	.18	--														
3. Ethnicity	-.13	-.14	--													
4. BDI total score	.05	-.10	-.19	--												
5. BAI total score	-.07	-.09	-.21*	.68**	--											
6. Conners Scales																
A. Scale A Inattention/Memory Problems	.07	-.15	-.29**	.59**	.46**	--										
B. Scale B Hyperactivity/Restlessness	.09	.08	-.17	.31**	.46**	.34**	--									
C. Scale C Impulsivity/Emotional Lability	.09	-.20*	-.17	.46**	.38**	.56**	.40**	--								
D. Scale D Problems with Self-Concept	.14	-.05	-.28**	.69**	.53**	.59**	.27**	.45**	--							
E. Scale E DSM-IV Inattention	.08	-.08	-.31**	.57**	.45**	.85**	.34**	.62**	.57**	--						
F. Scale F DSM-IV Hyperactivity-Impulsivity	.06	-.12	-.23*	.40**	.50**	.55**	.76**	.65**	.32**	.55**	--					
G. AD/HD Symptom Total	.04	-.14	-.30**	.54**	.54**	.81**	.60**	.69**	.51**	.88**	.85**	--				
7. Alerting Effect	-.16	-.08	.01	-.03	.05	.15	.10	.02	-.001	.08	.09	.11	--			
8. Orienting Effect	-.05	-.18	.04	.05	.02	.10	-.08	.03	.02	.14	-.02	.08	.22*	--		
9. Executive Effect	-.04	-.23*	.14	.02	.09	-.04	-.07	.16	-.02	-.01	-.05	-.03	.04	-.16	--	
10. Total Number of Errors	-.09	-.19	.09	.09	.11	.03	-.05	-.04	.04	-.03	-.08	-.04	.03	-.10	.13	--

*) p < .05; **) p < .01

Prediction of Executive Attention Efficiency

Hierarchical regression analysis was performed with executive attention efficiency as the outcome variable. Variables were entered in three steps. Since gender was found to be related to executive effect, it was entered into the model first, to account for any variance attributable to gender. The CAARS-S-L DSM-IV Hyperactivity-Impulsivity score was expected to be the best predictor of executive efficiency, thus it was entered into the model in the second step. The DSM-IV Inattention score was entered in the last step, since it was expected to be less predictive of the outcome variable.

The results of the hierarchical regression are presented in Table 8. After step 1, with gender in the equation, $R^2 = .05$ (Adjusted $R^2 = .04$), $F(1, 97) = 5.37$, $p < .05$. After step 2, with CAARS-S-L Hyperactivity-Impulsivity added to the prediction of executive efficiency, $R^2 = .06$ (Adjusted $R^2 = .04$), $F(2, 96) = 2.94$, $p < .06$. Addition of a measure of self-reported Hyperactivity-Impulsivity to the model did not result in a significant increment in R^2 . Addition of the CAARS-S-L Inattention score to the equation in step 3 also failed to add significant predictive variance, $R^2 = .06$ (Adjusted $R^2 = .03$), $F(3, 95) = 1.94$, $p < .15$. In summary, gender accounted for a significant but relatively small proportion of variance in the executive attention efficiency, with females having lower executive network efficiency (i.e., larger disruption in the face of incongruent flankers) in comparison to males. Neither Hyperactivity-Impulsivity nor Inattention contributed significantly to the prediction of executive attention efficiency.

Table 8.
Hierarchical Regression Analysis of Executive Efficiency

Variable	B	SE(B)	β	Sig.	95% CI for B	
					Lower	Upper
Step 1						
Constant	134.1	13.3		.00	107.6	160.5
Gender	-20.4	8.8	-.23	.02	-37.8	-2.9
Step 2						
Constant	141.2	16.1		.00	108.4	174.0
Gender	-21.1	8.9	-.24	.02	-38.7	-3.5
Hyperactivity-Impulsivity	-.83	1.1	-.07	.47	-3.1	1.4
Step 3						
Constant	140.8	17.2		.00	106.6	174.9
Gender	-21.1	8.9	-.24	.02	-38.8	-3.4
Hyperactivity-Impulsivity	-.90	1.4	-.08	.51	-4.0	1.8
Inattention	.12	1.2	.01	.92	-2.3	2.5

Note. $\Delta R^2 = .05^*$ for Step 1; $\Delta R^2 = .01$ for Step 2; $\Delta R^2 = .00$ for Step 3. * $p < .05$

Prediction of Alerting Attention Efficiency

Hierarchical regression analysis was performed with alerting attention efficiency as the outcome variable. The CAARS-S-L DSM-IV Inattention score was expected to be the best predictor of alerting efficiency, thus it was entered into the model in the first step. The DSM-IV Hyperactivity-Impulsivity score was entered in the second step, since it was expected to be less predictive of the outcome variable.

The results of the hierarchical regression are presented in Table 9. After step 1, with inattention in the equation, $R^2 = .01$ (Adjusted $R^2 = -.004$), $F(1, 97) = .65$, $p > .10$. After step 2, with CAARS-S-L Hyperactivity-Impulsivity added to the prediction of alerting efficiency, $R^2 = .01$ (Adjusted $R^2 = -.01$, $F(2, 96) = .45$, $p > .10$). In sum, neither Inattention nor Hyperactivity-Impulsivity significantly predicted the alerting effect.

Table 9.
Hierarchical Regression Analysis of Alerting Efficiency.

Variable	B	SE(B)	β	Sig.	95% CI for B	
					Lower	Upper
Step 1						
Constant	37.3	4.5		.00	28.4	46.2
Inattention	.40	.50	.08	.42	-.59	1.4
Step 2						
Constant	36.1	5.0		.00	26.1	46.1
Inattention	.24	.60	.05	.70	-.95	1.4
Hyperactivity-Impulsivity	.34	.67	.06	.61	-.99	1.7

Note. $\Delta R^2 = .01$ for Step 1; $\Delta R^2 = .00$ for Step 2.

Prediction of the Orienting Attention Efficiency

Hierarchical regression analysis was performed with orienting attention efficiency as the outcome variable. The CAARS-S-L DSM-IV Inattention score was expected to be the best predictor of orienting efficiency, thus it was entered into the model in the first step. The DSM-IV Hyperactivity-Impulsivity score was entered in the second step, since it was not expected to be as strong a predictor as inattention. The results of the hierarchical regression are presented in Table 10.

After step 1, with inattention in the equation, $R^2 = .02$ (Adjusted $R^2 = .01$), $F(1, 97) = 1.8$, $p > .10$. After step 2, with CAARS-S-L Hyperactivity-Impulsivity added to the prediction of orienting efficiency, $R^2 = .03$ (Adjusted $R^2 = .01$), $F(2, 96) = 1.5$, $p > .10$. Addition of a measure of self-reported Hyperactivity-Impulsivity to the model did not result in a significant increase in the predictive variance. In summary, Inattention and Hyperactivity-Impulsivity were not found to be reliable predictors of orienting efficiency.

Table 10.
Hierarchical Regression Analysis of Orienting Efficiency.

Variable	B	SE(B)	β	Sig.	95% CI for B	
					Lower	Upper
Step 1						
Constant	37.9	4.7		.00	28.6	47.2
Inattention	.70	.52	.14	.18	-.33	1.7
Step 2						
Constant	40.5	5.2		.00	30.1	50.9
Inattention	1.1	.62	.21	.09	-.16	2.3
Hyperactivity-Impulsivity	-.76	.70	-.13	.28	-2.1	.62

Note. $\Delta R^2 = .02$ for Step 1; $\Delta R^2 = .01$ for Step 2.

Prediction of the Number of Total Errors on the ANT task

In yet another regression model, presented in Table 11, it was investigated, whether the number of errors would be predicted by the CAARS-S-L DSM-IV Hyperactivity-Impulsivity score. The Hyperactivity-Impulsivity scale was not predictive of the total number of errors on the ANT with $R^2 = .01$ (Adjusted $R^2 = -.004$), $F(1, 97) = .58$, $p > .10$.

Table 11.
Regression Analysis of Number of Errors.

Variable	B	SE(B)	β	Sig.	95% CI for B	
					Lower	Upper
Step 1						
Constant	8.9	1.5		.00	5.9	11.9
DSM-IV Hyperactivity-Impulsivity	-.14	.18	-.08	.45	-.50	.22

Note. $\Delta R^2 = .01$.

Exploratory Analyses

Additional exploratory analyses were carried out after dividing the sample into two groups, based on the median split on the CAARS-S-L AD/HD Symptoms Total scale.

Correlation analyses were performed within each of these two groups. Results of these analyses are shown in Table 12 and Table 13.

In the above-median group, there was a significant negative correlation between age and alerting effect, with higher age associated with less efficient alerting (i.e., smaller RT benefit for cued trials). Further, the alerting effect was negatively correlated with the number of errors, with poorer alerting efficiency related to a greater number of total errors on the ANT. In addition, the Problems with Self-Concept scale correlated negatively with the alerting effect, so that a higher level of problems was associated with poorer alerting efficiency.

In the median-or-lower group, gender and BDI-II total score correlated positively with the executive effect, with female gender and a higher depression score being associated with poorer executive efficiency (i.e., larger disruption in the face of incongruent flankers). Further, the Inattention/Memory Problems scale was positively correlated with the alerting effect, indicating that higher level of problems was associated with larger alerting effect (i.e., larger RT benefit for cued trials). Additionally, greater alerting effect was related to greater orienting effect, and higher number of total errors on the ANT (i.e., large discrepancy between no-cue and cued trials was related to fewer number of errors).

Table 12. Correlations among demographic, questionnaire, and main ANT variables, in the “above- median group” (n=45).

	1	2	3	4	5	6 A	6 B	6 C	6 D	6 E	6 F	7	8	9	10
1. Age	--														
2. Gender	.35*	--													
3. Ethnicity	-.15	-.14	--												
4. BDI total score	.10	-.06	-.16	--											
5. BAI total score	-.14	.04	-.22	.63**	--										
6. Conners Scales															
A. Scale A Inattention/Memory Problems	.02	-.22	-.16	.56**	.36*	--									
B. Scale B Hyperactivity/Restlessness	.10	.33*	-.25	.19	.46**	.11	--								
C. Scale C Impulsivity/Emotional Lability	.01	-.29	-.08	.28	.17	.34*	.11	--							
D. Scale D Problems with Self-Concept	.17	.02	-.21	.70**	.30*	.44**	.07	.20	--						
E. Scale E DSM-IV Inattention	.03	-.15	-.19	.50**	.46**	.84**	.07	.40**	.41**	--					
F. Scale F DSM-IV Hyperactivity-Impulsivity	-.04	.01	-.20	.28	.45**	.36*	.67**	.43**	.02	.25	--				
7. Alerting Effect	-.32*	-.08	.15	-.12	-.09	.09	.24	.05	-.32*	.01	.28	--			
8. Orienting Effect	-.11	-.18	.13	.14	.01	.06	-.25	.16	.01	.09	-.16	.05	--		
9. Executive Effect	-.21	-.13	.11	-.21	.03	-.09	-.01	.16	-.23	.07	-.06	.07	-.04	--	
10. Total Number of Errors	.27	-.10	.01	.17	.18	.14	-.10	-.06	.21	.11	-.22	-.47**	-.25	.04	--

*) $p < .05$; **) $p < .01$

Table 13. Correlations among demographic, questionnaire, and main ANT variables, in the “median- or- lower group” (n=54).

	1	2	3	4	5	6 A	6 B	6 C	6 D	6 E	6 F	7	8	9	10
1. Age	--														
2. Gender	.05	--													
3. Ethnicity	-.06	-.18	--												
4. BDI total score	-.17	-.17	-.08	--											
5. BAI total score	-.14	-.14	-.07	.57**	--										
6. Conners Scales															
A. Scale A Inattention/Memory Problems	-.05	.04	-.35**	.28*	.15	--									
B. Scale B Hyperactivity/Restlessness	-.08	-.06	.12	-.01	.02	.02	--								
C. Scale C Impulsivity/Emotional Lability	-.01	-.04	-.07	.27	.18	.28*	.17	--							
D. Scale D Problems with Self-Concept	-.01	-.02	-.24	.49**	.36**	.49**	.03	.31*	--						
E. Scale E DSM-IV Inattention	-.07	.13	-.32*	.29*	.16	.69**	-.18	.16	.37*	--					
F. Scale F DSM-IV Hyperactivity-Impulsivity	-.03	-.18	-.05	-.07	.04	.12	.63**	.34*	-.01	-.05	--				
7. Alerting Effect	-.06	-.09	-.09	.08	.23	.35**	.06	.04	.24	.25	.02	--			
8. Orienting Effect	-.01	-.17	-.01	-.10	-.02	.12	.01	-.21	-.02	.20	.04	.31*	--		
9. Executive Effect	.12	-.31*	.20	.30*	.17	-.09	-.24	.21	.15	-.23	-.19	.02	-.26	--	
10. Total Number of Errors	-.06	-.26	.15	.05	.08	-.05	.04	.02	-.06	-.13	.10	.30*	-.001	.21	--

*) p < .05; **) p < .01

Based on significant correlations among variables, exploratory regression analysis was first carried out with the above-median group data, with age and CAARS-S-L scale Problems with Self-Concept, as the predictors and alerting effect as the criterion variable. Results are presented in Table 14. After step 1, with age in the equation, $R^2 = .10$ (Adjusted $R^2 = .08$), $F(43, 1) = 4.9$, $p < .05$. After step 2, with CAARS-S-L Problems with Self-Concept added to the prediction of alerting efficiency, $R^2 = .17$ (Adjusted $R^2 = .13$), $F(2, 42) = 4.4$, $p < .02$. The analysis revealed that in the above-median group, only age significantly predicted the variance in alerting efficiency. That is, higher age would result in smaller alerting effect (i.e., smaller benefit for cued trials in relation to no-cue trials).

Table 14.
Hierarchical Regression Analysis of Alerting Effect in the "Above-Median Group".

Variable	B	SE(B)	β	Sig.	95% CI for B		
					Lower	Upper	
Step 1							
Constant	66.9	12.4		.00	41.9	92.0	
Age	-1.3	.57	-.32	.03	-2.4	.05	
Step 2							
Constant	72.2	12.4		.00	47.1	97.2	
Age	-1.1	.56	-.27	.06	-2.2	.05	
CAARS Problems with Self-Concept	-1.1	.61	-.27	.07	-2.4	.09	

Note. $\Delta R^2 = .10^*$ for Step 1; $\Delta R^2 = .07$ for Step 2. * $p < .05$

Next, the median-or-lower group's data was analyzed. First, hierarchical regression analysis was completed with gender as the predictor in the first step, and BDI-II total score added in the second step, with executive effect as the

criterion variable. Results are presented in Table 15. After step 1, with gender in the equation, $R^2 = .10$ (Adjusted $R^2 = .08$), $F(1, 52) = 5.6$, $p < .05$. After step 2, with BDI-II total score added to the prediction of executive effect, $R^2 = .17$ (Adjusted $R^2 = .14$), $F(2, 51) = 5.3$, $p < .01$. Addition of a measure of depression to the model did result in a significant increment in R^2 .

In summary, in the median-or-lower group, gender and depression score were found to be predictive of executive attention efficiency. That is, females had larger executive effect, and higher depression score was predictive of larger executive attention effect (i.e., poorer executive attention efficiency).

Table 15.
Hierarchical Regression Analysis of Executive Effect in the “Median-or-Lower Group”.

Variable	B	SE(B)	β	Sig.	95% CI for B	
					Lower	Upper
Step 1						
Constant	142.2	17.6		.00	106.9	177.5
Gender	-26.5	11.2	-.31	.02	-49.1	-3.9
Step 2						
Constant	123.7	19.0		.00	85.5	162.0
Gender	-24.8	10.9	-.29	.03	-46.7	-3.0
BDI total score	2.2	1.0	.28	.04	.15	4.2

Note. $\Delta R^2 = .10^*$ for Step 1; $\Delta R^2 = .08^*$ for Step 2. * $p < .05$

Another analysis was completed with CAARS-S-L Inattention/Memory Problems scale as the predictor of alerting efficiency. Results are presented in table 16. With Inattention/Memory Problems in the equation, $R^2 = .12$ (Adjusted $R^2 = .11$), $F(1, 52) = 7.4$, $p < .01$. That is, the higher the inattention score, the larger the alerting effect was (i.e., there was larger RT benefit for cued trials).

Table 16.
Regression Analysis of Alerting Effect in the “Median-or-Lower Group”.

Variable	B	SE(B)	β	Sig.	95% CI for B	
					Lower	Upper
Step 1						
Constant	20.1	8.3		.02	3.6	36.7
Inattention/Memory Problems	2.5	.91	.35	.01	.65	4.3

Note. $\Delta R^2 = .12^{**}$ for Step 1. $^{**}p < .01$

In the total study sample the highest correlation among CAARS-S-L and ANT variables was between the Impulsivity/Emotional Lability scale and executive effect. Although the correlation was not significant at the conventionally accepted .05 level, a more lenient .10 significance level was reached. ANCOVA was conducted to explore possible differences in the executive effect between the high and low impulsivity and emotional lability groups. First, the CAARS-S-L Impulsivity/Emotional Lability variable was split at the median. Then, group membership was entered into the ANCOVA model as the independent variable, ethnicity was entered as a covariate, since the groups differed in the proportion of Caucasians and non-Caucasians, and executive efficiency was the dependent variable. Significant group differences emerged. As shown in Figure 1, the mean executive effect score was significantly greater in the high emotional lability group than in the low emotional lability group, $F(1, 98) = 5.0, p < .05$, indicating poorer executive attention efficiency in individuals who report higher levels of impulsivity/emotional lability.

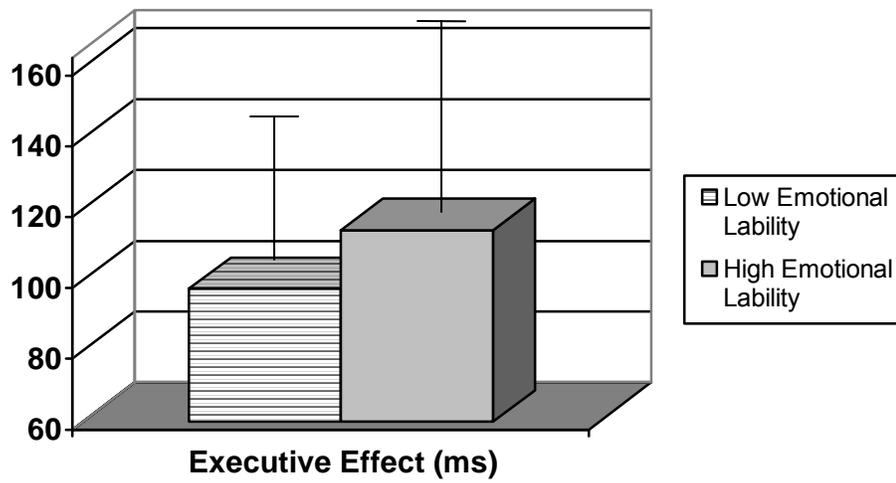


Figure 1. Mean Executive Effect scores in Low ($n = 55$; $m = 97.5$, $sd = 40.8$) and High ($n = 44$; $m = 114.1$, $sd = 47.2$) Emotional Lability groups.

CHAPTER 4

DISCUSSION

Review of Study Hypotheses

In the present study, I investigated the relationship between self-reported inattention and hyperactivity-impulsivity and attention network efficiency in a sample of college students. Previous research has shown that individuals endorsing symptoms consistent with AD/HD have deficient performance on tasks tapping different aspects of cognitive functioning. For example, individuals meeting the criteria for AD/HD have poorer performance on sustained, selective, and divided attention measures, when compared to control groups. However, it has not been satisfyingly clarified which specific areas of attention are influenced in adults who endorse differing levels of inattention and/or hyperactivity-impulsivity. That is, even though there is empirical evidence suggesting that the behavioral domains of inattention and hyperactivity-impulsivity are linked to functioning of independent and separate brain areas and neurotransmitter systems, the cognitive characterization of adults presenting with problems within these domains is not complete.

Posner's model of attention provided a well-documented basis for this study. He proposed that three separate but interconnected attention networks exist: the executive, alerting and orienting networks. These networks are governed by separable brain areas and are linked to different neurotransmitter systems. Fan et al. (2002; 2005) developed a task, the Attention Network Test that measures the

activation of these networks, and concluded that Posner's model appears to be supported by the patterns found on ANT and functional brain imaging.

Swanson et al. (1998) proposed that the alerting network activity is necessary for sustained attention, that the orienting network is associated with selective attention and that activation of the executive attention network is required for divided attention. Further, Swanson et al. (1998) theorized that behavioral domains of AD/HD could be linked to the dysfunctional attention networks, that is, hyperactivity-impulsivity would be the behavioral manifestation of a dysfunctional executive attention network, and inattention would be related to dysfunction in the alerting and orienting networks.

The aim for this study was to identify the cognitive correlates of the core behavioral domains that define the DSM-IV diagnosis of AD/HD (i.e., inattention and hyperactivity-impulsivity) in a non-clinical sample, using the ANT. Additionally, we explored whether other self-reported behaviors typically observed in adults with AD/HD would be related to the functioning of the attention networks.

Self-Reported Hyperactivity-Impulsivity and Executive Attention Network

In a functional imaging study, Fan et al. (2005) reported that anterior cingulate and lateral prefrontal cortex activation increased during the incongruent condition on the ANT task, suggesting that these brain areas are involved in the executive attention functioning in healthy individuals. Several imaging studies have shown that these same brain areas are dysfunctional in individuals endorsing inattention and hyperactivity-impulsivity (Casey et al., 1997; Hale et al., 2000;

Makris et al., 2007; Seidman et al., 2006; Vaidya et al., 1998). Further, individuals endorsing significant level of hyperactivity-impulsivity tend to make more errors of commission on for example continuous performance tasks (Johnson et al., 2001).

Thus, I investigated whether self-reported hyperactivity-impulsivity and inattention in adults would predict the efficiency of the executive attention network, as measured with the computerized attention task ANT, with hyperactivity-impulsivity being the stronger predictor. Additionally, I hypothesized that hyperactivity-impulsivity would predict the number of errors committed on the ANT. Since gender was found to be correlated with the executive efficiency measure, it was included in the analysis as a predictor.

The hypotheses were not supported in the current study: There were no reliable relationships detected between hyperactivity-impulsivity, inattention and either executive attention efficiency or the propensity to commit errors on the ANT. Gender accounted for a small but significant amount of variance on the executive attention efficiency.

Self-Reported Inattention and Alerting Network

Fan et al. (2005) found that frontal, parietal and thalamic areas were activated during ANT task components related to the alerting network. It has been suggested in the literature that inattention as it is seen in individuals with AD/HD could be linked to dysfunction in these brain areas (Swanson et al. 1998). Thus, we investigated whether primarily self-reported inattention, and secondarily hyperactivity-impulsivity would predict the efficiency of the alerting network. Our

initial hypotheses were not supported, because there were no reliable relationships detected between the predictor and the outcome variables.

Self-Reported Inattention and Orienting Network

Parietal brain areas and frontal eye fields have been found to be linked to the activation of the orienting network (Fan et al., 2005). Individuals endorsing symptoms of AD/HD are expected to have dysfunction within this network (Swanson et al., 1998). We expected that self-reported inattention as the primary predictor and hyperactivity-impulsivity as the secondary predictor would have a relationship with the efficiency of the orienting network. There were no reliable relationships found between the predictor and the outcome variables, and our initial hypotheses were not supported.

Discussion of Study Hypotheses

Previous studies reporting an association between AD/HD symptoms and attention difficulties have utilized participants with a clinical diagnosis of AD/HD, which requires the persisting presence of inattention and/or hyperactivity-impulsivity starting before age seven. It is possible that the present self-reports of hyperactivity-impulsivity and inattention do not reflect the same underlying brain – behavior relationships as do the AD/HD symptoms in individuals who have been experiencing these behaviors since childhood. I did not inquire about the participants' past history of hyperactivity-impulsivity and inattention due to the findings of a previous study indicating a strong relationship between self-reported childhood and current behaviors (Conners et al., 1999). However, this information

might have enabled me to investigate whether the relationship between CAARS scales and ANT efficiency measures differs as a function of persistence of inattention and hyperactivity-impulsivity from childhood into adulthood.

There were only a handful of participants with a previous diagnosis of AD/HD in our study. This raises the possibility that the high endorsers' self-reports could reflect problems that have started only recently, and might be related to increased general stress level, which has previously been associated with elevations on self-report measures assessing AD/HD and post-concussion symptoms (Harrison, 2004; Wang, Chen, & Deng, 2006). In my study, individuals who reported high degree of inattention and hyperactivity-impulsivity tended to also have high scores on the depression and anxiety measures. In fact, there were rather strong correlations among the CAARS-S-L subscales and the measures of depression and anxiety. This may be indicative of an overall high stress level, which may be situational in nature, and possibly related to the specific stage of life that college students have just recently entered.

It is a possibility that in this study, high self-report scores may not accurately reflect the level of cognitive functioning, and may be the reason underlying the lack of relationships between attention network functioning and self-reported inattention and hyperactivity-impulsivity. Previous research lends support to this hypothesis: On their study regarding base-rates of post-concussion syndrome in healthy individuals, Gouvier, Uddo-Crane, and Brown (1988) reported that students who attend college tend to highly endorse items on post-concussion self-report

measures suggesting that they have significant problems with temper outbursts (37%), irritability (31%), remembering things (20%), and significant chronic fatigue (28%). Gadzella (1994) suggested that college students are experiencing increased stress in general, which is why they may report a wide variety of symptoms, some of which may also be consistent with symptoms of adult AD/HD. Stressors during this developmental period include managing relationships, academic responsibilities, and challenges related to independent living (Harrison, 2004; Ross, Niebling, & Heckert, 1999). However, a large proportion of the students reporting high levels of inattention and hyperactivity-impulsivity would not meet the diagnostic criteria for post-concussive syndrome or AD/HD (Harrison, 2004). Thus, it is possible that high endorsing individuals' cognitive functioning is not impacted, regardless of the individuals' own perception of significant cognitive problems and high level of stress. In future studies, it would be desirable to attempt to account for response bias by adding for example a symptom validity measure into the study design.

Further, stress-related inattention does not appear to have the same neural basis as do persistent AD/HD symptoms. More specifically, neuropathological processes related to stress primarily involve the hippocampal formation and hypothalamus whereas, in adult AD/HD, primarily the basal ganglia, ACC and cerebellum have been implicated (McEwen, 2000; Schneider et al., 2006). Thus, if the elevated hyperactivity-impulsivity and inattention scales on the CAARS-S-L reflect stress rather than inattention and hyperactivity-impulsivity associated with

fronto-striatal dysfunction, then it would be expected that the ANT measures would not be related to these scales.

The current models of AD/HD are primarily based on studies conducted with children. Though some studies support the notion that AD/HD is a neurodevelopmental disorder that presents with the same core neurobiological substrate and behavioral/cognitive characteristics throughout the lifespan (Barkley, 1997; Wender et al., 2001), some studies offer conflicting data. For example Armstrong et al. (2001) reported that the only area of pervasive cognitive impairment in adults with AD/HD was in selective attention, and no evidence for behavioral inhibition deficit in adults with AD/HD was found. These results suggest that behavioral manifestations and cognitive profiles, as well as the underlying brain mechanisms in adults with AD/HD could be different than in children, due to both neural maturation and the development of coping strategies throughout the lifespan (Armstrong et al., 2001).

It is not clear, based on research conducted to date, which behavioral manifestations of AD/HD in adults are associated with specific cognitive profiles. It is possible that though the ANT task was able to identify differences in alerting efficiency in children with different subtypes of AD/HD (Booth et al., 2001, 2003), this same pattern may not be evident in adults manifesting inattention and hyperactivity-impulsivity. Booth et al. (2001; 2003) found that ANT alerting efficiency, but not executive or orienting efficiency, was impaired in children

exhibiting inattentive symptoms of AD/HD in comparison to children presenting with both inattentive and hyperactive-impulsive symptoms.

The performance on the ANT double-cue condition has been associated with frontal and parietal brain areas that are involved with vigilance and shifting of attention (Fan et al., 2005; Fernandez-Duque & Posner, 2001). In children diagnosed with AD/HD, parietal lobe abnormalities have been reported (Tamm, Menon, & Reiss, 2006), suggesting that dysfunction of the parietal lobe is one of the likely candidates underlying attentional difficulties in this population. Parietal brain areas have not been consistently reported to be impacted in adults with AD/HD: According to a recent meta-analysis of adult AD/HD imaging studies, the most robust finding has been dysfunction or structural abnormalities in the dorsal ACC, basal ganglia, and the cerebellum (Schneider et al., 2006). It is possible that the ANT task components did not consistently tap those attentional functions/brain areas that could be associated with for example self-reported inattention in this study's adult study population.

Exploratory Analyses

When the data were explored to investigate the possibility that individuals endorsing a higher level of AD/HD symptoms on the CAARS-S-L inattention and hyperactivity-impulsivity scales might have a different pattern in their cognitive performance compared to those who endorse fewer items, I found some interesting relationships among variables, some of which were unexpected.

Two groups were formed in order to investigate whether groups endorsing high and low levels of inattention and hyperactivity-impulsivity would present with different relationships among predictor and outcome variables. It was found that in the above-median group, age predicted the efficiency of the alerting network, so that the network was less efficient with increasing age. This finding is similar to Jennings, Dagenbach, Engle, and Funke (2007) study finding that aging is associated with decreased effectiveness of the alerting network. Jennings et al. (2007) found no age related changes in the orienting and executive attention efficiency. Increasing age has in general been linked to cognitive decline, especially in the areas of speed of processing, working memory and executive functioning (Bugg, Zook, DeLosh, Davalos, & Davis, 2006; Schretlen et al., 2000).

Further, several animal models and human studies have suggested that high level of stress, beginning as early as in infancy, seems to be a significant risk factor cognitive decline during later years in life (Brunson et al., 2005; Lupien et al., 1994; Lupien et al., 1998). These cognitive changes have been linked to neuronal cell damage, which is associated with heightened cortisol levels caused by psychological distress (Brunson et al., 2005; Lupien et al., 1994; Lupien et al., 1998). Thus, previous studies suggest that the aging human brain appears to be vulnerable to the presence of stress, and individuals with high level of distress are at risk for cognitive decline later in life.

Because the relationship between increasing age and poorer alerting network efficiency was not evident in the group endorsing low level of inattention

and hyperactivity-impulsivity, it is possible that individuals experiencing heightened level of stress in our study may have been more vulnerable to the impact of increasing age, with regard to the functioning of the alerting network.

In the median-or-lower group, female gender and higher depression score were associated with less efficient executive attention. This relationship was only evident in the median-or-lower group, but the association between gender and executive attention network was shown in the total sample, as well. Studies investigating the relationship among subjective cognitive complaints and objective cognitive performance in some patient populations (e.g., multiple sclerosis) have noted a discrepancy between high levels of cognitive complaints without significant objectively measured cognitive deficits in individuals endorsing high level of depressive symptoms. These individuals present with more accurate self-appraisals of their cognitive functioning after successful treatment of their depressive symptoms (Julian, Merluzzi, & Mohr, 2007; Maor, Olmer, & Mozes, 2001). In the current study, the high-endorser group demonstrated higher correlations among some CAARS-S-L scales and the BDI-II in comparison to the low-endorsing group. Thus, the finding that only low-endorsers' depression score was associated with the executive efficiency may be due to these individuals' more accurate view on their symptoms than those reporting a high level of problems on a variety of behavioral scales. This may have been reflected in the actual performance on the ANT task.

It is not surprising that the magnitude of the total depression score was predictive of the executive efficiency. It has been widely reported in literature that depressed individuals tend to have difficulty on executive function tasks. For example, individuals who suffer from severe depression have poorer performance on processing speed, attention, executive functioning and memory tasks when compared to controls (Austin et al, 1992; Dunkin et al., 2000). Further, neurotransmitter serotonin has been consistently linked to depressive symptoms in humans (Nemeroff, 2002). Interestingly, a recent molecular genetic study investigating the genetic basis of ANT performance in healthy adults revealed that a specific variation of a gene linked to the production of serotonin was significantly associated with the executive effect on the ANT, whereas surprisingly the gene variation linked to the catecholamine system was not (Reuter et al., 2007). Additionally, functional imaging studies have suggested that depression is linked to abnormal activity patterns in the ACC, prefrontal cortices and basal ganglia areas (Fitzgerald et al., 2007; Wagner et al., 2006). Thus, it may be that those individuals who were reporting more symptoms of depression even at a relatively low level had decreased frontal activity, which in turn might explain their weaker executive efficiency on the ANT task.

In the median-or-lower group, the score on the Inattention/Memory Problems scale was related to alerting efficiency. A higher level of Inattention/Memory Problems score was associated with larger discrepancy between the no-cue and double-cue conditions on the ANT, indicating better

alerting efficiency. It is possible that, in some instances, longer mean RTs on the no-cue condition on the ANT may reflect more effortful processing on this condition. This would then lead to a large alerting effect. Consistent with my study finding, Booth (2003) reported in her dissertation that children with Inattentive Type of AD/HD had larger alerting effect in comparison to children diagnosed with AD/HD Combined Type, but did not differ from the controls. The AD/HD subgroups did not differ from each other on the RT measures, though both groups were slower than the control group. Booth (2003) argued that the larger alerting effect in inattentive children is explained through “sluggish cognitive tempo” in this population. It is possible that in the current study, individuals with higher level of self-reported inattention may have slower performance in trials where no cues are present and they may benefit more from cues than those individuals with lower levels of inattention, regardless of the length of the RTs. In our study, the relationship between Inattention/Memory Problems and alerting effect was evident only in the median or lower group, possibly suggesting that individuals with lower level of general distress may be more accurate in their self-appraisals regarding their cognitive functioning than those individuals showing higher distress levels (Julian et al., 2007; Maor et al., 2001), thus showing a significant relationship between the ANT alerting effect and CAARS-S-L Inattention/Memory Problems scale.

Executive efficiency on the ANT has been found useful in discriminating adults presenting with emotion regulation difficulties, such as individuals with

Borderline Personality Disorder (BPD) characteristics, from individuals without these difficulties (Posner et al., 2002; Rogosch and Cicchetti, 2005). These studies suggest that the executive attention efficiency measure of the ANT may better reflect the functioning of the ventral ACC areas responsible for emotional processing in adults, rather than the more dorsal ACC areas responsible for cognitive processing (Bush et al., 2000). Interestingly, dorsal ACC is one of the key areas that have emerged as dysfunctional in imaging studies investigating the neural basis of adult AD/HD (Bush et al., 1999; Schneider et al., 2006). The previous study findings pointing at the association between emotion regulation and executive efficiency on the ANT lead us to explore this relationship in the current study. As expected based on previous literature, individuals with high scores on the CAARS-S-L Impulsivity/Emotional Lability scale had significantly longer RT's on the incongruent condition on the ANT in relation to RTs on the congruent task condition, in comparison to the individuals who had low scores on the scale. This difference suggests that even low levels of emotion regulation problems in college student population can be associated with poorer conflict resolution ability as measured with the ANT task, and may be indicative of dysfunction in the ventral ACC area. It is possible that the ANT executive efficiency measure is better suited to identify adults presenting with problems related to impulsivity/emotion regulation and possibly ventral ACC pathology, rather than individuals exhibiting inattention and hyperactivity-impulsivity, with possible dorsal ACC dysfunction. Future studies

employing functional imaging methodology should be conducted in order to acquire more support for these hypotheses.

Gender and Ethnicity Differences

Gender was found to be a significant predictor of the executive attention efficiency, with females having less efficient executive attention. Females also had longer RT's on all of the ANT conditions, with the exception of spatial cue and neutral flanker conditions, in comparison to males. No previous data on gender differences on the ANT have been reported to date. Previous studies have reported gender differences in reaction times, and on problem solving tasks, as well as brain activation patterns during cognitive tasks (Adam et al., 1999; Speck et al., 2000). In general, males have been found to outperform females on RT and visual-spatial tasks, whereas females typically perform better than males on e.g., verbal fluency tasks (Adam et al., 1999; Halari et al., 2005).

Previous literature suggests that differential performance on cognitive tasks might be due to gender differences in neuronal activation patterns and/or problem solving strategies among males and females. More specifically, in a study by Adam et al. (1999), females appeared to engage in a more time-consuming serial processing of visual stimuli whereas males approached a visual RT task with a faster approach, dividing stimuli into two halves, and processing them simultaneously, instead of serially.

The RT difference may also be due to gender differences in gray matter volume (GMV) and white matter volume (WMV), females presenting with higher

GMV in comparison to males and males having larger WMV when compared to females (Gur et al., 1999). WMV and white matter integrity in turn have been linked to response speed (Sanfilipo, Benedict, Weinstock-Guttman, & Bakshi, 2006; Tuch et al., 2005), higher volume and integrity being associated with faster responses.

Further, some studies have suggested that sex hormones such as estradiol and testosterone may be one of the underlying factors for the gender differences in cognitive functions (Schöning et al., 2007). More specifically, higher levels of testosterone have been linked to better performance on visual-spatial tasks and reaction time tasks, whereas higher concentration of estradiol has been found to be associated with poorer performance in the visual-spatial domain, but its effect on RT performance has not been consistently reported (Hausmann, Slabbekoorn, Van Goozen, Cohen-Kettenis, & Güntürkün, 2000; Schöning et al., 2007). ANT studies have not consistently investigated gender differences, thus, more studies are needed to explore whether hormonal differences could play a role in attention network performance or RTs.

It is possible that the task approach was different among males and females in the current study, leading to differences in reaction times and lower executive efficiency in females. Differences in brain WM volume and/or gonadal hormones between genders could also have contributed to the results.

In the current study sample there were significant correlations detected among ethnicity and several questionnaire measures, with Caucasians reporting significantly higher level of distress in comparison to non-Caucasians. It has been

reported that different ethnic groups have different response patterns on self-reports of psychological distress. For example, Bardwell and Dimsdale (2001) reported that African-Americans tend to underreport mood symptoms on self-report forms, making this group for example less likely to receive treatment for their distress than their Caucasian counterparts. The cross-cultural differences in self-disclosure tendencies may have played a role in the current study where non-Caucasians tended to report less severe symptoms on self-report measures than Caucasians. However, when measured with reaction times, non-Caucasians were performing less efficiently. No differences were detected on the attention network measures, indicating that ethnicity does not play a role in the efficiency of alerting, orienting and executive attention.

A study of children, using a CPT as the cognitive measure, revealed no ethnicity differences on the RT measures and error rates (Conners et al., 2003). This study did report that females tended to perform slower than males, and males tended to make more errors of commission and omission (Conners et al., 2003). No previous studies investigating RT differences in adults representing different ethnic backgrounds were found. Further, there are no prior studies available that have reported ANT RT's and efficiency measures separately for adult males and females.

Limitations and Future Directions

The reaction times and alerting, orienting and executive effect scores were roughly similar to those found in the Fan et al. (2002) sample utilizing healthy

adults, ages 20 to 44 ($m = 30.1$), and consisting of 23/40 females. Fan et al. report that there was a significant correlation between the “conflict” condition (i.e., executive effect) and the mean total RT. Similarly, in the current study, the executive effect correlated with the RT measures. However, there was a significant correlation among the alerting and orienting networks in my study, indicating that these two networks may not be independent, contrary to what was reported by Fan et al. (2002). Alternatively, this finding may reflect differences between the two study samples. For example, difference in the age or ethnic composition of these two study samples could have contributed to the different associations between the two networks. The mean age in the current study sample was approximately 10 years younger than in Fan’s study; information about the ethnicity of Fan et al.’s participants was not reported.

Nicotine and caffeine intake have been found to positively impact cognitive performance, especially attention, mostly in a short-acting manner (Ernst, Heishman, Spurgeon, & London, 2001; Foulds et al., 1996; Smit and Rogers 2000). In the current study, no information was gathered about nicotine or caffeine consumption on the day of the experiment. In future studies, researchers may wish to control for this variable. This could have been important in the current study given that previous research has revealed a strong comorbidity between depression/distress and nicotine dependence (Murphy et al., 2003). In the current study, it is a possibility that individuals endorsing high level of distress as well as inattention and/or hyperactivity-impulsivity during the past few weeks to months

could have potentially been smokers/coffee drinkers, and if they smoked and/or drank coffee before the experiment, the relationships between our predictor and outcome variables might have been distorted.

Redick and Engle (2006) summarize some problems with the ANT design. First, they noted that ANT network scores have not been reliably replicated in consequent studies. Additionally, it is possible that the efficiency measures do not tap the areas of attention they are thought to tap (i.e., with regard to the alerting condition, some individuals may divide their attentional focus among the two stimuli simultaneously on the double cue condition, whereas others may direct their attention to the two stimulus locations separately, one after the other, leading to longer RTs; Redick & Engle, 2006). These problems may have played a role in the current study, underlying the lack of relationships among the main predictor and outcome variables.

In the current study, the analyses were based on measures derived from the mean RTs on the ANT, according to the model provided by Fan et al. (2002) study. However, mean RT may not be the only indicator of the effectiveness of cognitive functioning in RT studies. Walhovd and Fjell (2007) suggest that calculating standard deviations for the RTs for each participant in a given study may be a more robust indicator of cognitive performance and underlying brain structure than simple mean RT. Future studies might focus on response variability rather than mean levels of performance as additional indicators of attentional inefficiency.

The current study was not primarily focused on the relationship among emotion regulation problems and the ANT performance. However, in the light of recent research findings, and the findings from the current study, it would be interesting to further investigate whether emotion regulation problems are stronger predictors than inattention and/or hyperactivity-impulsivity of the executive attention performance on the ANT. It would be interesting to compare individuals diagnosed with BPD to individuals with AD/HD in order to explore the relationships among symptom presentation, cognitive functioning and potentially also brain functioning in these two patient groups who appear to share some common brain dysfunction patterns (i.e., abnormal activation in the ACC area: Posner et al., 2002; Schneider et al., 2006). More specifically, it would be interesting to investigate the suggestion that dorsal ACC should be dysfunctional in individuals diagnosed with AD/HD and who should be primarily showing cognitive regulation problems, whereas individuals with emotion regulation problems should show abnormal ventral ACC functioning (Posner et al., 2002; Schneider et al., 2006).

Further, performance on the alerting and orienting measures of the ANT could be studied with individuals diagnosed with AD/HD, and individuals scoring highly on the self-reported symptoms of AD/HD but who do not have a long-standing history of these problems, in order to investigate whether a long-standing history of inattention (and/or hyperactivity-impulsivity) would be predictive of ANT performance. Functional imaging methodology would shed light on the neural basis of the relationship between inattention, hyperactivity-impulsivity and attention

network functioning in these groups. This type of a study would potentially help in the process of finding out whether long-standing AD/HD symptom picture, especially in the three AD/HD diagnostic subgroups, may have a different neural basis in comparison to more recently elevated scores on the CAARS scales.

In future studies, adding a psychophysiological measure to represent the level of acute stress might be worthwhile. This type of a measure might allow the researcher to provide a marker for heightened physiological arousal reflecting increased acute catecholamine levels that may impact the ANT performance, and allow discriminating individuals whose performance might be impacted by acute distress from those who do not show increased acute distress.

Summary

In conclusion, the results of this study did not support a relationship between self-reported symptoms of current inattention and hyperactivity-impulsivity and performance on the ANT in a nonclinical sample of young adults. Further, high levels of self-reported depression and/or anxiety did not seem to impact the efficiency of attention networks or reaction times to a significant degree in this population. Among demographic variables, gender had the most consistent relationship with ANT performance. Female gender was related to poorer executive attention efficiency in comparison to males. Different patterns of relations were observed in subgroups of individuals with high and low levels of both self-reported inattention and hyperactivity. High levels of self-reported inattention and hyperactivity-impulsivity may be a risk factor for poorer alerting

efficiency with increasing age. In addition, increasing severity of self-reported depression could lead to weaker executive attention efficiency in individuals reporting low levels of inattention and hyperactivity-impulsivity. Further, in individuals reporting low levels of inattention and hyperactivity/impulsivity, higher levels of self-reported inattention and memory problems were associated with larger alerting effect, indicating that these individuals may benefit more from cues preceding stimuli in conditions that activate the alerting attention network than do individuals with lower levels of inattention and memory complaints. In addition, individuals reporting high level of impulsivity and emotional lability had poorer executive attention efficiency in comparison to those reporting these behaviors and problems to a lesser extent. This finding is consistent with prior studies investigating the relationship between ANT performance and BPD characteristics (Posner et al., 2002; Rogosch & Cicchetti, 2005), and raises the possibility of an association among emotion regulation difficulty, ventral ACC dysfunction and weak executive efficiency on the ANT.

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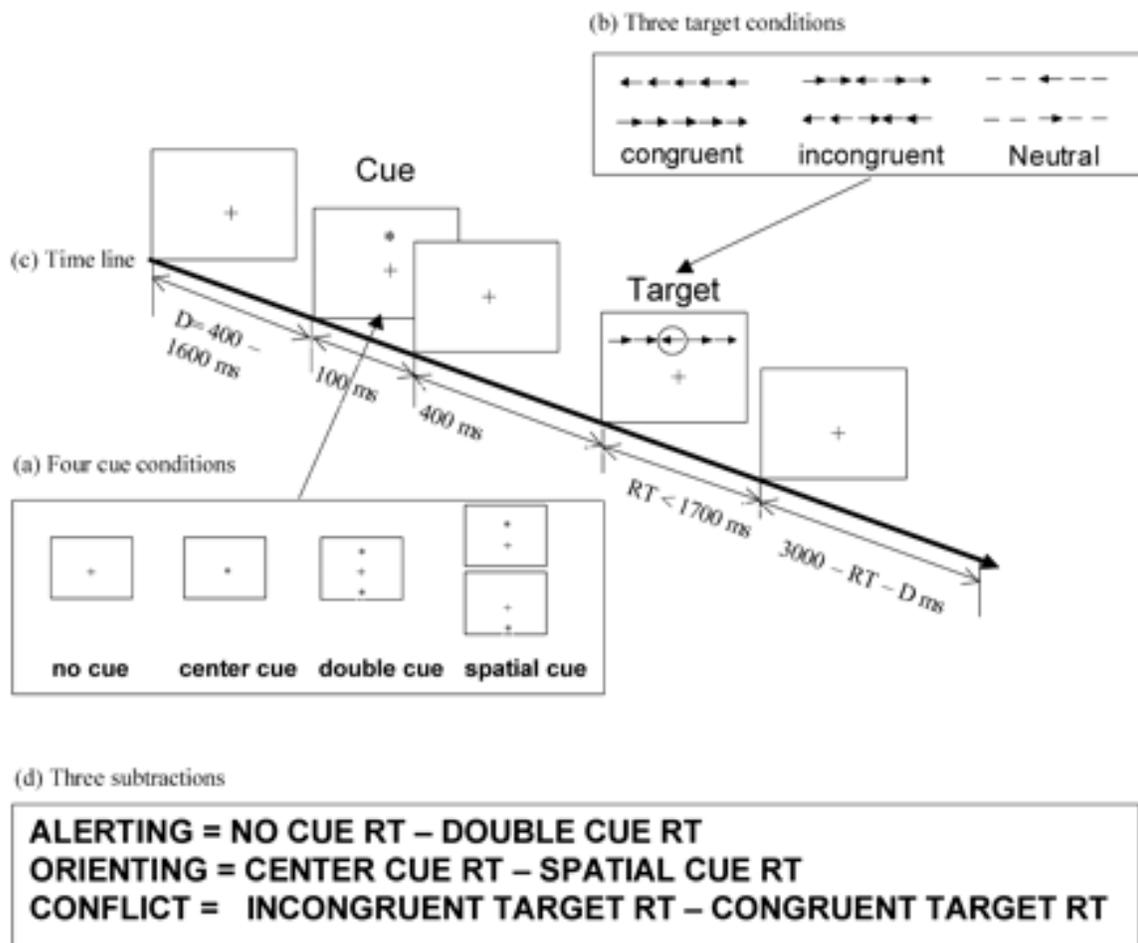
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Appendix 1. ANT Design. (a) The cue conditions used in the experiment. (b) Three types of targets. (c) Time line for each trial. (d) Subtractions used to form network scores. **COPIED FROM FAN et al., 2002**



Appendix 2.

Georgia State University
Department of Psychology

Informed Consent Form

Title: Study for Attention Network Test (ANT)

Principal Investigator: Mary K. Morris (Faculty)
Sanna Lehtonen (Student)

I. Introduction:

You are being asked to volunteer for a research study concerned with attention. The aim of the study is to investigate, whether there is a relationship among self-reported experiences and performance on a computerized attention test.

II. Procedure:

First, you will be asked questions pertaining to demographic characteristics, current medications and medical history. Then you will fill out three questionnaires asking questions about your recent feelings and experiences, and your typical behavior during the past few months. After completing these questionnaires, you will complete a computerized task. The task will take approximately 30 minutes. During the task, you will be required to focus your attention on the visual stimuli shown to you on the computer screen. You will be asked to respond to certain stimuli by pressing the buttons of a mouse. The entire study should take approximately 1 to 1.5 hours to complete. If you are currently taking stimulant medication, you will be invited to return again on a second day to complete some of the questionnaires and the computerized attention task again. If you are taking stimulant medication today, you will be invited to return for a second visit, after refraining from taking your medication for 24 hours. If you are prescribed stimulant medication, but did not take it prior to this appointment, you will be invited to return for a second visit after taking your prescribed dosage.

III. Risks and Benefits:

There are no readily identifiable significant risks associated with participating in this experiment. However, those participants volunteering to withhold prescribed medication may experience a transient increase in inattention and hyperactivity-impulsivity. You will be able to schedule the session off medication at your convenience to minimize any negative impact. Mild fatigue may be experienced during the completion of the computerized task. Also, it is possible that you may experience some discomfort when completing the questionnaires asking questions about your recent feelings. You will be compensated with 2 course credit hours for your time and effort, and the knowledge that

will be gained may benefit individuals with cognitive and/or psychological disorders that cause problems with attention.

IV. Voluntary Participation and Withdrawal:

You are free to choose whether or not to complete the study. You may stop the experiment at any time without being penalized in any way.

V. Confidentiality:

All the information collected in this study will remain confidential, and participant information will be identified by number only. The code linking names and numbers will be kept in a locked filing cabinet and will only be accessible to research staff under the supervision of Dr. Mary Morris, the faculty member supervising this project. Data for the study will be used in scientific reports, and no names or identifying information will be included in these reports.

VI. Contact Persons:

The experimenter will be happy to answer any questions that you might have about taking part in this study. If complaints or problems concerning this project should arise, they should be reported to Dr. Mary Morris in the Department of Psychology, phone 404 651 1611. The GSU Research Office (Susan Vogtner: 404 651 4350) can also provide you with general information about the rights of participants in research.

VII. Written Consent:

We will give you a copy of this consent form to keep.

If you are willing to volunteer for this research, please sign below.

Participant's Signature

Date

Experimenter's Signature

Date