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THE UNIVERSITY OF CALGARY

Differences in Adult ADHD Subtypes based on Comorbidities and Attention
Processes

by

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ABSTRACT

The current study compares populations of male and female adults with Attention Deficit Hyperactivity Disorder, Predominantly Inattentive Type (ADHD-PI), and Attention Deficit Hyperactivity Disorder, Combined type (ADHD-C). Comparisons are made using measures of depression, anxiety, and anger. In addition, comparisons are made using measures of selective and sustained visual and selective auditory attention.

Results indicate that individuals with ADHD-C experience higher levels of depressed mood and trait anger. Additionally, individuals with ADHD-PI are more able to limit the experience of anger than those adults with ADHD-C. Participants with either subtype showed elevated levels of trait anxiety; however, no significant differences in anxiety levels were detectable between subtypes. Group scores for adults with ADHD-C and ADHD-PI were remarkably congruent on all measures of visual and auditory attention and none of these measures was capable of distinguishing between these two subtypes in this study. Results do not indicate any significant association between ADHD subtype and sex.

Implications are discussed with regard to the underlying processes and treatment of ADHD in adults.

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Dedication

This thesis is dedicated to my wife Ruth who has weathered many changes in our lives over the past nine years but who has provided unfailing support for all of my endeavours in psychology.

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CHAPTER 1

INTRODUCTION

Since the 1930's researchers and clinicians have observed numerous children who display persistent symptoms of hyperactivity and impulsivity beginning in the preschool years (Bradley, 1937). There is also a consensus that some children develop difficulties with sustained attention, but without observable hyperactive or impulsive behaviors. Both of these behavioral syndromes tend to become problematic in structured learning, as well as in various social environments and have been subsumed under the rubric of what we know today as Attention Deficit Hyperactivity Disorder or ADHD (Barkley, 1996). Although attention and its neural correlates are presently an important investigative avenue, in ADHD research historically, investigation of childhood hyperactivity and lack of inhibition preceded research on attention (Barkley, 1996). Thus, early researchers were concerned with hyperactivity or as it was once referred to, "hyperkinesis", rather than specific abilities or deficits connected with attention (American Psychiatric Association [APA], 1968).

The past two decades have witnessed an enormous output of research on ADHD. The research interest regarding ADHD is partly due to its being the most common reason for referring children for pediatric consultation or psycho-educational evaluation (Stanford & Hynd, 1994). Not only is ADHD a common childhood syndrome, it is now known that the behaviors associated with this disorder persist into adulthood in about two-thirds of cases (Ingram, Hechtman & Morgenstern, 1999; Shekim, Asarnow, Hess, Zaucha, &

Wheeler, 1990). Thus ADHD has, in recent years, come to be recognized as a pervasive syndrome that may influence an individual throughout most of his or her lifetime.

One factor that has complicated research into childhood ADHD has been its frequent occurrence in combination with other symptom clusters such as those associated with aggression, depression, and anxiety as well as with chronic tic disorders such as Tourette syndrome (Spencer et al., 1998). The comorbidity with ADHD has also provided an opportunity for new understanding of the etiology of these associated disorders based on research into common vulnerabilities, and familial patterns. Comorbidity studies tend to focus on: a) familial and genetic patterns of appearance of multiple disorders, b) common comorbid symptom clusters in referred clinical populations, c) similarities and differences of common comorbid clusters in response to standardized or laboratory testing or to pharmacological treatment, and d) investigation of correlates of brain functioning using various neuroimaging techniques. Of course, combinations of these techniques are sometimes included in a single study.

The growing body of research into common comorbidities with childhood ADHD is relevant to the current research goal of further understanding the specific psychiatric correlates of ADHD subtypes. In particular, there have been recent challenges to the DSM-IV (APA, 1994) in which classification of ADHD is based primarily on aggregations of symptoms of impulsivity, hyperactivity, and inattention (APA, 1994). These published challenges suggest that ADHD co-occurs with various forms of externalizing and internalizing disorders so frequently that they may actually form unique

diagnostic syndromes that many authors argue should be included in upcoming DSM revisions (Jensen, Martin & Cantwell, 1997; Tannock, Ickowicz & Schachar, 1995). In addition, the high rate of observed comorbidity between ADHD and internalizing disorders has also been observed in adults (Biederman et al., 1993; Hornig, 1998). An examination of the most current literature indicates that ADHD co-occurs with anxiety disorders, depression, and aggression at rates that are much higher than would be expected for chance associations (Barkley, 1996; Eiraldi, Power & Nezu, 1997). In spite of the above finding, there has been little direct investigation of how these mood, anxiety, and aggressive disorders interact specifically with ADHD in its two most common forms.

In research and in practice the syndrome known most recently as ADHD is generally classified into two basic subtypes designated ADHD combined type (ADHD-C), which includes symptoms of inattention, hyperactivity, and impulsivity; and ADHD predominantly inattentive type (ADHD-PI) in which symptoms of inattention are observed but with minimal accompanying impulsive/hyperactive behaviors (American Psychiatric Association (APA), 1994; Barkley, 1996). It should be noted that the existence of the two subtypes of ADHD is based primarily on observations of behavioral syndromes in research and clinical settings. Barkley, DuPaul and McMurray (1991), and Stewart (1994) have suggested that it is essential that we find evidence that validates the differences between ADHD subtypes by moving beyond mere descriptions of core behaviors. This challenge is offered because currently, global ratings of inhibition, inattention, and hyperactivity are used to diagnose ADHD. However, studies that have looked for contrasts

between ADHD-C and ADHD-PI have often differentiated them based only on the relative intensity of these same three core behaviors (Stewart, 1994). The current study is designed to move away from the methodological problems just described. Evidence of specific patterns of comorbidity with ADHD-C and ADHD-PI will add to our understanding of how these two syndromes may differ from one another. This understanding will be further enhanced by an examination of similarities and differences between ADHD subtypes with regard to specific attention processes.

As noted in the opening paragraph, early research focused primarily on hyperactivity and lack of inhibition in children with ADHD. It was only recently that an examination of attention skills and deficits became an area of active ADHD research. In the past two decades, biological and cognitive psychologists have identified at least two basic attentional processes along with their respective neural substrates. These are defined as selective and sustained attention and are believed to be controlled by the posterior and anterior attention networks of the cerebral cortex (Rothbart, Posner & Hershey, 1995). Although there has been some speculation in the literature that deficits in sustained attention may be associated with ADHD-C (Barkley, DuPaul & McMurray, 1991), no direct investigation of these associations has been undertaken with children or adults.

Summary

It may be said that there is a gap in our knowledge of how the two most

common forms of ADHD interact with their most common associations, which are aggressive and internalizing disorders. In addition, although ADHD stands for Attention Deficit Hyperactivity Disorder we have little empirical knowledge of how specific attention skills and deficits interact with ADHD in its two most commonly observed subtypes. To restate the problem, there is a consensus that ADHD exists in two easily recognizable forms. However, these forms of ADHD have not been compared using information regarding common comorbid associations and recent evidence regarding human attentional processes. This is a critical problem since even a casual review of the literature indicates that, to date, we have only defined ADHD according to observable primary behavioral syndromes. While this definition has face validity and clinical usefulness with regard to assessment, it does nothing to aid in our understanding of the underlying cognitive processes associated with ADHD symptoms nor does it provide a solid theoretical basis for developing new forms of treatment (Stewart, 1994).

The current study examines common comorbidities and attentional processing in adults. An adult population is employed because, by the end of adolescence, many comorbid syndromes have fully developed and cognitive processing associated with attention has reached maturation. The following review of research literature will delineate the most robust findings related to comorbidities and cognitive processing in ADHD. It begins with the history of ADHD nosology as it has been defined and utilized by the American Psychiatric Association (APA).

ADHD - Diagnostic Criteria

ADHD Subtypes

As noted above, ADHD was originally referred to as “hyperkinetic reaction of childhood disorder” in the DSM- II due mainly to the emphasis on the motoric overactivity of children so identified (APA, 1968; Lahey et al., 1994). The classification was refined to include a category called ADD (attention deficit disorder without hyperactivity) in which inattention was the primary feature but without accompanying impulsivity or hyperactivity, as well as ADDH (attention deficit disorder with hyperactivity) in the DSM-III (APA, 1980). In spite of a much lower prevalence of ADD as compared to ADDH, the introduction of the former category was welcomed due to its validity and clinical utility (Quay, 1999). Using the DSM-III criteria, individuals were categorized as either ADD or ADDH based on minimum numbers of behaviors taken from three lists of symptoms: inattention, impulsivity, and hyperactivity. In spite of the utility of the DSM-III diagnostic system for ADD, the subsequent DSM-III-R collapsed the operational criteria of the DSM-III into a single list of symptoms made up of 9 items from the DSM-III with the addition of 4 new ones. Although the DSM-III-R provided a category that was described as “undifferentiated ADD” it effectively eliminated ADD-without hyperactivity, from the classification system (APA, 1987; Lahey et al., 1994; Morgan, Hynd, Riccio & Hall, 1996; Stewart, 1994).

The dismissal of ADD-without hyperactivity in the DSM-III-R was

highly problematic. Clinically, it meant that an individual could be diagnosed with ADDH with no symptoms of inattention whatsoever. As well, because it was required that an individual meet only 8 of the 14 criteria, two different individuals could be diagnosed with ADDH with as few as two congruent symptoms (Quay, 1999). From the standpoint of ADHD researchers, the changes to DSM-III were regarded as premature and in response, a considerable number of studies were initiated in order to determine the actual number of dimensions which underlie ADHD. Although the resulting research consistently showed that ADHD did not consist of a unitary dimension, it also tended to discredit the three dimensional approach (inattention, impulsivity, and hyperactivity) utilized in DSM-III (Barkley, 1996; Lahey et al., 1994). The evidence showed that two dimensions of symptoms- one of inattention and a second composed of hyperactivity *and* impulsivity- underlie ADHD (Lahey & Carlson, 1991; Lahey et. al., 1994).

In order to take the newest research into account, the DSM-IV included three distinct diagnostic categories. The first includes symptoms of hyperactivity and impulsivity but without substantial evidence of inattention and is termed ADHD-hyperactive impulsive (ADHD-HI) type. The second (which corresponds to DSM-III ADD) includes symptoms of inattention without substantial evidence of impulsivity or hyperactivity and is termed ADHD- predominantly inattentive (ADHD-PI) type. The final category includes symptoms of inattention, impulsivity, and hyperactivity and is referred to as ADHD-combined (ADHD-C) type (APA, 1994).

The analysis of the proposed categories for ADHD in the DSM-IV was published by Lahey et al. (1994) in order to demonstrate the validity of the

proposed differentiation of ADHD subtypes to scientists and clinicians who might wish to understand the rationale for the new classification scheme. The validity of the three subtypes was demonstrated in the study; however, some differences were noted in the demographics of individuals in the three classification categories. Most importantly, the mean age for children diagnosed with ADHD-HI was 5.68 years (standard deviation 1.77) whereas the mean age for the PI and C categories were 9.8 years (s.d. 3.23) and 8.52 years (s.d. 2.70) respectively. This finding was congruent with evidence from longitudinal research that suggested that with ADHD, symptoms of inattention remain relatively constant over time while hyperactivity and impulsivity decline substantially with increasing age (Lahey et al. 1994).

The prevalence and age distribution of DSM-IV ADHD subtypes in children and adolescents is of importance in determining which categories are most likely to be diagnosed in adults. In a study by Morgan, Hynd, Riccio, and Hall (1996), comparisons were made between DSM-III-R and DSM-IV diagnostic categories in late elementary age children with ADHD. Out of 58 potential subjects, the authors were able to find only two children who met diagnostic criteria for ADHD-hyperactive/impulsive type. More recent research has shed light on the prevalence and validity of the DSM-IV ADHD subtypes. McBurnett et al. (1999) examined 692 children and adolescents referred to a pediatric clinic for symptoms associated with ADHD. In their study, which was designed to cross-validate symptoms of DSM-III-R and DSM-IV ADHD, by far the smallest number of participants (7.3%) met diagnostic criteria for DSM-IV ADHD-HI type. The authors speculate that the ADHD-HI type may result from the tendency for very young children who are

overactive to be referred by parents only. Thus, a diagnosis may be made prior to recognition of attention problems which they state are more likely to be observed by teachers in structured academic settings. In previous research by this author (Dye, 1998), a sample of elementary school children aged 9-12 was studied and although some children met diagnostic cutoffs for ADHD-HI, significant differences in scores on the hyperactivity, impulsivity, and inattention scales of the Attention Deficit Hyperactivity Disorder Test (Gilliam, 1995) between ADHD-C and ADHD-HI groups were not observed.

A large scale study by Neuman et al. (1999) employed latent class analysis to determine the underlying structure of DSM-IV ADHD diagnostic categories. This research made use of parental reports on 1318 adolescent female twin pairs along with 855 male and female participants (age 7-17) ascertained from different sites. The results of the analysis were consistent between these groups and the pattern of latent classes strongly suggested the existence of two primary subtypes, that of an inattentive as well as a combined-inattentive/hyperactive/impulsive subtype. The authors note that a distinct hyperactive-impulsive subtype could not be detected in any of their samples.

To summarize, the research regarding DSM-IV ADHD criteria indicates that although ADHD-HI subtype has been diagnosed in children, these appear to be very young individuals. Consistent with this evidence is the finding that the HI type is rarely diagnosed in older children and adolescents. Most important is the question of whether the HI subtype, in which symptoms of impulsivity and or hyperactivity exist without any symptoms of inattention, exists in older children and adolescents. This question appears to have been

addressed sufficiently by the analysis of symptom clusters in the large scale Neuman et al. study (1999) study in which the HI subtype was not detected. Although it may be possible to diagnose ADHD hyperactive-impulsive type in some adults, the likelihood of ascertaining an experimental group of such individuals large enough for comparison purposes is low and thus, in the current study, only ADHD-C and ADHD-PI groups are included.

ADHD Comorbidity

Although the DSM-IV presents most disorders as existing in discrete categories, it is well known that comorbidity tends to be the rule rather than the exception. Kaplan, Dewey, Crawford and Wilson (2001) have argued convincingly that the term comorbidity is outmoded and is merely a reflection of the historical relationship between medicine and psychology. In the medical context, comorbidity referred to the presence of two or more symptoms which are not a product of the same underlying cause. Such determinations in neurobiology and, by association, psychology are much less secure due to the complex interrelationship of cerebral physiology and neurochemistry with observable behavior. The observation of comorbid syndromes along with a primary diagnosis of ADHD (or vice versa) is neither new nor controversial. However, rather than presenting a problem, the view taken in the current study is that careful delineation of the associations of comorbid syndromes with ADHD subtypes may offer new understanding of the differences between ADHD-C and ADHD-PI. In spite of the likely

inaccuracy of the term “comorbidity” for use with psychological research, for the purposes of the current study we will make use of this term in order to maintain consistency with the nomenclature of previous ADHD research.

Comorbidity in Childhood and Adolescent ADHD

The high rates of comorbidities with ADHD noted in the introduction have been observed for decades in research and in clinical practice (Barkley, 1996). A thorough review of the research from the period between 1981 and 1996 with regard to psychiatric comorbidities in childhood ADHD was recently conducted by Jensen, Martin, and Cantwell (1997). The authors described the common co-occurrence of ADHD with conduct/aggression problems, anxiety, and depression. They also attempted to disentangle the complex relationships between ADHD and the three most common comorbid syndromes noted above and argued that there is sufficient evidence to create an ADHD/aggressive and ADHD/anxious subtype for future DSM revisions. The authors did conclude that more research was required with regard to the frequency of associated syndromes and that comorbidity should be considered normal in ADHD research rather than just “noise”.

Evidence for a distinct ADHD/anxious subtype has also been provided by other researchers who have noted a differential response to methylphenidate in ADHD children with and without comorbid high levels of anxiety. Tannock, Ickowicz, and Schachar (1995) noted differential response on measures of working memory while Pliszka (1989) and DuPaul, Barkley and McMurray (1994) noted differential responses on a variety of behavioral

and academic outcome measures. In general, children with a history of noticeable anxiety were shown in these studies to be poor responders to methylphenidate, either showing little or no improvement on various tests or experiencing side effects which precluded further use of this medication.

Evidence for a distinct ADHD/aggressive subtype comes from various quarters. Most notably, the consistent association between aggression, conduct problems, and ADHD has led some researchers to conclude that there exists a specific pervasive form of Conduct Disorder that is marked by onset of severe ADHD symptoms in the preschool years (Hinshaw & Anderson, 1996). It should be noted that Hinshaw and Anderson consider a more general ADHD/aggression association to exist because of the difficulty in separating the overt behavioral symptoms of ADHD from oppositional and conduct disorders. More specifically, "aggression" is so commonly associated with ADHD (and particularly with the ADHD-C subtype) that it is questionable whether or not it can be used to establish a diagnosis of comorbid Oppositional Defiant or Conduct Disorder at all. It may be that different lines of investigation are needed to unravel the association between ADHD and aggression/conduct problems.

More recent research into childhood ADHD has continued to focus on the association between ADHD and conduct problems primarily because this association is demonstrably robust (Quay, 1999) but additionally because of the historical tendency for child/adolescent psychopathology research to focus on disruptive behaviors in general (Hinshaw & Anderson, 1996). In contrast, there has been a reluctance to acknowledge the presence of syndromes such as major depression in children, and thus there have been far fewer studies that

have sought to uncover the relationship between internalizing disorders and ADHD. The majority of studies that have examined the associations between ADHD and anxiety or depression in childhood have made use of the heterogeneous criteria used by the DSM-III-R rather than recognizing subtypes as in the DSM-III and DSM-IV. In spite of this, the research that does exist provides some valuable information regarding the association between ADHD and externalizing/internalizing disorders as well as compelling evidence of the continuity of ADHD and comorbid syndromes from childhood through adolescence.

A seminal study by Biederman et al. (1998) was designed to examine continuity of diagnostic associations between childhood and adolescent ADHD. Diagnostic comorbidities of ADHD with Conduct Disorder (CD), Major Depressive Disorder (MDD), multiple anxiety disorders, and substance abuse were observed in both groups, and rates of occurrence were found to increase from childhood to adolescence. The highest rates of comorbidity were with MDD, with rates of 44% for childhood (mean age 9.0 years) and 54% for adolescence (mean age 14.4 years). Rates of CD in ADHD children and adolescents were 25% and 42% respectively, and for anxiety they were 35% and 46%. Fully 22% of children and 28% of adolescents with ADHD met criteria for bipolar disorder. The authors concluded (and illustrated by graphic representation) that there was an almost identical pattern of correlates in multiple domains of assessment between child and adolescent ADHD subjects. Although the study was recent, DSM-III-R (as compared to DSM-IV) diagnostic criteria were employed and thus variable rates of comorbidities in comparison to ADHD subtype were not examined.

Diagnostic and Comorbidity Issues in Adult ADHD

A growing body of research has indicated that symptom clusters congruent with DSM-IV ADHD nosology are diagnosable in adults. In fact 50%-75% of individuals with childhood ADHD experience ongoing symptoms throughout adolescence and into adulthood (Barkley, 1996,1998; Ingram, Hechtman, & Morgenstern, 1999). The conclusion by the majority of ADHD researchers is that ADHD is a valid diagnosis in adults (Spencer, Biederman, Wilens, Faraone, & Li, 1994).

It is also recognized that the presence of comorbid diagnostic syndromes complicates the diagnosis of ADHD in adults (Hornig, 1998; Murphy & Barkley, 1996). Most importantly, however, is the finding that the rates of co-occurrence of MDD, bipolar disorder, and anxiety disorders with ADHD in adult populations is similar to that found in childhood and adolescent populations and that little difference in comorbidity rates exists between adults diagnosed with ADHD in childhood as compared to those diagnosed in adulthood (Biederman et al., 1993). This latter observation is not surprising given the research by Biederman et al. (1998) summarized above, which noted the strong continuity in rates of comorbid associations between childhood and adolescent ADHD.

A study by Shekim, Asarnow, Hess, Zausa, and Wheeler (1990) noted high rates of comorbidity in adults with ADHD, with over 80% of subjects meeting criteria for at least one other DSM-III-R disorder. The authors reported that over 50% of adult ADHD subjects met criteria for Generalized Anxiety Disorder (GAD) and 50% met criteria for either Dysthymic or

Cyclothymic disorders. Biederman and associates (1993) reasoned that if adult ADHD was a valid diagnostic entity, then similar rates of comorbidity between adult and childhood ADHD should be observed. Their study compared 84 ADHD adults with their non-referred relatives with ADHD, referred children with ADHD, and normal adult controls. Results indicated similar rates of comorbidity between children and adults with ADHD when allowances were made for age specific disorders such as Separation Anxiety Disorder (childhood only) and Generalized Anxiety Disorder (normally diagnosed in adults).

Internalizing Disorder Research and ADHD

Research that is primarily directed at examining internalizing disorders in children, adolescents, and adults also provides evidence of strong associations with ADHD. A study by Biederman, Faraone, Mick, Moore, and Lelon (1996) examined the presence of major depression in a population of 424 referred children and adolescents with various primary psychiatric diagnoses. The highest observed rate of comorbidity with severe and major depression was with ADHD, followed by oppositional defiant disorder, and then multiple anxiety disorders. Following correction for symptom overlap between depression and ADHD as well as for depression and ODD, results indicated that roughly 90% of MDD subjects would still maintain their comorbid ADHD or ODD diagnosis. Another interesting conclusion from the study was that, for subjects with MDD and any comorbid diagnosis, the comorbid disorder almost always preceded MDD developmentally. Mean age

of onset was approximately 4, 5, 6, 7, and 8 years for ADHD, anxiety disorders, dysthymia, ODD, and major depression respectively.

A study by Alpert and associates (1996) examined rates of ADHD in adults diagnosed with DSM-III-R MDD. In the Alpert et al. study an interesting distinction was made between adults with MDD only, those adults with MDD who had met diagnostic criteria for ADHD as children, and those adults who had some symptoms characteristic of ADHD but who did not meet diagnostic cutoffs as children (ADHD-subthreshold). Overall 16% of the adults met criteria in childhood for either of the above described ADHD categories and 12% reported persistence of meaningful symptoms of ADHD into adulthood. Similar patterns of comorbidity were found between the MDD only and MDD+ADHD/subthreshold groups with regard to anxiety disorders. Individuals who met diagnostic criteria for ADHD and MDD had somewhat lower rates of anxiety. No differences were found between groups on age of onset or course of MDD.

A study by Milberger et al. (1995) focused on the concept of overlapping symptoms between ADHD and Major Depressive Disorder (MDD) as well as Bipolar Disorder in children, adolescents, and adults. The goal of this study was to determine whether or not a diagnosis of comorbid ADHD might be the result of overlapping symptoms between it and MDD or Bipolar Disorder. After examining 128 ADHD probands and their relatives along with controls the authors noted very high rates of comorbidity in their clinically referred sample. The authors concluded that the ADHD diagnosis in this study was not merely the result of symptoms shared with other psychiatric disorders and that, conversely, these comorbid conditions themselves are not an artifact

of overlapping ADHD symptoms. With most of the participants a diagnosis of ADHD and depression could be made using non-overlapping symptoms.

Comorbidity in Association with ADHD Subtype: Recent Findings

From the forgoing discussion it may be observed that very little research to date has examined patterns of comorbidity in association with ADHD subtype. This is partly due to the fact that, prior to the publication of the DSM-IV in 1994, there was some confusion over how these subtypes should be identified in a manner that was uniform between researchers and clinicians. This has begun to change and as will be seen in the following summary, the inclusion of subtype in ADHD research reveals some relationships which have eluded past studies and which are relevant to the present study. In addition, by examining the distinctive ways in which anxiety and depression relate differentially to conduct/aggression syndromes in ADHD, patterns begin to emerge that will guide the hypotheses tested in the current study.

In one of the first reviews of childhood research literature pertaining to ADHD subtyping, Lahey and Carlson (1991) sought to uncover the most common comorbidities with DSM-III ADD and ADDH (corresponding to ADD-PI and ADD-C in the current study). The authors noted that children with behaviors congruent with DSM-III ADD tended to have less serious conduct problems than their counterparts with ADDH. They also presented evidence that children with ADD are less likely to be rejected by peers; however, they suggested that this same group was more likely to be

withdrawn and to have more problems with anxiety and depression.

Barkley, DuPaul and McMurray (1991) recognized potential differences in ADHD subtypes in one of the first studies looking at possible treatment differences between ADHD-PI and ADHD-C (termed ADD-H and ADD+H in their study). This research, aimed at determining differences in methylphenidate treatment outcomes in the two ADHD subtypes, found evidence of higher ratings of aggression in the ADHD-C subtype as compared to the ADHD-PI group. Most interesting was the finding that children diagnosed as ADHD-PI were much less likely to respond to methylphenidate or were more likely to respond to very low doses as compared to children with ADHD-C, who evidenced a very high rate of response to the medication.

Some recent research has specifically examined patterns of comorbidity in relationship to the DSM-IV classifications of ADHD-C and ADHD-PI. In the study by Eiraldi, Power, and Nezu (1997), noted in the introduction, rates of externalizing and internalizing disorders were examined in relationship to ADHD-C and PI. The results described a significant robust association between ADHD-C and externalizing disorders such as Oppositional Defiant and Conduct Disorders (ODD and CD) on both categorical and dimensional symptom measures. However, the association between ADHD-PI (called ADHD/I in that study) and internalizing disorders was ambiguous and the two ADHD groups could not be distinguished using this variable. The authors pointed to a contemporary study by Biederman, Faraone, Moore, and Lelon (1996) which found that ADHD children with externalizing disorders show increased tendency towards symptoms associated with mood lability, irritability, and outbursts as compared to children without similar

comorbidity.

An issue that is related to the observed relationship between ADHD-C and oppositional/conduct disorders but which has received little attention until recently is that of the association between aggression and ADHD. In a study by Matier, Halperin, Sharma, Newcorn, and Sathaye (1992), response to methylphenidate in aggressive and nonaggressive children with ADHD was studied. Although methylphenidate reduced inattention in both groups, only the non-aggressive children showed reductions in their rates of overactivity. The authors pointed to the fact that they used measures of pure physical aggression rather than measures which mainly tap into oppositional and disruptive behaviors. They argued that this was important because oppositionality and aggression are not necessarily the same thing. Although the authors maintain this distinction it would appear that aggression is a prominent feature of oppositionality (Quay, 1999; Waslick, Werry & Greenhill, 1999). Aggressive symptoms have however, been observed to be replaced by more covert forms of oppositional behaviors as the individual matures (Quay, 1999).

A major methodological problem with many of the ADHD comorbidity studies already described is that they collapse mood disorders such as Major Depressive Disorder and Dysthymia together with anxiety disorders into the heterogeneous grouping referred to as "internalizing disorders". This practice is presumably due to the commonly observed association between anxiety and depression in clinical syndromes, but it ignores the evidence that these may be distinct disorders with regard to etiology. In particular, with regard to ADHD research, an understanding of

the associations of specific disorders to ADHD subtypes may aid in a more detailed understanding of ADHD and provide more compelling reasons to initiate novel treatment regimens. The basic reason for this argument is that there is growing evidence for an association between depressive disorders and ADHD-C or more generally with an ADHD/aggression syndrome, as has already been suggested.

Studies of familial aggregation such as the one by Faraone et al. (1997) mentioned above have provided evidence of genetic linkage between ADHD and oppositional problems. Further, a study by Biederman et al. (1992) of 140 ADHD probands and their 822 first degree relatives provided strong evidence that ADHD and MDD share common familial vulnerabilities, while anxiety disorders appear to be transmitted independently of ADHD. Similar results come from a study by Perrin and Last (1996) in which 239 male children with ADHD and their 1,266 first degree relatives were assessed for the presence of ADHD and anxiety disorders based on DSM-III-R criteria. These authors concluded that ADHD and anxiety share common risk factors but are transmitted independently in families.

A number of studies have reported comorbidity rates of various disorders with ADHD either because these rates were central, or merely incidental, to their research. De Quiros, Kinsbourne, Palmer, and Rufo (1994) examined relative rates of problematic behaviors, mood and substance abuse disorders, and learning disabilities in a population of referred children with symptoms of either inattention only (I), inattention and impulsivity (II), or hyperactivity, inattention, and impulsivity (HII). They noted that children with the latter symptom cluster (which corresponds with DSM-IV, ADHD-C

subtype) had higher rates of depression, alcoholism and learning problems than the inattentive only subject group (the latter corresponding to DSM-IV, ADHD-PI subtype). Further, the I subgroup had significantly higher rates of internalizing disorders than the HII subgroup while rates of externalizing disorders were also significantly different but in the reverse direction (HII>I). The II subgroup that was included in this study does not correspond to any DSM classification but appeared to be behaviorally similar to the HII group.

In a study by Arrendo and Butler (1994) which examined the usefulness of mood stabilizers for treating adolescent ODD and CD, very high rates of affective disorders as well as ADHD were noted in a behaviorally disordered population. Interestingly a very low rate of anxiety disorders was observed. The observed high rate of association of ODD and CD with mood disorders may be significant when we also consider the high rate of comorbidity between ADHD-C, ODD, and especially CD. Although nearly 40% of the adolescents with CD in the Arrendo and Butler study had co-occurring ADHD, nearly 67% had co-occurring mood disorders with fully one-third of subjects experiencing MDD and one quarter meeting criteria for bipolar disorder.

In the two studies described above (Arrendo & Butler, 1994; DeQuiros et al., 1994), the low rate of comorbidity of anxiety disorder with conduct problems is noteworthy. In a study by Pliszka (1989), which involved 79 predominantly male children with DSM-III-R ADHD, rates of anxiety were determined. Initial assessments showed that fewer children with clinical levels of anxiety met diagnostic criteria for conduct problems as compared to those without anxiety. One peculiar finding of this study was that, of the children with ODD, approximately half also had clinical levels of anxiety

while none of the children with CD had comorbid anxiety. The children in the study were all between 7 and 10 years of age, and thus, the author's diagnostic methodology with regard to distinguishing ODD and CD is confusing since CD is normally diagnosed only in adolescents. The central goal of this research was to examine methylphenidate response and the results showed that ADHD subjects without anxiety had significantly better response to methylphenidate than those with anxiety.

To summarize the above findings we might suggest that depressive disorders are more likely to be associated with ADHD-C, especially when this subtype is found in association with conduct disorders or aggressive syndromes. Conversely, there is some evidence to suggest that anxiety in ADHD is inversely related to comorbidity with conduct/aggression problems. The relationship between ADHD-PI and anxiety and mood disorders is not clear at the present time and warrants further investigation.

Oppositional Behaviors and Aggression in Adults with ADHD

Many of the above noted findings have come out of the childhood/adolescent ADHD literature. The congruence of comorbidity patterns between children and adults with ADHD and the persistence of core features of ADHD (inattention and impulsivity) into adulthood provides some justification for extrapolating research predictions into adult ADHD populations. One area where this is problematic, however, is in the area of oppositionality and aggression. The pattern of DSM-IV nomenclature for these types of disorders based on age is as follows: ODD in children, CD in

adolescents, and finally Antisocial Personality in adults. Note that only a small percentage of adults who evidence symptoms of ODD and CD in childhood fully qualify for a diagnosis of Antisocial Personality Disorder [(APD) (Hinshaw & Anderson, 1996)]. Individual adults who qualify for a diagnosis of APD are also likely to have come into conflict with the justice system and are unlikely to be ascertained in studies which draw from typical clinical or community samples. Additionally, with regard to adults who do not currently meet criteria for APD but who may have qualified for a diagnosis of ODD or CD as children or adolescents, it is difficult to retrospectively diagnose such disorders with a great degree of accuracy.

In attempting to determine oppositional predisposition in adults, a more appropriate strategy would be to look for an underlying emotional construct which may be consistent with aggressive or oppositional tendencies in childhood but which might also be identifiable in adults. Some authors such as Hinshaw (1996) have noted that aggressive tendencies in children with oppositionality with or without ADHD results in negative evaluation and therefore rejection by peers. According to Hinshaw, anger is a consistently observed response to continuing peer rejection. Other authors such as Stark, Swearer, Kurowski, Sommer, and Bowen (1996) have suggested that anger is a response to irritability which is common in childhood depression. Most interesting is the fact that in the Stark et al. (1996) study as well as other research regarding combined treatment modalities for children, anger management is usually regarded as a necessary component. As described above both aggression and depression have been found to be associated with a very high percentage of individuals with ADHD regardless of age and thus

difficulties with angry temperament would be anticipated in such individuals, particularly those with ADHD-C.

With regard to adults with ADHD, it would be expected that the great majority have experienced censure by peers, teachers, or parents at some point in childhood or adolescence. The frustration felt by such individuals could be demonstrated in anger and aggression in youth. However, aside from those adolescents who demonstrated marked tendencies towards antisocial behaviors, there would be a gradual realization that overt anger and aggression is detrimental to achieving success in most adult endeavors and therefore greater effort would be expended in suppressing anger. It would be expected that indications of anger and a marked investment in suppressing it, would be most pronounced in those with ADHD-C because of observed higher rates of comorbidity with aggression and depression in these individuals as compared to those with ADHD-PI

In research which examined the underlying construct of anger in adults, Spielberger et al. (1995) have convincingly argued that a pervasive tendency towards aggression is revealed in what they describe as the trait component of anger or anger expression. These authors describe trait anger as that which is persistent over time and which is likely to be associated with clinical syndromes and pathology. The authors have used this research to develop an instrument to measure not only the intensity of the experience of anger in adults, but also the way in which anger is expressed and the relative investment that an individual makes in suppressing his or her anger. It may be, that with regard to adults with ADHD who have an interest in succeeding in typical adult pursuits and goals, anger is a valid construct with which to

measure aggressive tendencies since in these individuals overt aggression will be restrained in most social situations. Additionally, it is expected that the trait component of anger may be a useful variable in distinguishing individuals with ADHD-C from ADHD-PI.

Summary

The ADHD comorbidity research described above is somewhat difficult to interpret given different methodologies, discrepant terminology, and the fact that these studies were driven by varying research goals. In spite of these difficulties a number of consistent findings have begun to emerge. The first is that ADD-C (or its past diagnostic equivalent such as ADDH) is most commonly associated with conduct and/or aggression problems. Various lines of research regarding childhood, adolescent, and adult depression have concluded that clinical and sub-clinical levels of depression are strongly associated with ADHD in general and more specifically ADHD with comorbid conduct/aggression problems. Adding these findings together we might offer the view that ADHD-C is most often associated with depression and conduct/aggression problems.

In addition to the evidence regarding major depression, some of the studies reviewed above have noted an inverse relationship between anxiety and conduct/aggression problems in individuals with ADHD. Although some research has indicated a possible association between ADHD-PI and anxiety, this relationship is not well understood. Some of the evidence of differences between ADHD with and without comorbid anxiety has come

from drug treatment studies and thus the findings are difficult to interpret. However, the consistent finding that individuals with ADHD and comorbid anxiety are less likely to respond positively to methylphenidate treatment does add to the evidence of a possible difference between ADHD with and without comorbid anxiety. Only one study looked at methylphenidate treatment response differences in ADHD subtypes. However the finding that individuals with ADHD-PI were much less likely to respond to methylphenidate than their ADHD-C counterparts is compelling, particularly when compared with the above noted finding of differential response between ADHD with and without comorbid anxiety. This finding merely underscores the need to further question the association of anxiety and ADHD-PI which, based on extant research, has not been conclusive. Since many of the findings provided in the research reviewed above have come from child/adolescent studies, a careful examination of comorbidity in adult ADHD subtypes may provide us with more solid conclusions regarding these associations.

Attention Variables and ADHD Subtype

As stated in the introduction, differences in overt behaviors and symptoms of children, adolescents, and adults with ADHD-C and ADHD-PI are highly recognizable and allow clinicians and researchers to discriminate between individuals with either disorder with reasonable confidence (McBurnett et. al., 1999; Morgan et. al., 1996). The most noticeable behavioral distinction between the two ADHD subtypes is the relatively low level of

behavioral impulsivity and overactivity seen in ADHD-PI. In fact, using DSM-IV criteria, an individual may be diagnosed with ADHD-PI without meeting any of the criteria for symptoms of impulsivity/hyperactivity whatsoever, whereas the ADHD-C diagnosis requires meeting minimum “inattention” and “impulsivity/hyperactivity” criteria (APA, 1994). Thus the diagnostic criteria that ADHD-C and ADHD-PI share in common are those features that are related to the DSM-IV “inattention” construct.

A close examination of the “inattention” criteria list in the DSM-IV, however, reveals behaviors related to forgetfulness, disorganization, inability to plan ahead, and lack of motivation as well as those related to lack of attention. Thus the “inattention” criterion of the DSM-IV ADHD is multidimensional in nature as is the hyperactive/impulsive criterion. Unfortunately, this lack of precision in defining the construct of inattention, although congruent with the general atheoretical stance taken in the DSM-IV, provides little to aid in our understanding of the core deficits in ADHD. In light of this shortcoming, researchers have undertaken careful analysis of ADHD in order to understand the core factors which underlie this disorder. As described previously, such studies have consistently revealed inattentive and hyperactive/impulsive factors (Barkley, 1996; Hudziak et al., 1998; Lahey & Carlson, 1991).

The hyperactive/impulsive factor is most strongly related to the combined subtype of ADHD. This subtype, which is frequently found in association with conduct disorders, forms approximately two-thirds to three-quarters of all cases of ADHD presenting in clinical settings (Barkley, 1996; Morgan et al., 1996). This statistic, combined with the historical fact that DSM-

III-R made no provision for the predominantly inattentive subtype, means that ADHD- C (or more generally, attention deficit disorder with hyperactivity) has been the most studied form of ADHD. The tendency for research efforts to be directed at the combined subtype means that theorists have concentrated on attempting to explain the features of impulsivity in ADHD. This has resulted in theories such as the complex inhibitory control model by Barkley (1996, 1999) and the cognitive-energetic deficiency model of Sergeant and van der Meere (1999) that tend to focus on deficits in executive function and regulatory processes related to motoric output.

In his 1996 summary Barkley raised the issue of whether or not ADHD-C and ADHD-PI are truly related to each other at all. He also suggested that ADHD-PI may have a different attentional disturbance than ADHD-C. Subsequently, Barkley (1999) as well as Sergeant and van der Meere (1999) have raised the question of whether or not defective attention has a role in explaining the deficits exhibited by individuals with ADHD. The opinion which guides the present study is that, given the limited examination of attention deficits in ADHD research and the almost non-existent research on attention and ADHD subtypes, the dismissal by the above researchers is premature. This opinion is reflected by Douglas (1999) when she states that:

Although I accept arguments that ADHD children show problems implicating inhibition and motor output, I believe that ignoring or underestimating the importance of attentional and regulatory problems is likely to have negative effects on both theory building and the development of effective diagnostic and treatment procedures. (p. 107)

During the last two decades an extensive body of literature has examined various aspects of cognitive processing in children with ADHD. As stated above, most theories that attempt to explain primary ADHD symptoms in children focus on deficits in inhibitory mechanisms associated with frontal lobe function. Essential inhibitory function in humans is believed to be associated with what is referred to as higher order “executive function” and includes such abilities as internalized speech, planning ability, goal setting, and delay of gratification. In spite of numerous investigations, no pure measure of executive function has been derived and in studies using a variety of purported executive function measures, no clear difference has been found between ADHD combined or predominantly inattentive subtypes (Barkley, Grodzinsky, & DuPaul, 1992; Dye, 1998; Prout, 1999; Stewart, 1994).

This failure to find differences in cognitive processes associated with executive function between ADHD-C and ADHD-PI further reinforces the need to examine other possible avenues in understanding the observable but elusive differences between these two ADHD subtypes. The avenue advocated in the present study is to apply the substantial body of knowledge regarding attention networks and their neurological substrates to this problem in a way which, up to the present time, has not been done.

Attention Processes and Neural Substrates

The concept that attention is the domain of dedicated cognitive processes with specific neural substrates in humans was put forward decades ago by Luria (1973). In the intervening years, a great deal of research has been

aimed at understanding the basic components of attention as well as the neurological substrates that underlie these components. A survey of the modern cognitive literature reveals discussion of a process termed “selective attention” as well as one labeled “sustained attention” (Melnyk & Das, 1992; Prior, Sanson, Freethy & Geffen, 1985; Ruff & Allen, 1996). These processes have been associated with both auditory and visual modalities.

Berlucchi and Rizzolatti (1987) suggested that the validity of selective attention as a concept was clearly demonstrated in an experiment by Helmholtz in the nineteenth century. In this experiment Helmholtz examined a stereoscope containing two pictures that were made visible only briefly by an intermittent spark. Each picture had a tiny hole in the center through which ambient light was visible and Helmholtz focused on this light. However, he was also able to keep his attention voluntarily drawn to a different portion of the picture so that it could be observed when the spark occurred. From this Helmholtz concluded that “attention is quite independent of the position of the eyes and free to direct itself by a conscious and voluntary effort. . . .” (Berlucchi & Rizzolatti, p. 1).

A survey of the visual selective attention research literature indicates that the process of *switching* or *directing* attention to a specific point in space is the most concise definition of selective attention (Berlucchi & Rizzolatti, 1987; Harter, Miller, Price, LaLonde, & Keyes, 1989; Posner, Walker, Friedrich, & Rafal, 1987; Rothbart, Posner, & Hershey 1995). However, more recently visual selective attention has been defined as a process that involves attending to specific relevant information while ignoring distracting or irrelevant stimuli (Das, Snyder, & Mishra, 1992; Day & Peters, 1989). The latter

definition includes the concept of effort directed at looking for or at specific features of a given stimulus. This is more in keeping with Helmholtz's original concept of selective attention and is also reflective of the definition provided by Das, Snyder, and Mishra (1992) in their analysis of the characteristics of selective attention. This definition of selective attention will be used in the current study.

Sustained attention, as the term is generally used in the literature, is not a construct that is distinguished from selective attention so much as it is considered actually inclusive of it. In much modern research any attention task that is extended over a period of time may have been defined as sustained attention. In spite of this it is important to underscore the difference between sustained attention and what is termed "vigilance". Douglas (1999) has summarized evidence showing that much confusion has resulted from a failure to accurately define these terms in the extant research literature.

As defined by Rothbart et al. (1995), "vigilance" is the effortful process involving heightened awareness of the environment as one awaits a given auditory or visual signal. These authors also relate vigilance to maintenance of the alert state "in the foreperiod of a reaction time task, or when they attend to a source of signal while waiting for an infrequent target to occur. . ." (p.328). The distinction between sustained attention and vigilance is particularly relevant because of the common use of such measures as continuous performance tests (CPT) in ADHD research and the persistence in defining such tasks as measures of sustained attention. The CPT paradigm involves the use of an infrequent stimulus presented on a computer monitor

with the requirement that the participant either respond or else inhibit his or her response depending on the stimulus presented. Such a testing paradigm has poor ecological validity because it does not simulate the types of tasks that children and adults commonly undertake in which there are demands on attention. Further, as evidenced by recent lines of research, such tasks measure vigilance and not sustained attention specifically (Posner & Peterson, 1990.)

Stuss and Benson (1984) suggest that sustained attention “signifies the ability of an alert individual to direct effort and concentration for specific periods of time to specific tasks” (p. 10). Based on the cognitive literature, this is undoubtedly an accurate definition of sustained attention; however, the difficulty remains as to how to measure such a construct in a way that avoids confounding it with vigilance as well as other more complex cognitive tasks. Wilkins, Shallice and McCarthy (1987) were faced with this issue in measuring sustained attention in auditory and tactile domains. Their solution involved the use of a rapid presentation of stimuli in order to eliminate the requirement for vigilance on the part of the participant. In addition they noted that, by providing easily recognized stimuli, the demand on complex cognitive processing other than attention would be reduced considerably. Thus, they made use of an attention task that made few cognitive demands; however, as the task is extended over time to the point that maintenance of attention becomes demanding, it is regarded as a measure of sustained attention.

With regard to visual attention, Matlin (1994) described differences in the cognitive processing demands contrasting automatic detection

(preattentive processes) with high demand tasks that require feature detection. She suggested that automatic detection is mediated by purely visual recognition processes, whereas a controlled feature detection process requires a search for more specific aspects of a given visual stimulus and more concentrated attention. Based on this description by Matlin, it appears that it is possible to measure attention at two levels: the first making use of relatively automatic feature detection processes, and the second utilizing more concentrated or selective aspects of attention.

Ruff, Evans, and Light (1986) have extended this proposition to the design of a paper and pencil test of attention in which cognitive processing demands are kept to a minimum. In their pilot study using normal adults, they contend that a simple task which requires preattentive or automatic processes may be contrasted with a task which requires more complex feature detection. They present evidence that the complex feature detection task requires the use of "selective" attention and that a measure of this construct is possible when a participant's ability on the complex "selective" attention task is contrasted with his or her ability on the simpler automatic recognition task. This test, later named the "Ruff 2 & 7 Selective Attention Test" (Ruff & Allen, 1996), was developed into a measure of sustained attention by extending the time requirement of each of the two types of demand tasks to the point where effort is required to complete the test.

To summarize, the current cognitive literature provides evidence of a valid construct described as attention. Careful scrutiny of this body of research suggests that this process can further be broken down into relatively automated processes as well as a high demand task termed "selective

attention” which is distinguished from “vigilance”. Visual attention tasks which are extended in time to the point where effort is required to maintain concentration are considered to require sustained attention. Finally, in any purported measure of visual attention, the task itself has to be simplified to the point where the primary demand is on “attention” and not more complex cognitive processes normally associated with higher order executive function. This requirement mandates the use of a simple visual recognition task.

Neural Substrates of Attention Networks

Since Luria’s time, evidence has accumulated for the existence of at least two primary attention networks. As described by Rothbart, Posner, and Hershey (1995) these are: 1) the posterior attention network associated with the parietal lobes of the brain and which orient attention to novel visual stimuli, and 2) the anterior attention network, associated with the frontal lobes which appear to be active when concentration is required, particularly when a task requires a search for specific targets. More specifically, the posterior attention network is associated with the primary visual cortex and acts to bring attention to a location in space. The anterior attention network, which involves portions of the mid-prefrontal cortex and the anterior cingulate gyrus, is active during all tasks which require subjects to detect target visual stimuli whether they involve color, form, motion, or word semantics (Rothbart et al., 1995).

Unfortunately, the relationship between the two attention networks described above to the constructs of selective and sustained attention is not

direct. While the posterior attention network appears to direct attention to novel stimuli and thus facilitates the orienting operation strictly defined as selection, it is the anterior attention network that is functional in purposeful "selection" of predetermined stimuli. In the context of describing the role of the cortical neurotransmitter norepinephrine (NE), Pliszka, McCracken, and Maas (1996) provided a description of the relationship of the posterior and anterior attention networks when they stated that "NE inputs prime these components of the posterior system to react to the presentation of novel stimuli. If the person must mentally manipulate the information and make a response, the anterior cingulate becomes active " (1996, p.268). In other words the posterior network orients the individual to novel visual stimuli; however, if manipulation of or concentration on the stimuli is important then the anterior network becomes active.

Few researchers have speculated about possible differences in attentional processes between ADHD-PI and ADHD-C. Barkley, Grodzinsky and DuPaul (1992) have suggested that a deficit in different attention processes may be important in ADHD-PI as compared with ADHD-C. These authors have noted the evidence for localization of these attentional networks and thus the probability that they have different neuropsychological substrates; however, they did not offer any operational or theoretical rationales for these speculations. The evidence that may be used to build a hypothesis concerning the relationship of specific attention networks to subtypes of ADHD must necessarily come from studies that acknowledge the existence of specific attention processes; few of these exist in ADHD research.

That individuals with ADHD-C have difficulty with engagement of the

anterior attention network is supported by studies related to stimulant action on the human noradrenergic system. In the research by Pliszka et al. (1996) noted above, evidence is detailed which indicates that the locus ceruleus, which is the essential brain stem center that controls the input of norepinephrine (NE) to the parietal and frontal lobes of the brain, is overactive in individuals with ADHD. The main role of NE input from the locus ceruleus to the parietal lobes is to facilitate a smooth transition from the orienting task of the posterior attention network to the anterior network when a task requires concentration. Recent investigations have suggested that, for ADHD individuals, the normal state may be for the locus ceruleus to be overactive, thus increasing background activity or "noise" and decreasing the ability to provide smooth switching of function from the posterior to anterior attention networks when concentration or manipulation of stimuli is required (Halperin et al., 1997). In connection with the above, Pliszka et al. (1996) suggest that stimulants may reset the locus ceruleus to a lower level so that it is able to respond more readily to demand tasks (Halperin et al., 1997; Pliszka, et al., 1996).

The Pliszka et al. (1996) study describes a heterogeneous ADHD population but it is likely that their theory pertains to individuals with ADHD-C since these represent roughly three-quarters of the ADHD population (Barkley, 1996) as noted above. In support of their theory is the finding that stimulants such as methylphenidate and dextroamphetamine have been most effective for individuals with ADHD-C as compared to those with ADHD-PI (Barkley, DuPaul & McMurray, 1991). At this point it is not known if the Pliszka et al. theory pertains to individuals with ADHD-PI.

Relationship of Attention Difficulties to ADHD Subtype

It is tempting to speculate that one subtype of ADHD may be caused primarily by a deficit in the function of one or the other attention network. However, past research experience suggests that such an expectation may rest on an overly simplistic view of both the role and relative degree of association between the posterior and anterior networks. In the case of research on attention, Rothbart et al. (1995) have summarized evidence of *interdependence* between the anterior and posterior networks which includes the finding that there may be certain degree of control by the anterior *over* the posterior network.

There is, however, enough evidence of *independence* of these networks to offer hope that evidence of a significant association between one ADHD subtype and a particular attention deficit (selective as compared to sustained) may be found. This would, at the very least, increase our basic understanding of differences in underlying processing of ADHD-C as contrasted with ADHD-PI if such differences exist. Alternatively, it may be that both ADHD-C and ADHD-PI involve deficits in both selective or sustained attention but that one subtype demonstrates a more severe deficit than the other but not necessarily a significant one.

That some understanding of localization is available through exploration of specific attentional functioning is provided by the validation research into the Ruff 2 & 7 Selective Attention test by Ruff and Allen (1996). This research includes an examination of attention deficits for patients with specific focal lesions of the cerebral cortex. The sample included 30 adults with

unilateral focal lesions to either the anterior (frontal lobes) or posterior (involving portions of the temporal, parietal, or occipital lobes) regions of the cerebral cortex as determined by CT scans, neuropsychological, or neurosurgical reports. In order to determine the location of the cerebral lesions of the participants in this study, agreement was required among three clinicians. These individuals also screened participants for right handedness, absence of motor deficits associated with peripheral brain damage, and to exclude those who had been hospitalized for psychiatric reasons. The sample included eight patients each with either right or left frontal lobe lesions and six and eight patients with right and left posterior lesions respectively.

In the above validation study, Ruff et al. (1992) claim that they were able to correctly classify 76.7% of patients as either having anterior or posterior cortical lesions using the scores which discriminated between automatic versus selective attention tasks. In addition, a similar discriminant function analysis by these same authors was able to correctly classify roughly 90% of brain injured patients with either left or right hemisphere lesions using the same attention variables gathered from the Ruff 2 & 7 Selective Attention Test (Ruff & Allen, 1996). More specifically, the results of this research indicated that individuals with anterior (frontal) and right hemispheric lesions showed significantly higher rates of impairment on selective attention tasks.

The findings of the Ruff and Allen (1996) studies are important when we also consider that numerous researchers have noted similarities in the behaviors of individuals with frontal cortical lesions (particularly right frontal cortical lesions) and individuals with ADHD-C (for a review see

Barkley, 1996 and Castellanos, 1999). From this we might anticipate that individuals with ADHD-C might also demonstrate impairment in the selective attention domain on the Ruff 2 & 7 Selective Attention Test (Ruff & Allen, 1996).

In contrast to ADHD-C, ADHD-PI has been far less studied and therefore far fewer theoretical propositions have been offered to explain its major features. Some authors have noted that individuals with ADHD-PI appear sluggish with regard to their cognitive tempo and thus may have a deficit which reduces the speed with which they process information (Barkley, Du Paul, & McMurray, 1990; Barkley, Grodzinsky & DuPaul, 1992; Goodyear & Hynd, 1992; Lahey & Carlson, 1992). From the observations of these authors and anecdotal comments from clinicians experienced in ADHD assessment and treatment, it might be speculated that individuals with ADHD-PI may experience difficulties with sustained attention.

Modality in Attention Processes

Rothbart et al. (1995) have suggested that more is known about visual attention processing than auditory attention processing. However, they also suggest that with auditory attention there are processes that are parallel to those associated with visual attention. That is, there is an orientation process to auditory stimuli followed by a more focused processing of information (Posner, 1990). In association with the subject of auditory attention, the cognitive literature discusses basic listening and attending tasks; however, cognitive scientists have also attempted to investigate human capacity for

such things as divided attention. For example Galotti (1994) discusses the dichotic listening task wherein a subject is asked to attend to and recall information from two different messages, each being presented in a different ear. An alternate dichotic listening task is to ask the participant to ignore information presented in one ear while attending to information presented in the other ear. The first dichotic process noted above is described by Matlin (1994) as making use of divided attention processes and, while interesting, is not related to the everyday auditory attention processes since individuals are seldom directed to attend to two different auditory sources at once. However, the second dichotic process, in which the individual must make a specific effort to disregard material presented in one ear and pay specific attention to material presented in the other, is described by Matlin as being a selective attention process and may be relevant to ADHD research. More specifically, this form of selective attention may be relevant when determining whether or not individuals with ADHD have difficulty in screening out irrelevant auditory stimuli while attending to more important sounds such as that of the voice of someone lecturing in a classroom setting. Results of research into the dichotic "selective attention" processes shows that most individuals notice little about the irrelevant tasks as compared to the relevant task (Hawkins & Presson, 1986). Interestingly, research by Davidson and Prior (1978) and Prior et. al. (1985) failed to find differences between ADHD children and normals using the two different dichotic listening tasks just described. These authors advocated for future research to investigate other aspects of selective auditory attention skills and deficits in individuals with ADHD.

In the absence of evidence of differences between individuals with and

without ADHD on dichotic listening tasks, it is necessary to look for other tasks which make use of selective auditory attention processes and that are similar to everyday attention processes. It is suggested that a suitable task for measuring auditory attention would require the use of selective attention and some form of manipulation on auditorially presented information but in a way which simulates some types of demand tasks that are experienced in real life. The list of potential measures of auditory attention is extremely limited particularly given the need for simulation of everyday attention tasks. The most important criterion for such an auditory test would be the finding that it is primarily a measure of attention and that it does not require extensive additional cognitive processing.

Research designed to assess the construct validity of purported tests of attention along with those tests designed to assess "executive function" was conducted by O'Donnell, MacGregor, Dabrowski, Oestreicher, and Romero (1994). The authors stated that their study was motivated by the lack of clarity in the neuropsychological testing literature regarding the specific cognitive process that various commonly used tests were actually measuring. Their analysis compared the Wisconsin Card Sorting Test (WCST), the Category Test (CAT), the Visual Search and Attention Test (VSAT), the Trail Making Test-part B (TMT-B), and the Paced Auditory Serial Attention Test (PASAT), the latter being the sole auditory test included. Principal components analysis was performed on data from a group of adult participants aged 18 to 61 years. The analysis revealed two factors. The first (accounting for the majority of the variance) was defined by the PASAT, VSAT, and the TMT-B. The authors labeled this as the "focus execute" factor but most importantly they regarded

this as an “attention component that underlies tests of speeded mental processing” (p. 599).

The results of the O'Donnell et al. (1994) study suggest that the PASAT may be a purer measure of attention than of any other specific cognitive process. This is congruent with the conclusion by Lezak (1995) that the PASAT appears to measure auditory attention. However, as both O'Donnell et al. and Lezak suggest, there is an aspect of this test that pertains to processing speed. It appears to be unavoidable that any measure of cognitive function will involve overlap between two or more processes. However, the evidence provided above suggests that, with regard to the auditory domain, the PASAT does primarily measure attention processes. It is also noteworthy that the only visual test that the O'Donnell et al. study found to be primarily a measure of attention is the VSAT which is similar to, but less developed than, the Ruff 2 & 7 Selective Attention Test (Ruff & Allen, 1996).

As described above, in research by Davidson and Prior (1978) and Prior et al. (1985) dichotic listening tasks were unable to discriminate between children with and without ADHD. It is suggested that the dichotic listening paradigm actually involves vigilance as contrasted with selective attention. By comparison, the PASAT involves an auditory selective attention task which may include a temporal component since there is a limited amount of time to analyze the simple numerical addition problems which form the core task in this test. At the time of this writing no study had made use of this measure or anything comparable in an effort to discriminate ADHD-C from ADHD-PI in any age group. Thus it is difficult to speculate if adults with either ADHD subtype would experience comparatively greater problems with

the PASAT. However, if it is true that individuals with ADHD-PI do indeed display a slowed cognitive tempo, then we suggest that this would present a disadvantage with regard to the temporal component of the PASAT as compared to those adults with ADHD-C.

Summary

The research into the cognitive ability described as “attention” has been hampered by both inconsistent and inaccurate nomenclature and methodological difficulties related to the measures used. In the above review, an attempt has been made to sort through recent relevant cognitive and neurological research which provides defensible conclusions regarding attention processes. We have determined that the terms “selective” and “sustained” attention describe real and measurable processes particularly in the visual domain. Within the auditory domain, similar processes are measurable. Based on the limited validation studies as well as theoretical considerations it is suggested that the PASAT and Ruff 2 & 7 measure attention with fewer potential confounds than other available tests.

Most importantly, few if any studies in recent years have attempted to examine ADHD based on ability associated with selective or sustained attention. We have noted the failure of tests of “executive function” to determine substantial differences between ADHD-C and ADHD-PI subtypes and the fact that potential differences using attention processes have not been examined. The argument offered here is that it is important that this neglected area of research be examined with the goal of determining whether

significant differences exist between ADHD-C and ADHD-PI.

Direction of the Present Study

Authors such as Lahey and Carlson (1991) along with Stewart(1994) have challenged the research community to provide evidence of real differences between ADHD-C and ADHD-PI. While Lahey and Carlson along with Barkley (1996) have stated their belief that the observable behavioral differences between these two subtypes represent true underlying processing differences, Stewart (1994) has hypothesized that ADHD-PI and ADHD-C are different expressions of the same disorder with intensity being the distinguishing variable. Thus, at the present time, we have two quite different hypotheses regarding the nature of the two most common forms of ADHD. However, it may be that the observable differences between ADHD-C and ADHD-PI are the result of the same basic etiology interacting with other, as yet undetermined variables. Thus, future research need not find distinct differences between ADHD-PI and ADHD-C in many different domains. It may be that these two subtypes vary in one or two discrete cognitive domains while being similar in other ways.

It is argued here that the limited research into ADHD subtypes that does exist has attempted to search for differences using variables such as “executive function” which are difficult to define concisely much less operationalize. In addition, although we use the term “Attention Deficit” as a broad descriptor for all forms of the syndromes that we have been discussing, no extant research has utilized the concisely defined and more easily operationalized

“attention” domains that appear in the cognitive literature as comparison variables. In contrast to the paucity of ADHD subtype research using basic attention variables, there do exist a number of comparisons of subtypes using comorbid associations. Unfortunately such comparisons using adult populations with either ADHD-C or ADHD-PI are completely absent from the research literature.

The premise of the current study, is that those who experience persistent forms of impulsive behaviors and attention difficulties into adulthood are the least likely to have been misdiagnosed as having ADHD and thus are true diagnostic positives. True problems with attention will be those that have persisted into adulthood and thus the measures being used in the present study will likely capture real attention processing as opposed to more situationally determined variables. It is also argued that adults have more insight into externalizing and internalizing mood difficulties and are more likely to know the difference between general and situationally determined mood problems. This is contrasted with children whose mood symptoms are often transient and situationally determined but whose insight into the difference between these and more persistent mood syndromes is limited.

A final subject that relates to the goals of the current study is that of control groups for comparison purposes. The current study employs mood and attention measures that were standardized using large groups of participants obtained from the United States or Canada. These samples, averaging 1000 individuals or more, obtained from the community and clinical settings, provide more than adequate data from which to make

comparisons with the adults with ADHD in the current study. Thus it was determined that obtaining a normative sample for comparison purposes would be redundant. In addition, in a study of this size, it would be impossible to obtain a control sample even remotely comparable to those used in establishing standard data for the measures used in this research.

Goals and Hypotheses

Research Objectives

This study set out to determine differences between male and female adults with either ADHD-C or ADHD-PI using attention processes and comorbid mood associations as dependent variables.

Goals

The goal of this research is to increase the existing knowledge base regarding subtype of ADHD in adults of both genders and to provide more information that may be used to uncover the differential or common etiologies of both of these subtypes. Specifically the study was designed to:

1. Determine whether differences exist between ADHD subtypes with respect to state and trait anxiety, trait anger and anger expression, and depressed mood.
2. Determine whether differences exist between ADHD subtypes with respect to selective and sustained attention in visual and selective attention in auditory domains.

3. Although not a core goal of the present study the ascertainment of males and females with both subtypes of ADHD offers the opportunity to determine if one subtype is associated with a specific gender. Additionally the present study will examine gender differences between ADHD subtypes using the mood and attention variables described above.

Hypotheses

Regarding Mood Associations

based on findings by Biederman et al. (1992), and De Quiros, Kinsbourne, Palmer, and Rufo (1994):

- 1) Higher levels of depression will be evident in those adults with ADHD-C as compared with those with ADHD-PI

based on findings by Barkley, DuPaul, and McMurray (1991), Eiraldi, Power, and Nezu (1997), and Lahey and Carlson (1991):

- 2) Higher levels of anger will be displayed by those with ADHD-C compared with those with ADHD-PI.

based on research by Arrendo and Butler (1994) and De Quiros, Kinsbourne, Palmer, and Rufo (1994):

- 3) In adults with both subtypes trait anger will be positively correlated with level of depressed mood and negatively correlated with level of trait anxiety.

Regarding Attention

based on Barkley, (1996), Castellanos, (1999), and findings by Ruff and Allen, (1996):

1) Adults with ADHD-C will demonstrate greater deficits in selective visual attention than those with ADHD-PI.

based on findings by Barkley, Du Paul, & McMurray, 1990; Barkley, Grodzinsky, and DuPaul (1992); Goodyear & Hynd, (1992); Lahey & Carlson, (1992):

2) Adults with ADHD-PI will demonstrate greater deficits in sustained visual attention than those with ADHD-C.

and

3) Adults with ADHD-PI will demonstrate greater deficits in selective auditory attention than those with ADHD-C.

No hypotheses are offered in regard to gender differences in ADHD subtypes using either mood or attention variables since extant adult ADHD research literature contains virtually no information on this subject.

CHAPTER 2

METHODOLOGY

Subjects

Male and female adults, aged 18-60 years, were solicited from among volunteers who had received services for themselves or for their children at the Alberta Children's Hospital and the Calgary Learning Centre. In addition, participants were obtained through advertising at the Disability Resource Centre and the Student Counseling and Development Centre of the University of Calgary (Appendix A). The majority of participants came from the greater metropolitan area of Calgary, Alberta, a city of approximately 900,000 inhabitants.

Individuals who were included in the study were those with a previous diagnosis of ADHD or who reported experiencing symptoms congruent with this disorder. Participants were estimated to have normal intelligence based on their successful completion of high school and post secondary training or education. Subjects who reported having been diagnosed with pervasive developmental disorder (a list of examples was given over the phone), schizophreniform disorder, a neurological disorder or neurological dysfunction due to known brain insult were excluded from the study.

Sample Size

The current study compares two groups of individuals with ADHD. Based on authors such as Kazdin (1999) and Tabachnik and Fidell (1996) a goal was set to obtain 40 or more individuals from each group to provide adequate effect size for comparison. Another method of determining sample size is the general rule of thumb of obtaining 10-15 participants for each dependent variable (Norman & Streiner, 1997). The most complex analyses in the current study includes 4 variables; based on the most conservative requirements (15 subjects per variable) this would indicate the need for a minimum of 60 participants in total. Based on past research experience it was determined that the ADHD-PI group would be the most difficult to obtain and thus would likely be a limiting factor. In all, 88 subjects were involved.

Measures

Confirmation of Diagnosis

Adult-Attention Deficit Disorder Evaluation Scale (A-ADDES)

The Adult Attention Deficit Disorders Evaluation Scale or A-ADDES was developed by McCarney and Anderson (1996) to fill the need for a diagnostic tool that would be useful in identifying the presence of clinical levels of ADHD symptomatology. Although based on childhood DSM-IV criteria, the A-ADDES was also developed using the most current research

into adult ADHD.

The A-ADDES was standardized on 6,074 ratings (of approximately 2000 individuals) for the three versions of the scale and provides separate norms for male and female adults 18 through 65 years of age broken down into eight age categories. An attempt was made to represent American national percentages of sex, race, geographic area, and occupation in the standardized sample. Internal consistency for each version of the A-ADDES, using Cronbach's Coefficient Alpha, ranged from .97 to .98. Content validity was established through the initial development process.

The A-ADDES has two scales labeled Inattention and Impulsivity/Hyperactivity that allow evaluation of symptom clusters related to the diagnostic categories of ADHD-Combined Type (ADHD-C) and ADHD-Predominantly Inattentive Type (ADHD-PI). The A-ADDES is available in three versions as follows: self-report (58 items), home (46 items for use by significant other) and work (54 items for use by co-worker). The A-ADDES uses a scale in which the participant is asked to rate the frequency of each of 58 ADHD related behaviors from 0 (does not engage in the behavior) through 1, 2, 3, or 4 (One to several times per month, week, day, or hour respectively).

Following administration and scoring, three types of information may be obtained: 1) for each individual item on the A-ADDES the frequency rating score may be considered a measure of severity for a particular symptom, 2) adding all the scores on either the Inattentive or Hyperactive-Impulsive scales provides a raw score which in turn may be used to obtain a standard score using normative tables, 3) adding together the standard scores from the Inattentive and Hyperactive-Impulsive scales provides a third score which

may be used to obtain an overall percentile ranking of ADHD symptoms using normative tables.

Dependent Measures of Affect

State-Trait Anxiety Inventory (STAI)

Although there are a number of extant measures that are suitable for measuring levels of anxiety in adults, only one was designed to distinguish between anxiety that is considered to be part of the individual's personality (Trait) and anxiety that is situation-specific (State). The State-Trait Anxiety Inventory was developed by Spielberger, Gorsuch, and Lushene (1970) in order to provide a behavioral inventory capable of measuring (and discriminating) these two aspects of anxiety just described. An extensive revision process resulted in the 1983 version of the STAI (Spielberger, 1983) which was used in the current study.

The STAI consists of two questionnaires containing 20 questions each. The individual is asked to read the questions and to respond to a 4-point Likert type scale in which endorsements range from "almost never" to "almost always". Examples of questions from the state form (form Y-1) include "I feel strained " and "I feel nervous". Samples from the trait side (form Y-2) include "I feel satisfied with myself" and " I worry too much over something that really doesn't matter".

The original STAI was normed on 6000 young adults, 600 psychiatric patients and 200 prison inmates. An additional 5000 individuals were added to the normative sample for the 1983 revision (Spielberger, 1983). Test-retest

reliability for the STAI Trait scale averages .86 for adult males and .76 for adult females at a 20 day interval. For the State scale the test-retest reliability for adults was .54 for males and .27 for females. Note that the authors describe these differing reliabilities as consistent with the intent of the STAI since state anxiety should vary over much shorter lengths of time than trait anxiety. Reliability coefficients of the two STAI scales have been compared with other well established measures of anxiety. In a study comparing properties of the Beck Anxiety Inventory or BAI (Beck, Epstein, Brown, & Steer, 1988) with the STAI, Creamer, Foran and Bell (1995) described characteristics of the BAI which make it a measure of state anxiety. They then noted that the BAI has a seven week test-retest reliability of 0.62 which is comparable to the STAI-State which was 0.68. In contrast the seven week test-retest reliability of the STAI-Trait was 0.85 in their study.

The concurrent validity of the STAI has been examined through comparisons of STAI scores with a number of other standardized measures of anxiety, using samples of college and psychiatric patients. Convergent and discriminant validity have also been examined with consistent results in the expected directions (Spielberger, 1983). Factor analytic studies conducted using the early version of the STAI were employed to ensure an improved two factor solution for the 1983 revision (Spielberger, 1983). Further confirmation of validity and utility of the STAI with clinical populations was provided in a study by Dreger and Brabham (1987).

The STAI raw scores may be converted to standardized T-scores based on age and sex differences noted during development of this measure.

State-Trait Anger Inventory (STAXI)

The State Trait Anger Expression Inventory (STAXI) was developed by Spielberger in 1988 to measure the experience, expression, and control of anger. The STAXI was also designed to measure more enduring aspects of anger which may be typical of those who have a tendency towards aggression (Trait Anger) as compared to those whose hostility and anger is more situationally determined. Alpha coefficients are .82 and .90 for the Trait Anger and State Anger scales respectively.

With regard to the validity of the STAXI, Spielberger (1988) has found a single factor solution to State Anger; however, Trait Anger loaded on two factors labeled angry reaction and angry temperament. Further confirmation of the factor loadings of the STAXI was found in a recent study by Forgays, Forgays, and Spielberger (1997). As with the STAI described above, the STAXI was normed on a very large sample of younger adults, working adults, patients, military personnel, and prison inmates. The Trait Anger Temperament Scale of the STAXI was found to correspond to individuals who are quick tempered, impulsive, and lacking in anger control (Spielberger, 1988). In a series of studies designed to assess correlates and consequences of Trait Anger, Deffenbacher and colleagues (1992) found individuals with high Trait Anger to report more intense and more frequent day-to-day anger across a wide range of anger provoking situations.

The Trait Anger domain of the STAXI can be broken down into three additional major components. These are Anger In which is a measure of effort made at not expressing experienced anger, Anger Out which is a measure of overt expression of experienced anger, and Anger Control

which is a measure of success at reducing or controlling feelings of anger in anger provoking situations.

The STAXI is constructed as a 44 item pencil and paper test which requires approximately 10 minutes to complete. Each item is rated using a four item Likert type scale as with the STAI described above. Addition of ratings for each test item yields a total numerical score for the Trait and State scales as well as Anger In, Anger Out, and Anger Control. Normative tables allow for calculations of T-scores based on age and sex differences which were uncovered during the standardization process.

Beck Depression Inventory-Second Edition (BDI-II)

The Beck Depression Inventory version II or BDI-II (Beck, Steer & Brown, 1996) is the latest version of one of the most popular depression rating inventories for adolescents and adults. Improvements in the current version reflect recent research which has provided refinements in understanding and assessment of depression. By design, the BDI-II assesses current behaviors and symptoms (over the previous two weeks) which reflect DSM-IV nosology. The BDI-II contains 21 groups of statements which reflect various symptoms related to depression. The subject merely circles the number of the sentence on each item which best reflects how they have felt over the previous two weeks. The total score yields continuous ratings of 0-63. Alternatively the manual provides four scoring ranges which may be used as cut-offs to classify level of depressive symptoms as minimal, mild, moderate, and severe.

The BDI-II normative sample included 500 outpatients of various

psychological clinics in the United States along with 120 college students from the University of New Brunswick, Canada. The coefficient alpha for the BDI-II was .92 for the outpatient sample and .93 for the college sample. Test-retest reliability for a small subset of outpatients was .93. Comparisons of ratings, using the BDI-II with other measures of depression as well as measures of anxiety disorders, have provided correlations which demonstrate convergent and discriminant validity.

Although the BDI-II is designed to be a unidimensional measure of depression, factor analysis by Beck, Steer, and Brown (1996) indicates two factors: one which appears to be a somatic/affective dimension and a second which is associated with the cognitive aspects of depression. The correlation between the two factors using the normative population was .66. The BDI-II does not provide age or sex normative data but makes use of raw scores and cut-off levels for mild, moderate, and severe depression as described above.

Dependent Measures of Attention

Ruff 2 & 7 Selective Attention Test (Ruff 2 & 7)

Prior to the publication of the Ruff 2 and 7 (Ruff & Allen, 1987) no paper and pencil measure of selective *and* sustained attention had been developed which included accompanying broad normative data. The Ruff 2 & 7 has normative data for adults from age 16 to 70 years. Recently, the scoring system of the Ruff 2 & 7 has been refined to increase sensitivity and improve differentiation between functions. Factor analytic studies have confirmed that the Ruff 2&7 measures both sustained and selective attention (as noted in the

literature review above). Further studies have been conducted to determine the relationship of the Ruff 2 & 7 to current theories of selective attention in patients with cerebral lesions (Ruff, Niemann, Allen, & Farrow, 1993).

Major advantages for using the Ruff 2 & 7 in the current research are its portability and the fact that both selective and sustained attention scales generate numerical scores which are valuable for comparative analysis. As described in the literature review, assessment of visual sustained attention requires a test in which vigilance and sustained effort are required in a task in which the subject must ignore distracters. Assessment of visual selective attention requires a task involving selection of appropriate stimuli. In the Ruff 2 & 7 test, the numbers 2 and 7 are embedded in a series of numerals in one condition and in a series of letters in the second as in the examples provided in Figure 1 below.

7 1 3 0 4 9 2 1 7 8 2 9 4 3 1 7 4 4 1 0 9 8 7 3 2 3 1 6 6 0 9 1 4 8 5 7
 2 9 5 9 8 3 6 2 5 6 0 1 3 0 8 6 5 4 7 4 3 1 8 2 3 4 1 7 3 6 9 9 2 1 7 0
 0 9 1 2 4 0 7 1 1 4 6 5 3 7 1 9 0 4 5 2 3 5 7 9 8 7 1 2 0 8 2 8 4 8 6 7

2 G H I K I 7 P L T W N V B 2 Z Q X O 2 N E 7 M 2 T Y 2 S K S Z
 N Y P J 7 U W E O R 7 S I 2 A S B I 7 Q P 2 F G H W O P W 2 Z V
 H J U 2 K S W G 2 J P O 7 Q R I 2 S P J H J 7 E E S Q 2 V P L S 7

Figure 1. Example of Ruff 2 & 7 distracter conditions

In each of the two conditions illustrated in figure 1 the subject is asked to identify each occurrence of the numerals 2 and 7; however, as an examination of the above examples indicates, it is far easier to identify 2s and 7s in the letter distracter as compared with the numeral distracter. As indicated above, the authors regard the identification of 2s and 7s in the letter distracter as an example of automatic process whereas identification of the numerals 2 and 7 from amongst other numerals requires a more complex search task (Ruff & Allen, 1996).

Normative data for the 2 and 7 was based on an examination of the results of testing of 360 adult participants. Split half and test-retest reliability were found to be within an acceptable range. Further analysis revealed that scores in all four testing domains were partially dependent on age and level of education. Based on these findings normative data were derived for each of four adult age ranges (16-24, 25-39, 40-54, and 55-70) and three education levels (less than or equal to 12 years, 13-15 years, and 16 or more years of education).

Following administration of both a sample portion and the main body of the Ruff 2 & 7, the test is scored by examining each block of three lines for 2's and 7's that were correctly identified and crossed out. The scoring requires working backwards from the last 2 or 7 that the participant crossed out in a given block and counting successful "hits". In addition, errors of omission (missed 2s and 7s) along with errors of commission (anything other than a 2 or 7 that is crossed out) are also counted. The hits and error scores are entered separately on the scoring page and are added for each of the automatic (letter distracter) and controlled search (numeral distracter) conditions. These numbers are added to provide raw accuracy and speed values. The scoring

page allows for the determination of three types of scores. The first is a T score for speed and accuracy in both the Automatic and Controlled Search domains using the normative tables provided in the manual. The second are referred to as "Total Speed" and "Total Accuracy" where scores from both Automatic and Controlled Search conditions are combined and a second set of T scores are obtained from normative tables. Finally, provision is made for determining differences in accuracy and speed for Automatic and Controlled Search conditions and an additional normative table provides significance levels for this data. For the purpose of this study, the first set of scores described above, that is T scores for both speed and accuracy for each of the Automatic and Controlled search categories, were considered most important for comparison purposes. This is because the current study is aimed at uncovering differences in selective and sustained attention between ADHD-PI and ADHD-C groups of adults rather than determining if a single individual has a deficit in one or the other attention domain based on normative data.

Paced Auditory Serial Attention Test (PASAT)

The PASAT is a test of selective auditory attention developed by Gronwall and colleagues in 1974 (Roman, Edwall, Buchanan, & Patton, 1991) which requires approximately 20 minutes to complete. Although the PASAT is scored by the individual who is conducting the administration, the test makes use of a prerecorded male voice that provides basic instructions and reads a list of 60 single digit numbers in each of four possible series. The task of the participant is to add together each of the last two numbers that are

spoken in the series and to state the answers out loud. For example, if the numbers 2, 7, 6, and 5 were given in a series, then the correct response would be 9, 13, and 11, respectively. The participant must inhibit the desire to add the numbers continuously in order to add together only the last two numbers heard as the series progresses. The PASAT makes use of a list of 60 numbers read at time intervals ranging from 2.4 to 1.2 seconds, the time interval being decreased in each of four trials. However, in this study, only the 2.4 second and 2.0 second interval trials were employed reducing administration time to 10 minutes. Research aimed at determining normative scores on the PASAT by Roman, Edwall, Buchanan, and Patton (1997) indicated an approximate six point reduction in raw score from first to second trials for young and middle-aged (under 60 years) adults without cognitive impairment and thus it was estimated that two trials would be sufficient to avoid ceiling effects for adults with ADHD. Additionally, past research has noted a high frustration factor when individuals were required to complete all four trials of the PASAT (Lezak, 1995). Thus only the first two conditions were employed because of the high frustration already encountered by those with ADHD in high demand tasks

The PASAT fulfills the auditory selective attention paradigm in that some of the information being presented has to be ignored while specific information has to be attended to. In addition, the subject must perform a processing task that requires some effort and forms a measure of processing capacity, which is also considered an aspect of auditory selective attention. As indicated previously, factor analytic studies, in which the PASAT was compared to other measures of cognitive processing, have confirmed that it

loads more on attentional/information processing than on memory factors (Larabee & Curtis, 1996; O'Donnell, MacGregor, Dabrowski, Oestreicher, & Romero, 1994).

Designers of the PASAT did not initially develop age normative data; however, these were developed in subsequent investigations by a number of different researchers. Results of research on the PASAT indicated that the standard (i. e., unmodified) version was not sensitive to the effects of gender, ethnicity, or education. However, a significant effect was found for age (Wiens, Fuller & Crossen, 1997). This effect was clarified by Roman, Edwall, Buchanan and Patton (1991) who examined performance on the PASAT in an extended age group (aged 18-75) and found significantly reduced scores in the 60 to 75 year olds as compared to the younger adults in the study. The current study excluded adults over the age of 60 years.

Procedure

Following University of Calgary and CRHA ethics approval, a request was made to the director and/or senior staff and researchers of the Alberta Children's Hospital-Behavioral Research Unit and The Calgary Learning Centre to provide names of those who had granted permission to be contacted for the current research. In addition, permission was granted by the director and senior staff of the University of Calgary Student Counseling and Development Centre, the University of Calgary Disability Resource Centre, and Bow Valley College to set up advertising directed at potential participants.

Potential participants solicited from the Alberta Children's Hospital,

Behavioral Research Unit, were those who had previously participated in ADHD research and who had indicated a desire to be contacted for future research involvement. Potential participants from the Calgary Learning Centre were first contacted by a research volunteer from the Centre and asked if they would be interested in participation. Potential participants from the University of Calgary and Bow Valley College responded by placing a phone number or e-mail address in a box accompanying the advertising. A small number of individuals heard of the research indirectly from mental health and education professionals in the community and contacted me or Dr. Kaplan regarding involvement in the current study. Once permission was granted for access to potential participants, they were contacted by phone to obtain inclusionary and exclusionary information following a predetermined format (see demographic information form in Appendix B). This phone contact was used as an opportunity to describe the study in sufficient detail for potential participants to determine if they would like to be involved.

During the phone interview, individuals were asked to answer questions from a list of exclusionary criteria, indicate which, if any prescription medications they were currently taking, and indicate their highest level of educational attainment. If the potential participant reported a past diagnosis of developmental disorder, schizophreniform disorder or a known neurological disorder or impairment due to brain injury, it was explained that it is necessary to exclude them because of potential difficulties in analyzing the results of testing. Potential participants were also questioned to determine whether they had achieved a grade 12 or higher level of education and to determine the relative degree of ADHD symptomatology

that they were experiencing. Individuals who indicated a previous ADHD diagnosis or long-standing difficulties with attention and/or impulsivity and hyperactivity were asked to participate. Those potential participants who were currently taking stimulant medications were requested not to take any medication within the 12 hour period prior to testing.

Participants who agreed to be included in the study were tested at either the Calgary Learning Centre, The University of Calgary, or at their own homes when necessary. During the in-person interview, participants were first asked to read and sign the consent form (see Appendix C). Participants were then asked to complete the A-ADDES provided that they had not done so in recent testing. Twenty eight of these participants had recently been involved in a research study on adult ADHD conducted by Kim Galbraith also of the University of Calgary Clinical Psychology program. These individuals had filled out the A-ADDES during the 2000 calendar year and thus, were not requested to do so again since their ADHD subtype classifications were listed in the Behavioral Research Unit database.

Once the A-ADDES had been completed by participants, they were asked to fill out the mood questionnaires in the following order: BDI, STAI, and STAXI. Following a short break, when needed, the participants were tested using the Ruff 2 & 7 Selective Attention test followed by the PASAT. Appointments for participant testing were booked for one and one-half hours and this was almost always sufficient. In only one instance was it necessary to book a second appointment in order to complete the testing.

Determination of Subtype

The determination of diagnosis of ADHD was made using the A-ADDES completed by each participant. In order to substantiate a diagnosis of ADHD, combined standard scores from both scales had to indicate symptom intensity at or above the 75th percentile based on A-ADDES normative data. Ratings over the 75th percentile on both Inattentive and Hyperactive/Impulsive ratings scales were considered evidence of ADHD-C. Categorization of ADHD-PI was indicated by standard scores at or above the 75th percentile on the Inattentive Scale of the A-ADDES but combined with Hyperactivity/Impulsivity standard scores that were required to be at least one standard deviation lower than Inattentive scores as shown on the A-ADDES profile sheet. A cross-check of subtype categorization was provided using DSM-IV criteria for all participants (APA, 1994). As indicated above, an attempt was made to balance the numbers of subjects in each of the ADHD subtype classifications for the purpose of analysis.

Stimulant Medication in Testing

As noted above participants were requested to refrain from taking stimulant medications for twelve hours prior to testing; however, this did not represent a risk to these individuals since stimulants for ADHD are normally used on an "as needed" basis, particularly with adults. Also, previous research at the University of Calgary and other institutions have used this drug-free period as a standard. The half-life of stimulants is short

(e.g. methylphenidate is 2.3 hours) and thus 12 hours is sufficient to remove the effects of the drug almost entirely (Canadian Pharmaceutical Association, 2000).

Special Provisions for Participants

It was anticipated that during the course of determining the presence of ADHD symptoms, clients would be identified who needed an assessment or treatment for managing those symptoms. In addition it was anticipated that, while rating symptoms of depression and anxiety, participants might be identified who exhibit symptoms congruent with major depression, dysthymia and/or anxiety disorders. In fact, in the course of testing, a number of participants displayed elevated symptoms of depression. In all cases, individuals who displayed moderate levels of depression (no participants scored in the severe range) on the BDI-II were already receiving assistance from mental health professionals. A number of participants who were interested in a complete diagnosis and assessment for ADHD were referred to the Calgary Learning Centre, The University of Calgary Disability Resource Centre and/or Health Services, or clinicians in the community who specialize in the diagnosis and treatment of ADHD.

Analysis of Data

A chi-square analysis was performed to determine if a significant association existed between sex and ADHD subtype. In addition a proportionality test was used to determine if there were significantly higher numbers of males or females in each subtype. Separate intercorrelation tables were completed for all emotion and attention variables. Correlations were examined to determine the degree and significance of positive and negative relationships and to determine which variables should be included in multivariate analysis.

T-Scores obtained from the three symptom intensity scales which included the STAI-State and Trait Anxiety and STAXI-Trait Anger, formed the three continuous dependent variables. The categories of ADHD (ADHD-PI and ADHD-C) along with gender were coded 1 and 2 to form the discrete independent variables. The data was examined for outliers and missing information and to determine suitability for analysis of variance based on normality and linearity. Following this determination a 2 X 2 between-subjects MANOVA was conducted in order to determine the effect of gender and subtype on the combined emotion variables. Subsequent univariate tests were employed to uncover variables that contribute to an observed significant main effect or interaction.

A second 2 X 2 between-subjects MANOVA was employed to determine if gender and/or ADHD subtype significantly affected the combined variables of Anger In, Anger Out and Anger Control. Once again subsequent univariate tests were employed in order to examine the

contribution of any of the anger variables to an observed effect.

Because the BDI-II utilizes raw scores rather than T-scores, as is the case for the other emotion variables used in the MANOVA's, a factorial between-subjects ANOVA was completed to determine if subtype of ADHD and/or gender affected level of depression.

For the examination of cognitive processing in ADHD subtypes, the standardized speed and accuracy T-scores on the Ruff 2 & 7 Automatic Detection and Controlled Search scales were used as four continuous dependent variables. Once again the subtypes of ADHD (ADHD-C and ADHD-PI) along with gender were coded 1 and 2 to form the discrete independent variables. Following examination of the data for outliers and missing information and suitability for analysis of variance, a 2 X 2 between subjects MANOVA was performed to examine the effect of ADHD subtype and gender on the combined dependent variables. Subsequent univariate tests examined the contribution of each dependent variable to any main effect.

The PASAT utilizes raw scores rather than T-scores as is the case for the attention variables on the Ruff 2 & 7 and thus a factorial between-subjects analysis of variance (ANOVA) was utilized to determine the effect of ADHD subtype and gender on PASAT scores.

Analyses were conducted using Statistical Package for the Social Sciences (SPSS).

CHAPTER THREE

RESULTS

A total of 88 adults between the ages of 18 and 60 participated in this study. Only one individual obtained from the sources listed in the methods section was unable to participate based on exclusionary criteria. All individuals who volunteered for the study were found to meet criteria for ADHD-PI or ADHD-C. Approximately half of the participants were using stimulants to treat their ADHD symptoms and most of these were adults with ADHD-C. Six adults with ADHD-C and one with ADHD-PI reported being treated for depression using medication at the time of testing.

Table 1 on the following page provides information regarding the age and sex of participants and, as this table indicates, a total of 40 adults with ADHD-PI and 48 with ADHD-C participated in the study. Figure 2 on page 70 illustrates the similarities in mean scores between the two ADHD subtypes on the A-ADDES domain of "inattention". Figure 2 also illustrates the differences between the two ADHD subtypes on the A-ADDES domain of "hyperactivity/impulsivity". Not illustrated by figure 2 is the fact that, on the A-ADDES domain of "hyperactivity/impulsivity", mean scores for adults with ADHD-PI were almost two standard deviations below those scores for adults with ADHD-C.

A chi-square analysis was employed to determine if significant associations existed between sex and ADHD subtype. Table 2 on page 71 provides a summary of cross-tabulated data. Results of Pearson chi-square statistical analysis indicated no significant associations between ADHD

TABLE 1
AGE DATA (IN YEARS) FOR PARTICIPANTS BY ADHD SUBTYPE AND SEX

	ADHD - C (N=48)		ADHD - PI (N=40)	
	FEMALE (N=25)	MALE (N=23)	FEMALE (N=26)	MALE (N=14)
MEAN	35.88	40.217	36.07	35.93
S.D.	9.79	13.20	12.43	12.54
RANGE	23-51	18-56	19-60	20-59

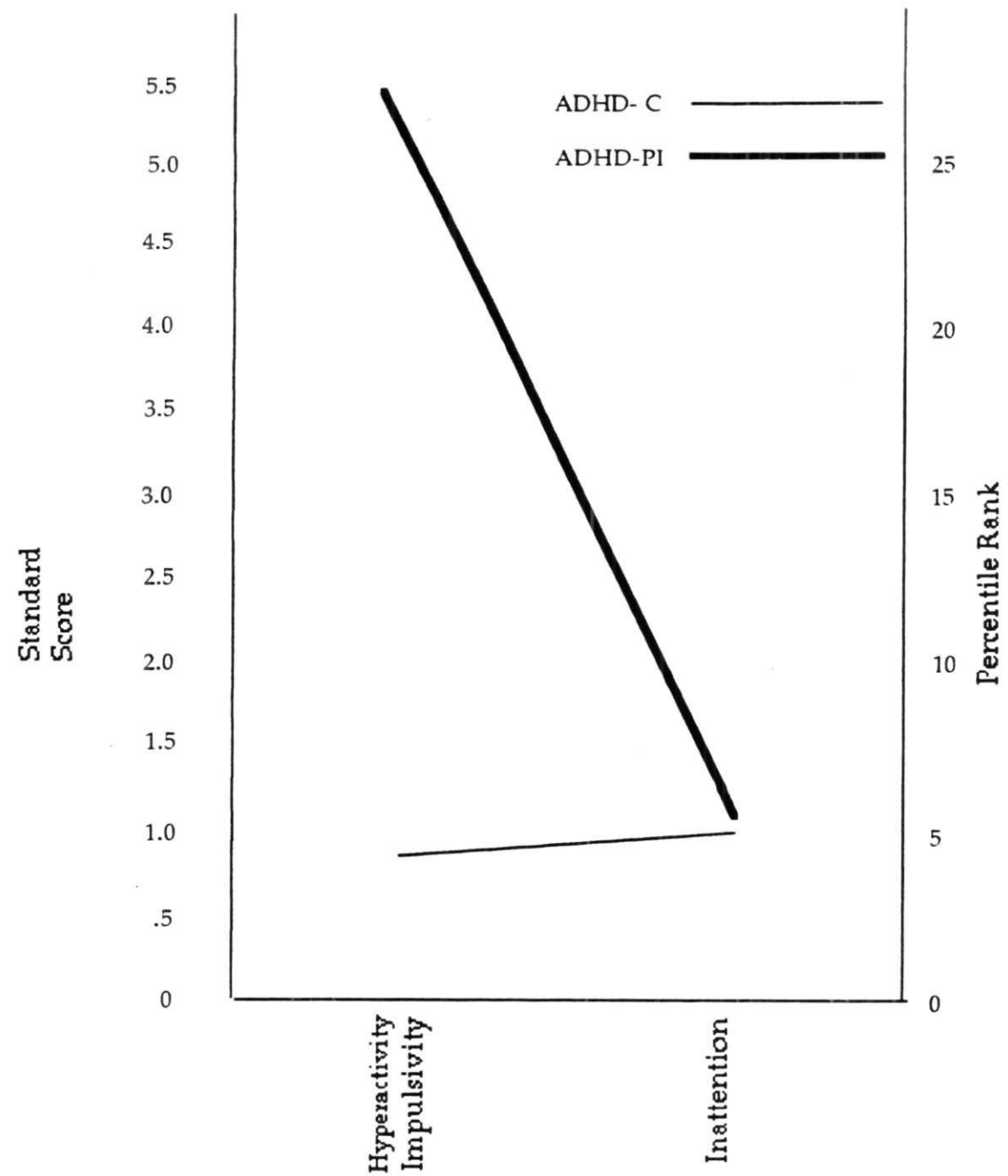


Figure 2. Mean ratings of hyperactive/impulsive and inattentive behavior for ADHD-C and ADHD-PI participants using the A-ADDES standard score and percentile rankings. Note: severity of symptoms is inversely related to numerical standard score ratings.

TABLE 2
PROPORTION AND CHI-SQUARE ANALYSIS OF SEX BY ADHD SUBTYPE

	ADHD - C	ADHD - PI	ROW TOTAL
FEMALE			
COUNT	25	26	51
ROW %	27.8	23.2	58.0
MALE			
COUNT	23	14	37
ROW %	20.2	16.8	42.0
COLUMN TOTAL	48	40	88
TOTAL%	54.5	45	100
PROPORTION SIGNIFICANCE	ns	<.05	
CHI-SQUARE	VALUE	df	SIGNIF.
PEARSON	1.4939	1	ns

subtype and sex. However, proportion analysis indicates that for the PI subtype there were significantly more females than males in this study.

Table 3 on page 73 provides intercorrelation data for all emotion variables. Highly significant correlations were noted between State and Trait anxiety, BDI depression scores and Trait Anger, and between Trait Anger and Anger Out. The highly significant correlation between BDI scores and Trait Anger provides evidence to support the hypothesis that was proposed regarding this relationship. Table 3 also indicates non-significant correlation between Trait Anger and Trait Anxiety along with a non-significant negative correlation between Trait Anger and State Anxiety. It was hypothesized that Trait Anger would be negatively correlated with both State and Trait Anxiety and therefore this hypothesis was not supported by the data. However, highly significant negative correlations were noted between Anger Control and both Trait Anger and Anger Out (see note in table 3 for definitions of these terms). These associations were in the same direction as indicated by Spielberger (1988).

A MANOVA was performed on three dependent variables: State Anxiety, Trait Anxiety, and Trait Anger. Independent variables were ADHD combined and predominantly inattentive subtypes along with gender. Results of evaluation of assumptions of normality and linearity were satisfactory. With the use of Wilks' criterion the combined dependent variables were significantly affected by ADHD subtype ($p < .01$) as indicated in table 4 on page 74. There was no significant interaction between ADHD subtype and gender. As also shown in table 4 subsequent univariate analysis indicated that adults in the study with ADHD-C have significantly higher trait anger ratings

TABLE 3
CORRELATION COEFFICIENTS (AND SIGNIFICANCE) FOR EMOTION VARIABLES

VARIABLE:	BDI	STATE ANXIETY	TRAIT ANXIETY	TRAIT ANGER	ANGER IN	ANGER OUT	ANGER CONTROL	
BDI	-	-.1375	.1197	.3785 (***)	.3216 (**)	.1799	-.2488 (*)	
STATE ANXIETY		-	.4583 (***)	-.1080	.1822	.1630	.2588 (*)	
TRAIT ANXIETY			-	.0861	.2890 (**)	.2956 (**)	.1128	
TRAIT ANGER				-	.3411 (***)	.4945 (***)	-.5217 (***)	
ANGER IN					-	.1511	.0000	
ANGER OUT						-	-.4367 (***)	
ANGER CONTROL							-	
								SIGNIFICANCE LEVEL
Note: Anger In- withholding the expression of angry emotion								* p<.05
Anger Out- expressing experienced angry emotion								** p<.01
Anger Control- ability to control development of angry emotion								*** p<.001

TABLE 4
MULTIVARIATE AND UNIVARIATE RESULTS FOR EMOTION VARIABLES

SOURCE	VARIABLE	ADHD - C	ADHD - PI	F	df	p
		mean (s.d.)	mean (s.d.)			
GROUP	COMPOSITE			5.4795	3,84	<.01
GROUP	ADD X GENDER			.3460	3,82	ns
	STATE ANXIETY	59.81(7.23)	58.08(7.36)	1.2384	1,86	ns
	TRAIT ANXIETY	64.04(6.47)	61.28(6.62)	3.9072	1,86	ns
	TRAIT ANGER	57.38(10.46)	49.60(10.27)	12.2533	1,86	.001
	BDI-II	16.69(10.56)	10.78(8.98)	7.8224	1,86	<.01
	BDI-II ADD X GENDER			.1470	1,84	ns

($p=.001$) than adults with the ADHD-PI diagnosis. This result is congruent with hypotheses regarding the association between trait anger and ADHD subtype.

The BDI-II provides a four level depression classification system based on numerical ratings, which is not included in table 4. However, the total mean group scores for participants with ADHD-PI on the BDI-II indicate minimal depressed mood. By comparison, group mean scores for those with ADHD-C on the BDI-II indicate mild levels of depressed mood (Beck et al., 1996). Results of a factorial ANOVA using BDI-II total scores as the dependent variable and ADHD subtype and gender as the independent variable is also reported in table 4. Adults with ADHD-C subtype have significantly higher BDI-II scores ($p<.01$) than adults with the ADHD-PI diagnosis in accordance with our hypothesis. No significant interaction between ADHD subtype and gender was indicated.

Results of a second MANOVA using the Anger In, Anger Out, and Anger Control components of State Anger as dependent variables and ADHD subtype and gender as the independent variables, are reported in table 5 on page 76. Following satisfactory indications of normality and linearity, and using Wilks' criterion, the combined dependent variables were significantly affected by ADHD subtype ($p<.01$). However, no significant interaction between subtype and gender was indicated. As also reported in table 5 subsequent univariate analysis indicated that adults with ADHD-C had significantly higher Anger In ratings ($p<.01$) than adults with ADHD-PI. The results also indicate that participants with ADHD-C had significantly higher Anger Out ratings ($p<.05$) as compared with those with ADHD-PI.

TABLE 5
MULTIVARIATE AND UNIVARIATE RESULTS FOR ANGER EXPERIENCE VARIABLES

SOURCE	VARIABLE	ADHD - C	ADHD - PI	F	df	p
		mean (s.d.)	mean (s.d.)			
GROUP	COMPOSITE			4.7273	3,84	<.01
GROUP	COMPOSITE ADD X GENDER			.7299	3,82	ns
	ANGER IN	60.79(9.81)	53.60(12.77)	8.9217	1,86	<.01
	ANGER OUT	56.21(11.72)	50.43(11.64)	5.3486	1,86	<.05
	ANGER CONTROL	46.33(12.19)	50.43(9.59)	2.9707	1,86	ns

TABLE 6
CORRELATION COEFFICIENTS (AND SIGNIFICANCE) FOR ATTENTION VARIABLES

VARIABLE:	AUTOMATIC DETECTION SPEED	AUTOMATIC DETECTION ACCURACY	CONTROLLED SEARCH SPEED	CONTROLLED SEARCH ACCURACY	PASAT	TOTAL SPEED	TOTAL ACCURACY
AUTOMATIC DETECTION SPEED	-	.0394	.8031 (***)	-.0806	.2565 (*)	.9403 (***)	-.0203
AUTOMATIC DETECTION ACCURACY		-	-.0020	.5958 (***)	.2359 (*)	.0306	.8509 (***)
CONTROLLED SEARCH SPEED			-	.1362	.3136 (**)	.9491 (***)	.0836
CONTROLLED SEARCH ACCURACY				-	.2465 (*)	.0329	.9178 (***)
PASAT					-	.3000 (**)	.2469 (*)
TOTAL SPEED						-	.0356
TOTAL ACCURACY							-

(SIGNIFICANCE LEVELS * <.05 ** <.01 *** <.001)

Intercorrelations for all attention variables are reported in Table 6 on page 77. Highly significant correlations were noted for Ruff 2 & 7 Automatic Detection Speed with Controlled Search Speed and for Automatic Detection Accuracy with Controlled Search Accuracy. Most importantly, the correlations of Ruff 2 & 7 Total Speed with Automatic and Controlled Search speeds were well above .90. Additionally, the correlations of Ruff 2 & 7 Total Accuracy with Automatic Detection and Controlled Search Accuracy T-scores was above .85. Because of these high correlations and based on the view represented by Tabachnik and Fidell (1996) that highly correlated variables are unsuitable for inclusion in multivariate analysis it was decided to exclude Total Accuracy and Total Speed T-scores from the analysis of attention variables. Finally, consistent, significant correlations ranging between $r=.23$ and $r=.32$ were noted between PASAT scores and all other attention variables.

The results of MANOVA using automatic and controlled search speed and accuracy scores as four independent variables and ADHD subtype and gender as the independent variables are reported in table 7 on page 79. ADHD subtype did not significantly affect the combination of visual attention variables and in fact, the similarity in mean scores on all visual attention variables for both ADHD-C and ADHD-PI groups is striking. Additionally, no significant interactions were observed between subtype and gender. Also reported in table 7 are the results of a factorial ANOVA using PASAT scores as the dependent variable and ADHD subtype and gender as the independent variables. Scores on the PASAT were not significantly affected by ADHD subtype and mean scores were remarkably similar for both groups. In addition, no significant interactions were observed between ADHD subtype

TABLE 7
MULTIVARIATE AND UNIVARIATE RESULTS FOR ATTENTION VARIABLES

SOURCE	VARIABLE	ADHD - C	ADHD - PI	F	df	p
		mean (s.d.)	mean (s.d.)			
GROUP	COMPOSITE			.0785	4,83	ns
GROUP	COMPOSITE ADD X GENDER			.2473	4,81	ns
	AUTOMATIC DET.SPEED	51.67(10.90)	51.40(9.83)	.0143	1,86	ns
	AUTOMATIC DET.ACCURACY	47.98(8.12)	48.40(8.32)	.0573	1,86	ns
	CONTROLLED SEARCH SPEED	49.83(10.10)	49.93(10.31)	.0018	1,86	ns
	CONTROLLED SEARCH ACCURACY	46.69(10.60)	46.55(11.02)	.0035	1,86	ns
	PASAT	77.92(19.33)	77.23(18.58)	.0289	1,86	ns
	PASAT ADD X GENDER			2.011	1,84	ns

and gender.

Based on the above results, the hypotheses regarding the effect of ADHD subtype on visual and auditory attention variables are not supported and in fact the participants in this study with either ADHD-C or ADHD-PI show remarkably similar mean scores. Finally, figure 3 on page 81 illustrates the interquartile range of scores for all four visual attention variables obtained from the Ruff 2 & 7 separated according to ADHD subtype. Most notable are apparent ceilings for T-scores on the Automatic Detection Accuracy (ADA) and Controlled Search Accuracy (CSA) domains for participants with either subtype.

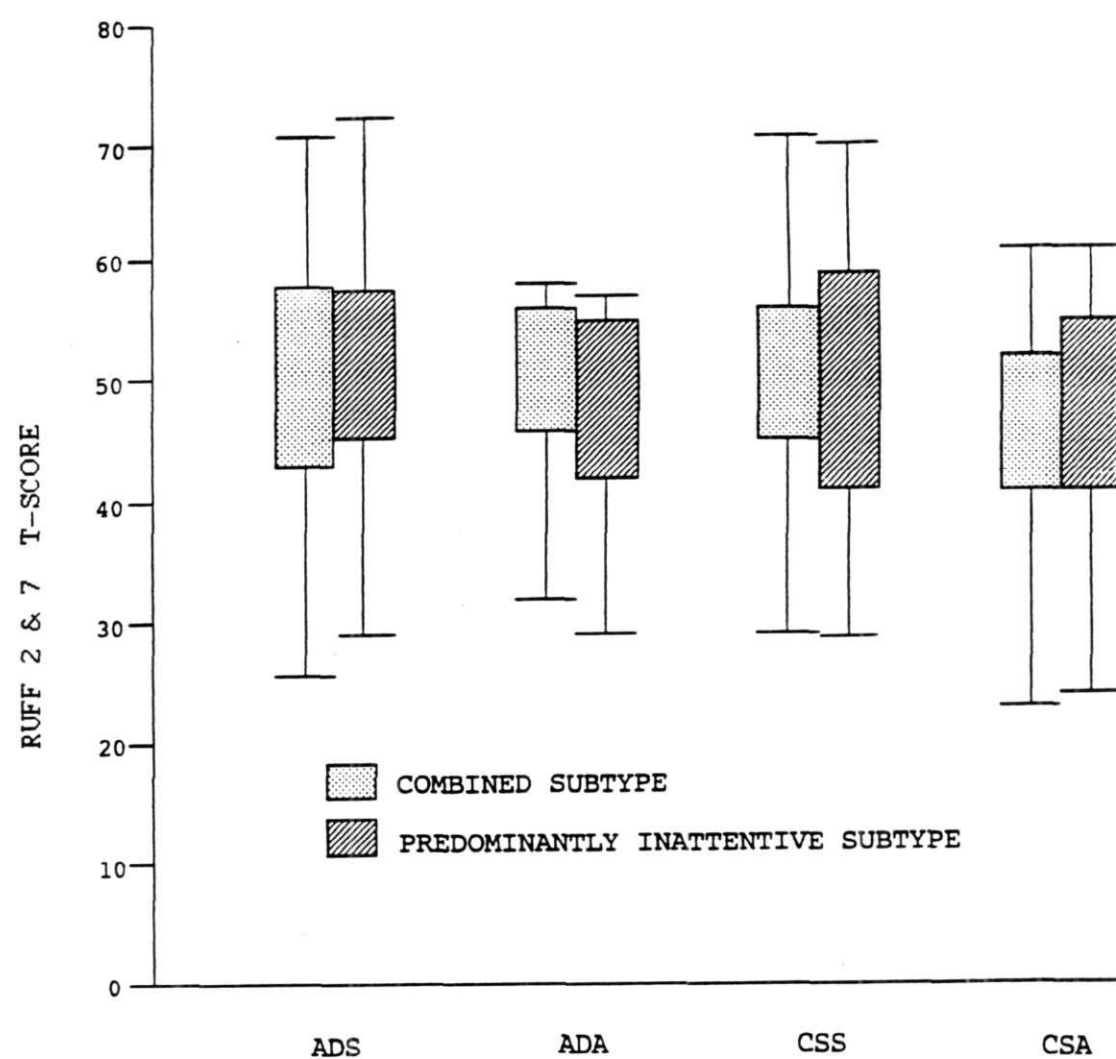


FIGURE 3. RUFF 2 & 7 T-SCORE INTERQUARTILE RANGE BY ADHD SUBTYPE

LEGEND: ADS- AUTOMATIC DETECTION SPEED
 ADA- AUTOMATIC DETECTION ACCURACY
 CSS- CONTROLLED SEARCH SPEED
 CSA- CONTROLLED SEARCH ACCURACY

CHAPTER FOUR

DISCUSSION

The strongest finding of the current study is that of the significantly increased trait anger and depression of participants with ADHD-C compared to those with ADHD-PI. Further, when the components of trait anger were explored, it was found that participants with ADHD-C were significantly more likely to repress feelings of anger. Individuals with ADHD-C were also significantly more likely to express angry feelings as compared with those with ADHD-PI.

Findings Related to Specific Goals and Hypotheses

Relationship of Sex to Subtype

One goal of this study was to verify the existing evidence regarding the relationship of subtype of ADHD to sex. A problematic view, often heralded by the popular press, is that of ADHD being specifically related to being both young and male. This view does indeed reflect early research findings (Barkley, 1996; Lahey, Miller, Gordon & Riley, 1999). However, more recent research has indicated two important findings. The first is that of age-related decreases in symptoms of hyperactivity along with age-related increases in symptoms of inattention (Lahey et al., 1999). Secondly, although male: female ratios of ADHD are reportedly highest in elementary age children (as high as 3:1), research suggests that this ratio decreases to almost 1:1 in late adolescence

(Barkely, 1996).

With regard to subtype, evidence from the child/adolescent ADHD research literature seems to suggest that ADHD-PI is less prevalent than ADHD-C and practically all studies involving subtypes employ smaller groups of participants with the former subtype as compared with the latter (e.g. Nolan, Gadow, & Sprakin, 2001). The recent study by Nolan et al. is one of the few studies to report male: female ratios for ADHD subtypes using child and adolescent participants. Results of chi-square analysis in their study indicated significantly higher rates of ADHD of all subtypes in males as compared with females. Prior to the current study no extant research has reported rates of subtypes by sex in adults with ADHD. In this study, as shown in Table 1 of the results section, higher numbers of females as compared with males in both subtypes, were ascertained. With regard to ADHD-PI the number of females was roughly twice that of males. Chi-square analysis indicated no significant relationship between sex and ADHD subtype. However, as indicated by the proportion analysis in Table 2 on page 71, for the PI subtype only, there was a significantly higher number of females as compared to males. Combining these results we might suggest that gender is not specifically associated with either subtype, however, within this study we did obtain more females with ADHD-PI. Analysis of gender by subtype interaction, in a larger sample of adults in future ADHD research may help to clarify the nature of this relationship.

With regard to ascertainment, it is noteworthy that subjects in the current study were obtained from at least four different sources and ranged widely in age. A possible source of ascertainment bias was that of soliciting

participants through agencies and settings where individuals are either seeking assistance with mental health or learning problems for themselves or for their children. Thus one might conclude that this was a clinical population as compared with a community based sample. It may be of interest to determine prevalence of ADHD subtypes in a community based sample of adults in future research; however, this might prove to be problematic. Normally, community based samples in childhood ADHD research are obtained through elementary and secondary schools; however, finding similarly large heterogeneous groups of adults is more difficult. Post secondary institutions often fulfill this role; unfortunately, the demographics of individuals attending such institutions favors younger age groups and so samples obtained from such settings are biased.

Although ascertainment in the current study is biased towards clinical populations, the measures utilized to obtain participants ensured a wide cross-section of adults from the Calgary region. The time constraints of the study required targeting of institutions where individuals are likely to seek help for attention problems and this combined with funding restrictions precluded advertising aimed at the general public. Nevertheless the cross-section of adults in the current study was diverse with regard to age, educational background, and reported occupation.

Hypotheses Regarding Emotional Variables

Emotion and ADHD Subtype

The findings regarding adults with ADHD-C may be summarized by stating that these individuals reported experiencing higher rates of all of the emotions studied in this research: anger, depression, and anxiety. This general finding contradicts earlier hypotheses, such as the one by Lahey and Carlson (1991) and Barkley (1996) in which the authors suggested that anxiety may be associated more closely with ADHD-PI as compared with ADHD-C. The most recent research regarding common associations with ADHD subtypes in children and adolescents is that by Nolan et al. (2001) noted above. Results of this study indicate that rates of major depression and dysthymia, were higher in individuals with ADHD-C as compared with ADHD-PI. These findings provide replication of past research such as that by Eiraldi et al. (1997) and Gaub and Carlson (1997) showing that the pattern of higher overall association with mood and externalizing problems with ADHD-C may be regarded as having been established with some confidence. With the results of the current study, we have expanded this to include adults with non-clinical levels of depression, anger, and anxiety.

Depressed Mood and ADHD-C

The first hypothesis proposed that adults with ADHD-C would experience higher levels of depression than adults with the ADHD-PI subtype. This is arguably the most conservative of all the hypotheses

proposed for the current study. This is because of the consistent finding of associations between Major Depressive Disorder (MDD) and ADHD, particularly the combined subtype, in children and adolescents (Biederman, 1992; DeQuiros, Kinsbourne Palmer & Rufo, 1994). In addition, findings of increased rates of MDD and Dysthymia with ADHD-C are noted in studies on children and adolescents in non-clinical as well as clinical populations (Nolan et al., 2001). However, three important considerations distinguish the findings in the current study from past research. The first is that past research has normally employed high symptom severity cutoffs such that only Dysthymia and MDD were utilized as dependent variables. Secondly, the majority of past research has concentrated on emotional variables in children and adolescents rather than adults. Finally, to date no study has made use of depression as a continuous variable in a comparison of ADHD subtypes in adults.

Some recent research has begun to shed light on emotional experiences in adults with ADHD. For example, a study by Rucklidge and Kaplan (1997) noted higher current levels of depression and past depressive episodes in adult women with ADHD as compared to female participants without ADHD. Research by Galbraith (2000) made use of ratings of depression on the BDI-II as did the current study. Results of the Galbraith study indicated high rates of depression in adults with ADHD. The study also found increased levels of depressed mood in ADHD-C as compared with ADHD-PI.

The finding in the current study that adults with the combined subtype of ADHD had higher levels of depressed mood than those with the predominantly inattentive subtype is congruent with previous research.

However, the unique finding of the current research is the higher levels of depressed mood even in individuals who do not meet criteria for Dysthymia and MDD at the time of testing.

At least three major explanations may be offered for the finding regarding depressed mood in adults with ADHD-C. The first is that of Biederman et al. (1992) who obtained evidence from familial patterns of transmission of DSM-III-R ADHD, depression, and anxiety, that there may exist a genetic linkage between ADHD and depression but not between ADHD and anxiety (Note the participants in this study were almost entirely those diagnosed with the equivalent of DSM-IV ADHD-C). Thus there may exist an etiological factor linked to inheritance that results in common vulnerabilities for symptoms of both ADHD and major depression and dysthymia but not anxiety. The second is that of Gaub and Carlson (1997) and Lahey et al. (1994) that ADHD-C is associated with higher overall risk for psychopathology. These authors do not speculate about whether or not this risk arises from genetic or other causes.

A third possible explanation for the observed association between depressed mood and ADHD-C arises from clinical experience and from explanations provided by participants in this and other studies. For example, in their study regarding psychological functioning of women with ADHD, Rucklidge and Kaplan (1997) state that "women with unidentified ADHD felt extremely helpless to make changes as children and viewed their childhood relationships with parents, peers, and teachers more negatively than women without ADHD" (p.173). Similarly, in the current study, participants, particularly those with ADHD-C, indicated a variety of difficulties relating to

same age peers, parents, and teachers. This, in turn, led to a feeling of helplessness and in some instances feelings of despair following attempts to fit in with peer and adult expectations, according to the recollection of these participants. Frustration levels apparently arose from the inability to control behaviors related to impulsivity and poor concentration in spite of adult expectations that, as children, these individuals were capable of exerting control over their behavior.

As indicated in the literature review, the most common association with ADHD-C in childhood is oppositionality and conduct problems. This association may, in some instances, provide a further explanation of the stronger association between ADHD-C and depressed mood as contrasted with ADHD-PI. In this writer's clinical experience, adults with ADHD who recalled being aggressive and oppositional as children also remembered frequent confrontation with same-aged peers. These individuals also recalled avoidance on the part of these same peers and the fact that they themselves, in turn, responded by avoidance and isolation. In connection with the above, research by Quiggle, Garber, Panak, and Dodge (1992) indicated a correlation of .73 between conduct disorder symptoms and depression based on reports by children, parents, and peers. The authors also found similarly high correlations between aggression and depression.

The participants in the current study were not intentionally interviewed regarding their experience of depressed mood; however, approximately half of these adults offered that they sensed that feelings of frustration and failure, along with a long history of confrontation with peers and adults, had contributed to their sense of despondency. It should be noted

that, for many of the participants in the current study, the sense of frustration and failure had not subsided substantially during their adulthood. However, adults who had received a past diagnosis of ADHD felt more reassured because of a sense of understanding and relief that their longstanding difficulties with impulsivity and poor concentration were attributable to an external cause. This relief and hopefulness, based on the sense that their difficulties were due to something that was outside of their control, was one of the more interesting qualitative findings of the present study (Rucklidge & Kaplan, 1997, 2000).

Individuals in the current study with ADHD-PI had far fewer symptoms of impulsivity (based on A-ADDES ratings and self-report) along with fewer reported difficulties with aggression or conduct, than those with ADHD-C which is in keeping with findings from other studies (Gaub & Carlson, 1997; Lahey, 1994). This would suggest that these individuals received considerably less censure from peers and adults and thus less likelihood of frustration which, in turn, might be linked with the generation of depressed mood. In spite of this, many individuals with the PI diagnosis also reported high levels of personal failure especially with regard to academic work. In this case the frustration was primarily related to unexplained difficulties in academic settings which were often attributed to other causes (e.g. laziness). However, in spite of a sense of past failure that adults with both subtypes shared, the differences that appear to be linked to generation of depressed feeling may be the greater interpersonal difficulties reported by those with ADHD-C.

The mean BDI-II scores for adults with ADHD-PI in the current study

are indicative of minimal levels of depression based on BDI-II criteria (Beck, Steer & Brown, 1996). By contrast, group mean scores for those with ADHD-C indicate at least mild levels of depressed mood based on the same rating system. The cause of the higher rating for the ADHD-C group may be longstanding interpersonal difficulties and frustrations in dealing with greater impulsivity and aggression as speculated above; however, evidence from past studies indicates that individuals with ADHD-C may also have a genetically influenced tendency towards depressed mood. Alternatively, the mild depressed mood observed in the current study may be generated by interpersonal problems whereas the rates of MDD (which would be consistent with moderate to severe BDI-II ratings) observed in the Biederman et al. (1992) study may be linked to a genetic/biological predisposition that interacts with interpersonal stressors to produce recurring major depressive episodes in some, but not all, individuals with ADHD.

Anger and ADHD Subtype

A second hypothesis offered in the current study is that individuals with ADHD-C will experience greater levels of trait anger than those with ADHD-PI. This was confirmed and, as indicated in Table 4 on page 74, mean group Trait Anger scores for participants with ADHD-C was significantly higher than for those with ADHD-PI.

Although the State-Trait Anger Inventory (Spielberger, 1988) was designed to also measure State Anger, early on in the study it was observed that nearly half of all participants did not endorse any symptoms of State Anger whatsoever. Of those who did endorse symptoms of State Anger, the

ratings were generally very low. This floor effect of the State Anger domain of the STAXI along with the peculiar non-normal distribution obtained from the scores, rendered this domain entirely unsuitable for analysis. When queried regarding their low rate of endorsement of State Anger symptoms, individual participants indicated that there was little in the testing situation that evoked feelings of anger. (This is in marked contrast with State Anxiety which is discussed below.)

In contrast to State Anger, Trait Anger is a measure of the participants' overall experience of angry feelings and expressions in a wide cross-section of settings. Individuals with high Trait Anger experience the arousal of angry feelings quite readily and with less provocation than would someone with low Trait Anger. It is noteworthy that individuals with ADHD-PI in this study had a group mean T-score of approximately fifty (Table 4). This would indicate that their levels of anger in most situations are about average as compared with the normative sample used to develop the STAXI (Spielberger, 1988). By contrast the group mean T-score of participants with ADHD-C was approximately eight points higher. This would indicate levels of angry feelings and anger expression that are somewhat higher than average for this group of individuals.

The basis of the increased levels of anger seen in the ADHD-C group may be regarded as arising from two possible sources. The first may be linked to irritability which is a prominent but seldom discussed feature of anger, aggression, and depression and is linked to the serotonin hypothesis of aggression and impulsivity discussed below (Hammen & Rudolf, 1996; Kalat, 1994; Quist & Kennedy, 2001). A second possibility is the general increased

arousal apparently experienced by individuals with ADHD-C. A number of adults in the current study recalled intense feelings of anger and frustration at even slight provocations, during their adolescence and young adulthood. In contrast, many indicated an increased frustration level at their inability to control such feelings as they aged. Many individuals with ADHD-C were interested in the fact that the study took anger into account as a possible variable in ADHD subtypes. While filling out the STAXI, a number of participants remarked that although they had not initially considered anger a salient experience in connection with their ADHD, as they went through the State Anger scales they identified strongly with many of the behaviors and thoughts that were included in the question booklet.

The STAXI also allows for the division of State Anger into components which describe the control and level of expression of angry feelings. These components include Anger In which is a rating of an individual's attempts to withhold the expression of angry emotions which they are experiencing, Anger Out which is a rating of the tendency to overtly express experienced anger, and Anger Control which is a rating of the relative ability to prevent angry feelings from developing in anger-provoking situations. Individuals with ADHD-C were significantly more likely than adults with ADHD-PI to inhibit the expression of their feelings of anger. As shown in Table 5 on page 76, individuals with ADHD-C were also significantly more likely to express their feelings of anger than those with ADHD-PI. It would appear that adults with ADHD-C experience angry feelings more often and in more situations than those with ADHD-PI but are slightly more likely to restrain their expression of anger than to express it.

The apparent paradox provided by the results of the STAXI Anger In and Anger Out scales, in which adults with ADHD-C were higher on both scales is completely congruent with the finding that this group had significantly higher trait anger overall. As indicated in Table 5, the ADHD-C group had higher Anger In ratings than Anger Out which may indicate that they were more likely to be successful in withholding the expression of anger. The participants were not asked to rate changes in their ability to restrain themselves from expressing anger as they aged, but it is likely that they would be more successful at such restraint in adulthood as compared to adolescence. The Anger Out ratings for the ADHD-C group were somewhat higher than for the ADHD-PI group; however, the ADHD-C group mean (56.2) indicates only a moderately increased likelihood of resorting to overt expressions of anger such as swearing, slamming doors, or engaging in verbal confrontations with others, than the STAXI normative sample.

A final finding from the ratings using the STAXI is that individuals with ADHD-PI reported being more adept at preventing angry feelings from developing in the first place. This Anger Control is not to be confused with Anger In, described above. Anger Control is a measure of the ability to keep from getting angry when situations develop that would normally elicit such feelings. Individuals with ADHD-PI were slightly better than those with ADHD-C at keeping feelings of anger at bay. This finding may indicate that the increased anger experienced by those with ADHD-C may be a function of slightly increased arousal or irritability. In other words, there may be some component of the tendency to experience anger that is beyond the individual's control. At the same time, the rather small differences in ratings

between the two groups combined with the fact that neither group displayed ratings that were far from the STAXI normative sample mean may indicate that adults with ADHD have learned to remain calm in anger provoking situations. It may be valuable for future research to obtain ratings of adolescents with ADHD in the domain of STAXI Anger Control, in order to determine if such control is noticeably poorer in such populations as contrasted with adults.

No specific hypothesis was made regarding anxiety in this study; however, one of the stated goals was to determine if differences existed between either ADHD subtype on ratings of state and trait anxiety using the State-Trait Anxiety Inventory (STAI). As indicated in Table 4, adults with ADHD-C and ADHD-PI experienced above average ratings of State Anxiety. The design of the STAI is such that State Anxiety in this case became a measure of anxious arousal in a testing/interview session. As contrasted with the results of the State Anger domain of the STAXI, all participants endorsed some symptoms of State Anxiety. When queried regarding this, most participants indicated some apprehension during testing situations such as those employed in this research. In some instances the participants were visibly anxious. When questioned, these individuals usually indicated past difficulty in successfully completing exams as the reason for their anxiety. They tended to associate participation in research with a testing situation and thus experienced the same feelings of anxiety.

Participants in this study endorsed symptoms of Trait Anxiety at even higher levels than for State Anxiety. Individuals with ADHD-C had higher ratings of Trait Anxiety than those with ADHD-PI but not

significantly so. Most importantly, mean T-scores for both groups of adults were higher than average indicating that anxiety may be a common association with adult ADHD. This is a peculiar finding given the conclusion by Biederman et al. (1992) that, based on genetic studies, anxiety does not share a common familial association with ADHD. Once again, however, we are faced with the dilemma of trying to determine whether or not an emotion associated with ADHD, in this case anxiety, is the result of learning or shared inheritance. It is likely that longitudinal research would be necessary to determine the basis of the elevated ratings of anxiety in both subtypes.

With regard to depression, anger, and anxiety some hypotheses were made as to how these three variables might be correlated. It was predicted that, in adults with either subtype, trait anger would be correlated with level of depressed mood because of the possibility that such emotions may share common vulnerabilities as indicated above. Table 3 (page 72) indicates that ratings of depression using the BDI-II are significantly correlated ($r=.38$) with trait anger.

It was also predicted that trait anxiety would be negatively correlated with trait anger. This hypothesis was offered as a test of the assumed association between childhood aggression and adult levels of anger and the tendency for the childhood literature to report reduced aggression in children with anxiety (Hinshaw & Anderson, 1996). Instead trait anger and anxiety were essentially uncorrelated ($r=.09$). This finding may also reflect the growing evidence, that in individuals with conduct problems or ADHD, the association of anxiety symptoms may be more complex and developmentally determined than was indicated in early research (Barkley, 1996; Pliszka, 1992).

In the current study, anger and anxiety were all higher than average in adults with ADHD-C; however, anxiety was elevated in both C and PI subtypes.

In the current study, the overall findings have been in agreement with past research regarding the association between externalizing / internalizing syndromes and ADHD. Given the overall results of this study and evidence from past research, it may be that differences in the level of mood associations may be among the few characteristics which help to distinguish ADHD-C from ADHD-PI aside from the differences in impulsivity/hyperactivity. Recent research by Neuman et al. (1999) noted above, made use of a latent class analysis of symptom profiles of over 1300 pairs of monozygotic and dizygotic pairs of twins. The overwhelming evidence from this large scale study indicates clearly the robustness of the ADHD-C and ADHD-PI symptom profiles along with evidence that membership in these subtypes is influenced by genetic factors.

Combined with evidence from previous studies regarding the associations of subtype with rates of externalizing and internalizing disorders and the findings of the current study of similar associations in adults, it is concluded that a clear picture of mood profiles of ADHD-C and ADHD-PI is emerging. As described above this profile includes the association of ADHD-C with externalizing disorders in childhood and possibly increased levels of trait anger and depressed mood in adulthood. Based on findings from this study, increased levels of anxiety, which have not generally been associated with childhood ADHD, appear to be a concomitant of adult ADHD, regardless of subtype. Unfortunately, to date, very few theories have been available to tie together an understanding of the observable behaviors of each subtype

with their respective mood associations.

Hypotheses Regarding Attention

The first hypothesis regarding attention predicted that individuals with ADHD-C would demonstrate greater deficits in selective attention than those with ADHD-PI. Using the Ruff 2 & 7, the relative measure of selective attention is based on scores from the Controlled Search domain. As the authors state " in the second condition, *Controlled Search*, . . . the respondent cannot use a simple categorical distinction between numeric targets and alphabetical distracters. . . target selection requires the involvement of working memory and is therefore effortful and resource limited " (Ruff & Allen, 1996, p. 1).

As indicated in Table 7 on page 79, the mean group T-scores for Controlled Search speed and accuracy for participants with either subtype were remarkably congruent as were the standard deviations. In addition, these group means are basically identical with that of the normative sample used in the development of the Ruff 2 & 7. This would appear to indicate that adults in the study with ADHD-C do not demonstrate difficulties or deficits with regard to their selective attention abilities that are greater than adults with the ADHD-PI diagnosis.

A second hypothesis predicted that individuals with ADHD-PI would demonstrate more difficulties with sustained attention than those participants with ADHD-C. The theoretical foundation for the Ruff 2 & 7 suggests that total accuracy and total speed scores are appropriate measures of

sustained attention (Ruff & Allen, 1996). This is in accordance with the definition of sustained attention indicated in the literature review. That is, sustained attention is not a separate construct as much as it is a measure of the requirement to maintain attention over an extended period of time. Accordingly, the Ruff 2 & 7 measures both automated and selective attention processes which, when extended for more than a few minutes, require enough effort and concentration to be considered sustained attention.

Ruff and Allen (1996) have suggested that the completion time for the Ruff 2 & 7 test, which is exactly five minutes, is sufficient to provide a measure of sustained attention. Without further evidence, this could be construed as a rather arbitrary method of determining the lower temporal boundary for sustained attention and no specific theoretical underpinnings are offered. However, the authors suggest that the length of the 2 & 7 test was determined based on the feedback obtained from participants during the development of this test and on their own experience in neuropsychological testing. Notably, most participants in the current study indicated that they found the length of the test sufficiently taxing. Further, participants indicated that they experienced a deterioration in their ability to concentrate, well before the end of the test. Based on the above evidence we may safely conclude that the Ruff 2 & 7 is capable of measuring sustained attention.

In spite of the convenience of using total speed and accuracy scores to determine group differences, a dilemma presented itself when the correlations for the different component scores of the Ruff 2 & 7 were examined. Specifically, and as indicated in table 6 on page 77, the total speed

and accuracy scores were very highly correlated with the individual speed and accuracy scores of the Automatic Detection and Controlled Search domains on the Ruff 2 & 7. A number of sources indicate that, when determining suitability of variables for comparisons using multivariate techniques, highly correlated variables indicate redundancy and thus one of the correlated variables should be excluded from analysis (Tabachnick & Fidell, 1996). Since total speed and total accuracy T-scores are determined by adding together Controlled Search and Automatic Detection scores, the correlations were not surprising. However, it was considered important to be able to compare components of both selective and sustained attention. It was determined that there was enough independence of the four primary component T-scores of the Ruff 2 & 7 to be included in the analysis. Correlations of these T-scores were moderate but not high enough to indicate total redundancy of any two variables.

Results indicated that, as with the Controlled Search variables, the Automatic Detection T-scores for ADHD-C and ADHD-PI subtypes were almost identical. Again, the mean group scores are very close to 50 (see table 7) for both Automatic Detection speed and accuracy scores. These group means are therefore very similar to the mean T-scores for the normative sample used in the development of the Ruff 2 & 7. This would appear to indicate that impairment of automatic attention processing is not necessarily a feature of either subtype of ADHD.

As stated above, the measure of sustained attention is based on total speed and total accuracy scores (Ruff & Allen, 1996). From table 7 it is clear that adding together the speed and accuracy components of Automatic

Detection or Controlled search domains of the Ruff 2 & 7 would still provide total scores that are remarkably congruent between subtypes. That is, the total speed and total accuracy scores of the 2 & 7 were not used in the analysis; however, their components, the means of speed and accuracy scores for each of Automatic and Controlled search domains were almost identical. Therefore no argument could be made for differences in sustained attention based on ADHD subtype in adults regardless of the method of analysis. Thus it is concluded that the hypothesis that suggested that there would be a greater deficit in sustained attention for those adults with ADHD-PI as contrasted with those with ADHD-C, is not confirmed by this data.

The remarkable congruence of mean group scores and standard deviations for ADHD-C and PI adults in this study on all domains of the 2 & 7 appears to indicate that, at the most basic level of attention processing, there are few differences between subtypes. However, another important source of information is the range of scores for both subtypes on the the Ruff 2 & 7 Automatic Detection and Controlled Search domains. Figure 3 on page 80 provides illustrations of box plots for each subtype on all four 2 & 7 domains. While the plots for the Automatic Detection and Controlled Search speed domains show wide ranging T-scores, the Automatic Detection and Controlled Search accuracy scores show an upper limit that is consistent between subtypes. More specifically, the upper limit of scores is 58 and 57 respectively for ADHD-C and PI on the Automatic Detection accuracy domain. Similarly, the upper limit of T-scores is 61 for both ADHD-C and PI subtypes on the Controlled Search accuracy domain of the Ruff 2 & 7.

Taken together these results indicate that adults in this study with

either subtype were unable to perform sufficiently to obtain scores above the 77th percentile. In spite of academic achievement that ranged from basic post-secondary training to master's degrees and wide ranges of occupations and hobbies, none of the 88 individuals in this study was able to score above this apparent ceiling.

There are two specific questions that arise from the evidence described above. The first is whether or not the apparent ceilings are indicative of an attention deficit that is shared by both subtypes. A second and related question is why this apparently applies to accuracy and not speed scores for both the Automatic Detection and Controlled Search domains.

To answer these questions we must first reconsider the construction of the Ruff 2 & 7. As figure 1 on page 57 of the methodology section illustrates, the individual is required to cross out 2s and 7s as they are encountered in either letter or numeral distracters. In order to determine the participant's speed for each domain it is merely necessary to tally all of the successful hits, that is correctly crossed-out 2s and 7s, regardless of errors of omission or commission. This speed score only takes into account the total number of 2s and 7s that are noticed by the participant. The participant may scan as far ahead as they want as long as they proceed from left to right and from top to bottom. To an extent therefore, this is more a visual process than one of focused or selective attention. Thus, the speed scores for either the Automatic Detection or Controlled Search domains of the Ruff 2 & 7 would not be as affected by impairment in selective scan and by association, selective attention.

For the purposes of obtaining accuracy scores on both domains of the

Ruff 2 & 7, the number of errors of omission and commission are also tallied and used along with the sum of successful “hits” to create an accuracy score. Therefore, the accuracy scores include a measure of the number of 2s and 7s that were missed during the participant’s scan of each row and thus provide a relative numerical estimate of ability in the domain of selective attention.

A possible objection to the claim that the Ruff 2 & 7 actually measures attention would be that, by including errors of commission and omission, what is truly being measured is impulsive responding. However, a survey of the responses by the adult participants in this study indicates that practically all errors (99% or more) were errors of omission. In fact, only four participants committed errors of commission. Given a pattern of impulsive responding it would be reasonable to expect a much higher rate of commission errors, particularly in the Automatic Detection domain since letters such as Z could easily be construed as a 7 or a 2. In fact, all observed errors of commission involved the inadvertent circling of the letter Z. Further, the concept of impulsivity as it is outlined in major theories such as that of Barkley (1996) is described as a deficit in the ability to withhold a response to irrelevant environmental stimuli. The controlled conditions and lack of competing stimuli in testing situations using the Ruff 2 & 7 in the current study further argues against the conclusion that the deficits that we observed are the result of impulsive responding rather than a true attention deficit.

In the light of the evidence presented by these results we may conclude that what we are observing in the apparent ceiling on Ruff 2 & 7 accuracy scores is a true limitation in selective attention ability. This conclusion also

speaks to the question that was raised as a conceptual issue in our literature review: whether or not Attention Deficit Hyperactivity Disorder involves a true deficit in a basic cognitive ability that can clearly be described as attention. While the answer appears to be yes, there are also some caveats that must be placed on such a claim. The first and most obvious is that these results would have to be replicated with a different population of adults. The second and less obvious objection is that of the clinical usefulness of such a finding.

Ideally, in designing tests that may have usefulness in identifying individuals with a specific disorder we would want a measure whereby true diagnostic positives would be identified by a high or low score on a given test. In contrast what we have, based on the results from the Ruff 2 & 7 scores in the current study, is a possible ceiling on ability such that, if an individual achieves a score under the 77th percentile in accuracy domains, we have evidence of a possible deficit in selective attention. This of course, is far removed from the ideal of having a true “test” for attention deficits and by association, ADHD.

Summary of Findings

The findings in this study have begun to fill in a gap in extant ADHD research. To summarize, tests of complex executive function have not been found to distinguish between ADHD subtypes (Barkley, Grodzinsky, & DuPaul, 1992). Tests of vigilance are likewise unable to differentiate between subtypes although they are claimed to distinguish between children with and without ADHD (Barkley et al., 1992; Gordon, 1987; Fischer, Newby, & Gordon,

1995). The current study is the first to compare ADHD subtypes on basic cognitive processes identified specifically with visual attention from the cognitive psychology literature. As summarized above, evidence from this study suggests that ADHD subtypes are not distinguishable using robust measures of visual selective and sustained attention.

One area where an additional gap exists in ADHD subtype comparison research literature is that of comparing subtypes on everyday attention tasks. Such research would require the evaluation of attention ability in a setting that approximates normal demand situations such as a classroom setting. This would also imply the presence of distracters such as other individuals in the same room. It would also require the design of measures that place little demand on more complex abilities such as executive function. Unfortunately, everyday attention is not easily equated with specific neural substrates and cognitive processes and so, in traditional experimental psychology, interest in such an approach is likely quite limited. From the standpoint of the rationale for the current study it was deemed necessary to examine more basic attention variables before proceeding to more complex ones in future research.

Localization of Attention Function

During the development of the Ruff & 7 the authors proposed that Controlled Search and Automatic Detection accuracy scores are affected by functioning in the right hemisphere of the brain (Ruff & Allen, 1996). The authors also proposed that selective attention is a function of prefrontal regions of the brain whereas automatic detection is a function of posterior

cerebral regions. This proposition is uncontroversial and follows from previous findings regarding the localization of attention and visual-attention processes (Rothbart, Posner, & Hershey, 1995).

As already described in the introduction to the current study, in order to test the ability of the Ruff 2 & 7 to determine localization of specific attention problems a separate study was employed by the authors (Ruff & Allen, 1996). In this study the authors were able to correctly classify over 75% of patients with identifiable focal lesions. The Ruff and Allen study involved classifying participants as impaired if they had a T-score on Automatic and Controlled Search domains that was below 35 (placing them at or below the 5th percentile for age and education classification, based on normative data). Unfortunately, it was impossible to make any such determinations in the current study because of the low rate of individuals who would be qualified as impaired, based on Ruff and Allen's criterion. This is not unexpected given that individuals with actual focal lesions would likely be more impaired than individuals with a diagnosis of ADHD. Based on the localization data, however, we can make a general inference using the data from the current study. That is, because of the ceilings and lower group means for accuracy scores versus speed scores indicated in the results section, it is possible that we are seeing a greater tendency towards impairment in right brain function for the participant group as a whole. Without indications of more severe impairment for either ADHD-C or PI groups however, this remains a very tentative inference.

Hypothesis Regarding Auditory Attention

The lack of available data with regard to auditory attention processes in ADHD subtypes limited the specific hypotheses that could be offered concerning subtype differences using the PASAT. The hypothesis that was offered, that adults with ADHD-PI would have lower scores than and thus greater deficits in auditory attention than those with ADHD-C, was based primarily upon evidence from studies by Barkley, DuPaul, and McMurray (1991), Barkley, Grodzinsky, and DuPaul (1991), and Lahey and Carlson (1991). These authors have presented evidence to the effect that individuals with ADHD-PI appear to have a slower cognitive tempo than those with ADHD-C. In association with this, approximately half of the participants in the current study with ADHD-PI reported difficulty in following verbal instructions and, in structured learning environments, preferred to take written notes for later study. It is not entirely certain whether this qualitative information, provided by participants with ADHD-PI, is associated with the evidence obtained from the studies indicated above. However, additionally, in this writer's clinical experience the slower pace of language and the appearance of slower cognitive tempo in ADHD-PI has been a consistent observation.

The PASAT requires that participants be able to hear and attend to the numbers being presented while ignoring the answers they themselves are providing to the examiner. At the same time, the basic numerical operation, which in this case is simple addition, requires rapid processing. In the absence of any clear evidence from previous studies, that either ADHD subtype involved specific auditory attention deficits, it was estimated that the slower

cognitive tempo of those with ADHD-PI would limit full scale scores as compared with ADHD-C. It is not known to what extent lower capacity for processing of auditory information is related to attention deficits *per se*; however, these processes are so interrelated that separating them into constructs that could be individually operationalized would not likely be possible with the present level of knowledge (Rothbart, Posner, & Hershey, 1995). As noted in the literature review, some overlap between cognitive processes is inevitable regardless of the type of measure that is used. In the case of the PASAT, the overlap with other processes besides attention is minimized.

In the absence of specific normative data published by its developers, Wiens, Fuller, and Crossen (1997) tested 821 adults using the PASAT, in order to obtain information that could be used for comparison purposes in future studies. The adults in their study had been previously screened for health problems and substance abuse and had undergone psychological and neuropsychological testing. The data from the Wiens et al. study included scores for each of the four series or trials of the PASAT. A comparison of the cumulative scores for the first two trials indicates group mean scores of 72.9 and 73.8 for males and females respectively in their study. By comparison the group means for the first two trials of the PASAT in the current study were 77.9 and 77.2 for the ADHD-C and ADHD-PI subtypes respectively. Standard deviations were considerably lower in the Wiens et al. study than in the current one but this is likely due to the much larger size of the participant group and thus a predictable change in distribution of the scores. Based on comparisons with results from normative studies indicated above, it may be

concluded that adults with ADHD in the current study, far from displaying deficits in the auditory attention domain measured by the PASAT, appear to be well within the average range.

The failure to find differences in auditory attention between the two ADHD subtypes may not be unexpected given the results of testing using visual attention tests in the current study. In addition, as noted in the literature review, significant deficits in auditory processing have not been found on attention tests such as the dichotic listening task (Prior et al. 1985). As discussed in the literature review, the PASAT is thought to measure selective auditory attention but due to its relative brevity cannot be described as a measure of sustained attention.

With regard to testing using the PASAT it is also noteworthy that the correlations among all four domains of the Ruff 2 & 7 and the PASAT scores are remarkably consistent. The PASAT scores correlate between .23 and .32 with the Automatic Detection and Controlled Search speed and accuracy domains of the Ruff 2 & 7 (see table 6). While this consistency may partly reflect the intercorrelations among the four Ruff 2 & 7 domains it may also reflect the presence of an underlying construct that is made up of an attention component. The fact that the correlations between the PASAT and Ruff 2 & 7 are moderate rather than high may reflect differences in auditory and visual attention processes plus overlap from complementary cognitive processes.

Conclusions Regarding Attention and Adult ADHD

The results of the current study offer evidence that differences in basic attention processes between ADHD-C and ADHD -PI, if they exist, are either minimal or unlikely to be detected given current investigative methods. Additionally, there appears to be limited evidence for an overall deficit in attention for adults with ADHD as a whole based on our present findings. In spite of this, a curious ceiling for the scores on the accuracy domains of the Ruff 2 & 7 was observed and may reveal limitations in visual selective attention for both subtypes. Based on the data from the current study, adults with ADHD-PI and C are remarkably congruent in their performance on these measures and thus appear to be similar with regard to sustained attention in the visual domain and selective attention in both visual and auditory domains.

Summary

The goal of the current study was to address the lack of research regarding possible differences between ADHD subtypes. We earlier argued that this type of research was best conducted with adult populations, partly due to a lack of published data in this area, but more importantly because of the likelihood that with adult participants complex developmental issues would not add potential confounds to our interpretations of the results as they do with children and adolescents. In connection with this it was estimated that cognitive function related to attention would have reached a

developmental end point by early adulthood. With regard to co-occurring mood syndromes, we noted that adults would likely have greater insight into current emotional functioning as well as the factors influencing the development of the emotions that they had experienced in association with their ADHD.

We have noted evidence that suggests that the two subtypes of ADHD are readily distinguished and that recent evidence suggests that it is likely that ADHD-PI and ADHD-C have different genetic components. In spite of this, few studies have been able to unravel the reasons for the different behavioral presentation of each subtype. We had hoped that some recognizable difference in cognitive processing related to attention would be in evidence. However, in general agreement with past studies on subtype, evidence of cognitive processing differences between ADHD-C and ADHD-PI are not only absent, but instead we have observed remarkable congruence in mean group scores on all of the attention measures used in the current study.

The finding that ADHD-C and ADHD-PI have somewhat different mood associations is also in general agreement with past findings. We have observed evidence that ADHD-C is associated with a higher level of emotional disturbance and that these differences are most notable with regard to depressed mood and anger. With regard to anxiety we have provided evidence that both subtypes are associated with elevated levels of state and trait anxiety. While the state anxiety may be explained based on past learning and failure, the trait anxiety is not so easily accounted for.

It should also be noted that the current study has examined sub-clinical levels of emotion rather than clinical levels of depression, anger, and anxiety.

Nor have we looked at specific anxiety or mood disorders. Instead one of the goals in the current study was to examine the trends in association with subtype regarding co-occurring emotion. In addition we have added an examination of anger as a construct that may relate to childhood and adolescent aggression.

The general finding that adult ADHD-PI and ADHD-C are different only in regard to associated mood will prove puzzling and disappointing to some. However, more recent research regarding the role that the serotonin system plays in moderating the catecholnergic system of the brain offers the hope of understanding these interactions. Quist and Kennedy (2001) summarized evidence that indicates the involvement of serotonin regulation of catecholamines in ADHD. Up to the present time most theories regarding the control of behaviors associated with ADHD have concentrated on the role of dopamine and norepinephrine. These theories did not provide information which would explain the association of internalizing disorders with ADHD since these were normally associated with dysregulation of the serotonin system in humans (Kalat, 1994). Recent studies have shown that when laboratory animals are genetically altered so that they lack certain serotonin receptors the resulting behavior includes increases in impulsivity and hyperactivity (Brunner, Buhot, & Hofer, 1999; Saudou, Amara, Dierich, et al., 1994). Additionally, animals in some studies showed increase in locomotor activity when given certain serotonin agonists (Rempel, Callaway, & Geyer, 1993). Based on these and other lines of evidence, Quist and Kennedy concluded that there is a complex relationship between dopamine and serotonin regulation such that serotonin significantly affects the regulation of

dopamine in the prefrontal cortex and other areas of the brain. Serotonin has also been implicated in the regulation of moods such as irritability and aggression and there have been a number of studies that have focused on this subject, although the results have been far from conclusive (Berman, Tracy & Coccaro, 1997). The summary provided by Quist and Kennedy combined with growing evidence of a consistent association between mood dysregulation and ADHD offer hope that the findings of the current study will be better understood at some point in the future. It is possible that differences in neurochemical function may be significant enough to produce the behavioral differences between ADHD subtypes that are so readily noticeable.

Regarding the arguments by various authors as to whether or not ADHD subtypes do represent valid classifications we can state that there is growing evidence that such is the case. Thus we would reject the arguments of Stewart (1994) who suggests that ADHD-C and ADHD-PI categories (or their equivalents in past DSM revisions) are merely variations in intensity of symptoms. We would also be forced to reject the suggestion of Barkley (1996) that ADHD-PI and ADHD-C have different underlying attention deficits. Instead we may be on the verge of a new understanding of ADHD and its subtypes based on the daunting but relevant task of uncovering the role of the serotonergic system and its interaction with the catecholnergic neurotransmitters.

A final note regards the clinical utility of the findings in the current study. The hope of discerning significant differences in cognitive processing relates to the desire to modify learning environments to accommodate children and adults with ADHD. The identification of real processing

differences between subtypes would have also allowed the possibility of new assessment instruments for assessing ADHD. The actual finding of differences in mood between subtypes does suggest a refined approach when dealing with adults with ADHD. In particular it means that symptoms of anxiety, anger, and depression are real and pervasive associations with adult ADHD which should be addressed in interventions. Finally, if our understanding of the role of the serotonergic system in ADHD is refined it may also offer the hope that the newest generation of pharmacological interventions aimed primarily at mood disorders may also help in alleviating a number of symptoms associated with adult ADHD.

Limitations of the Current Study and Future Directions

The current study was limited by a number of factors. The first of these is the limited sample size which was hampered by the difficulty in finding substantial numbers of adults with ADHD-PI. These individuals are somewhat less likely to seek assistance with their difficulties than those with more severe problems with impulsivity as is the case with the ADHD-C groups. In connection with this, individuals with ADHD-C are more likely to have been diagnosed as children and thus, having a previous diagnosis, would be more likely to respond to advertising for participants in a study such as this.

An area that was not examined in the current study was that of intensity of ADHD symptomology in association with severity of mood or attention problems. While this has been an area of investigation in a limited number

of past studies it is difficult to operationalize symptom severity using DSM-IV diagnostic criteria. The A-ADDES used as an assessment instrument in the current study does allow some limited estimation of symptom severity. However, we noted a ceiling effect that applied mainly to the ADHD-C group in that their impulsivity / hyperactivity scores were almost universally in the upper 5% range. Impulsivity scores for those assessed with ADHD-PI were more variable but often remained within a limited range. Inattention scores for both subtypes were also consistently high and were limited to the upper 15th percentile range on the A-ADDES. Alternate ADHD assessment tools may be more sensitive to symptom severity level and may be useful in studies which make use of ADHD subtype severity as a continuous variable.

Other limitations in the current study were also based on the types of measures used. While we were satisfied with the range and utility of the STAXI and STAI we noted that the BDI-II, although reliable and sensitive to recent depressed mood, does not measure long term depression tendencies, or what might be referred to as state depression. In the current study we relied on historical information supplied by participants to evaluate their history of depressed mood. This information was not solicited but was voluntarily supplied by participants on a rather inconsistent basis.

With regard to attention measures, the current study was limited by a lack of a suitable instrument with which to measure sustained attention in the auditory domain. It may be that limitations in auditory attention between subtypes may be distinguishable if testing is sustained over extended periods of time. Although the PASAT has two additional trials that were not employed in the current study we note that each of these involves a

corresponding reduction in the interval between the presentation of the numerals. The additional stress of speeding up the presentation of the numerals is not comparable to sustained attention. In order to measure sustained attention the demand task remains consistent and is merely extended over time.

The current study has attempted to fill in gaps in existing research; however, a number of possible avenues of investigation remain open. The first might be that of examining age-related effects of ADHD symptomology in adults. This may involve a closer look at age-related depression or anxiety or an interaction between the two. In this context it may be useful to examine gender differences in moods with age as a covariate. Another possibility would be to examine family history of mood or anxiety problems in order to determine the possible origin of the increased anxiety seen in ADHD in general and depressed mood in the ADHD-C subtype. Of course, longitudinal research regarding mood associations in ADHD would provide very valuable information regarding the origin of mood differences in ADHD. Finally the complex and expensive job of unraveling the role of serotonin in ADHD may require assays of metabolites of various neurotransmitters in individuals with varying combinations of ADHD subtype and associated mood or anxiety syndromes. In connection with this, various types of studies could be designed to determine the usefulness of selective serotonin reuptake inhibitors (SSRI's) in treating a number of symptoms associated with ADHD in adults.

With regard to cognitive processing in adults with ADHD we have already mentioned the possibility of examining everyday attention processing

in more environmentally rich settings. Such research would be difficult to design but may yield valuable insights. Another needed avenue of investigation is to determine if the observed differences in what is referred to as “cognitive tempo” between ADHD-PI and ADHD-C is related to any particular process or some as yet undiscovered factor related to arousal. Finally there may be some value in determining if specific learning styles are related to specific ADHD subtypes. Learning styles as they are commonly used relate to auditory, visual, and kinesthetic learning.

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APPENDIX A

**Adults with Attention Deficit
Disorder**

*A U of C Clinical Psychology Student is conducting research
into Adult ADD which you can be a part of by investing about
1-1.5 hours of your time*

We are investigating emotions associated with ADD and ADHD

*We are also investigating visual and auditory attention
associated with ADD and ADHD*

*(please note that your participation in this research does not in
any way influence the service that you receive from the
Disability Resource Centre)*

If you are interested please fill out one of the slips below

.....

APPENDIX B

Demographic Information Sheet

ID Number (Code): _____ Gender: _____

1. What is your Date of Birth ____/____/____/ (month/day/year)

2. What is your highest level of education ?

3. Are you currently taking any prescription medications ? Yes___ No___

if yes what medication(s) _____

4. Have you ever been diagnosed with: (please circle those that apply)

Schizophrenia Multiple Sclerosis Epilepsy Fibromyalgia

Spina Bifida Autism, Asperger's or Rett's Disorder

Any disorder that has affected your ability to work or attend school on a regular
basis _____

Any other known disorder that affects neurological functioning

5. Have you ever suffered a head injury with loss of consciousness ?

If yes, when and how did it occur and what was the length of unconsciousness ?

Comments: _____

APPENDIX C

CONSENT FORM FOR THE STUDY OF ADULT ADHD

Title: Differences in Adult ADHD Subtypes based on Comorbidities and Attention Processes

Investigators: Bradley Dye, M. Sc. Clinical Psychology Student, Bonnie Kaplan, Ph.D.

This consent form is only part of the process of informed consent. It should give you the basic idea of what the research project is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

Attention-Deficit Hyperactivity Disorder (ADHD) is a common childhood behavioral disorder which recent evidence suggests continues into adulthood in about two-thirds of cases. ADHD can be further divided into a primary subtype which includes problems of impulsivity and inattention and a secondary subtype which features difficulties with inattention only. Both subtypes often co-occur with other emotional difficulties and it is the purpose of this study to uncover which types of emotions are associated most strongly with each of the two subtypes of ADHD. A second aspect of this study is intended to determine the types of visual and auditory attention problems that are most strongly associated with each of the two subtypes of ADHD.

Participation in this study requires approximately two hours of your time. You will be asked to answer questions with regard to your experience of ADHD and additionally, either a member of your family or a fellow worker or associate of your choice will be asked to answer similar questions about your ADHD behaviors. You will also be asked to fill out three short questionnaires regarding your emotions. In the second phase, which may be completed at a separate time, you will be asked to complete a simple paper and pencil task that takes about 7 minutes. Finally, you will be asked to complete a task which requires the recall and addition of single digit numbers that are provided to you on a prerecorded tape. This final task takes about 30 minutes.

You will be assigned a code number, and all of the data that we collect will be identified only with that code and not your name. Only the investigators will have access to the data. If the results of this study are published only group data will be

used and the names of individual participants will not appear.

We do not believe that participation in this study will be harmful to you, nor do we believe that participation will provide any individual benefit to you. Your participation in this study is a selfless contribution to scientific research. However, we do believe that your participation will assist in providing a greater understanding of ADHD which may lead to improved treatment and delivery of mental health services.

Your participation in this study is completely voluntary. If you do not want to participate in this study, or if you decide part-way through that you want to stop, you are certainly free to do so.

In the event that you suffer injury as a result of participation in this research, no compensation or treatment will be provided to you by the University, the Calgary Regional Health Authority, or the Researchers. You still have all your legal rights. Nothing said here about treatment or compensation in any way alters your right to recover damages.

Your signature on this form indicates that you have understood to your satisfaction the information regarding your participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time without jeopardizing your health care. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation. If you have further questions concerning matters related to this research, please contact Brad Dye at 220-5568 or 289-7946 or Dr. Bonnie Kaplan at 229-7365. If you have any questions concerning your rights as a possible participant in this research, please contact the Office of Bioethics, University of Calgary at 220-7990.

Participant

Date

Investigator

Date

Witness

Date

A copy of this consent form will be given to you. Please keep it for your records and future reference.