Adults with Attention-Deficit/Hyperactivity Disorder: 
A Study of Neuropsychological, Psychological, 
And Functional Outcomes

Roberta Dobson-Patterson
B. Psy (Hons) Griff

School of Psychology
Faculty of Health
Griffith University

Submitted in fulfilment of the requirements of the degree of 
Doctor of Philosophy in Clinical Psychology

September 2010
Abstract

Attention-Deficit/Hyperactivity Disorder (AD/HD) is now recognised as a chronic condition that continues into adulthood. A great deal of research has been done to validate the diagnosis in adults, but studies of the neuropsychological, psychological and functional outcomes of adults with AD/HD have been inconsistent. In addition, there is an assumption that underlying neurological deficits are responsible for the poor functional outcomes found among adults with AD/HD, yet this association has not been demonstrated empirically.

Sixteen adults with AD/HD, Inattentive subtype, 16 adults with AD/HD, Combined subtype, and 30 control adults matched to the AD/HD adults by gender, age, years of education and estimated IQ were compared on a battery of attention, memory, and executive functioning tests. A number of methodological changes were made in an attempt to address the limitations of previous studies, and to characterise adult AD/HD more accurately. In addition all participants completed self report inventories of depression, anxiety, stress, social, vocational, family/home, and financial functioning. The relationships between variables were examined to determine whether neuropsychological deficits are related to functional outcomes in the AD/HD group.

The Inattentive subtype group was found to be poorer in focused attention, verbal memory, visual memory, depression, anxiety, stress and social functioning. The Combined subtype group was found to be poorer in verbal memory, response inhibition, anxiety, stress, and financial functioning. Neuropsychological test performances better predicted AD/HD status than did psychological variables. For the AD/HD group as a whole, psychological variables best predicted social and vocational functioning, while both psychological and neuropsychological variables predicted family/home and financial functioning. The results indicated that the subtype groups were substantially
different to each other in their neuropsychological performance profiles, which supports the contention that the two subtypes are separable diagnoses. However, the results also indicated some overlap between the subtypes on verbal memory test performance, and on self-reported symptoms of anxiety and stress. The results also suggest that adults with AD/HD are best characterised in terms of their underlying neurological deficits, and not psychological factors, such as depression, anxiety or stress.

These findings partially support the contention of researchers and clinicians that the neurological deficits of AD/HD predict difficulties with day to day functioning. However, it was shown that psychological factors also predict day to day functioning. The implications of the findings are that individuals with Inattentive subtype AD/HD may require specialised assessment and treatment, the focus of which may be quite different to that needed for the Combined subtype group, who have traditionally been the focus of most treatment studies. The findings also imply that researchers need to specify and compare subtype groups in their studies of adults with AD/HD to best characterise adult AD/HD attributes and difficulties. The findings indicate that the remediation of neurological deficits is as important as the treatment of mood and anxiety symptoms in this population. Finally, the findings of this study imply that the treatment and remediation of both neurological and psychological problems are necessary to ensure that adults with AD/HD are able to function at a level commensurate with other adults in the community.
This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

______________________________
Roberta Dobson-Patterson
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Acknowledgements

I would like to acknowledge and thank a number of people who made it possible for me to carry out this research. Firstly, Professor David Shum, whose support, patience and guidance was unfailing from the beginning, right through to the end. He enabled me to indulge my passion for the project and to realise both my personal and professional dreams, and for this I am humbly grateful.

Professor John O’Gorman made a significant contribution to this thesis, both in the early thinking and design of the project, and in influential comments on a later draft. His incisive thinking about conceptual design has been invaluable.

Veronica Conners, Professor Geoff Mitchell (UQ), and Dr Brian Ross were invaluable in assisting me to recruit participants. All instinctively understood how difficult recruitment would be in Brisbane, given the lack of awareness among professionals, and were quick to lend their support to the project out of generosity and dedication to the standards of their professions.

I especially owe a large debt of gratitude to the participants who volunteered for this study, who gave generously of their time and were so positive and supportive. Thanks also go to the members of the Adult AD/HD support group under the umbrella of ADDAQ (ADD Association of Queensland), and their friends and relatives, who also gave generously of their time, and who patiently helped me to gain some understanding of their world.

My husband Ian has been unfailing in his support, and has shown me what it means to be truly generous in your love. My children Ana and Andrew, who have had to endure a mother whose attention was often focused on her research, have also been unselfish in encouraging me and cheering me on during difficult times. I was also very blessed to have my good friend Louise, who many times had to sit me down and convince me of the importance of this project when I was ready to give up.

Finally, this dissertation is dedicated to the generation of misunderstood, misdiagnosed and often maligned adults with AD/HD who have made their way in the world despite the odds, and who continue to inspire me with their enormous courage and resilience.
Chapter One

Background to the Study

Attention-Deficit/Hyperactivity Disorder (AD/HD) is a complex condition that is defined as impairment in a person’s ability to regulate attention and/or behaviour in more than one setting (American Psychiatric Association, 2000). Research has demonstrated that it is a condition that predisposes individuals to a wide range of serious functional difficulties in many domains, and for most, it continues throughout their lifetime. Researchers have investigated the extent to which these impairments continue to adulthood and what form they take, and some tentative conclusions have been advanced. However in many instances, more research is needed to answer these questions well enough to inform treatment approaches.

The recognition of AD/HD in adulthood was first suggested by five longitudinal studies that retained 50% or more of their sample to adulthood (Barkley, Fischer, Smallish, & Fletcher, 2002; Biederman et al., 1998; Hart, Lahey, Loeber, Applegate, & Frick, 1995; Mannuzza, Klein, Bessler, Malloy, & LaPadula, 1993; Weiss & Hechtman, 1993). Occurring parallel to this research was the growth of consumer demand for treatment of childhood AD/HD by parents, who often sought treatment from clinicians for their own symptoms, as well as those of their children. Once the methodological limitations of the longitudinal studies were addressed, it became apparent that the disorder did not always remit at adulthood. In 2000, the American Academy of Pediatrics published new treatment guidelines for AD/HD, with the primary recommendation that treating physicians establish a management program recognising AD/HD as a chronic condition (2000).
First identified in 1902, the validation of AD/HD as a disorder was subjected to the progression (and limitations) of each decade’s knowledge of psychology, medicine, education, biology and neuroscience. In 2002 researchers from a number of countries issued an International Statement of Consensus about the disorder (Barkley, 2002). For a detailed account of the history of AD/HD, see Barkley (2006) or Doyle and Doyle (2004). According to Barkley (2006), AD/HD is best conceptualised as:

a mature disorder and topic of scientific study, widely accepted throughout the mental health and pediatric profession as a legitimate developmental disability. At this time, it is unmistakably one of the most well-studied childhood disorders; it is also the object of healthy, sustained research initiatives into its adult counterparts, which should eventually lead to as widespread an acceptance of adult AD/HD as has occurred for the childhood version of the disorder. (p. 39)

Changes to the name and defining features of the disorder in the various editions of the Diagnostic and Statistical Manual of Mental Disorders (DSM) over time have reflected the context, viewpoints and research focus of each era, and represent a historical depiction of the prevailing trends in psychiatry and psychology at each point. Since the 1990s change has been rapid, and the current definition of the disorder under the DSM-IV-TR (American Psychiatric Association, 2000) describes three subtypes. Researchers agree that these are neurobiologically and behaviourally distinct from one another, making individuals with the diagnosis a heterogeneous group (Rohde, 2008). Symptom descriptions often describe child-like behaviours that are difficult to apply to adults in adult settings. The diagnosis, however, can be applied to adults under DSM-IV-TR rules. Table 1 depicts the DSM-IV-TR criteria for AD/HD (American Psychiatric Association, 2000).
Table 1

**DSM-IV-TR Criteria for Attention-Deficit/Hyperactivity Disorder**

A. Either (1) or (2):

1. six (or more) of the following symptoms of inattention have persisted for at least six months to a degree that is maladaptive and inconsistent with developmental level:
   
   **Inattention**
   
   (a) often fails to give close attention to details or makes careless mistakes in schoolwork, work, or other activities
   
   (b) often has difficulty sustaining attention in tasks or play activities
   
   (c) often does not seem to listen when spoken to directly
   
   (d) often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions)
   
   (e) often has difficulty organizing tasks and activities
   
   (f) often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework)
   
   (g) often loses things necessary for tasks or activities (e.g., toys, school assignments, pencils, books, or tools)
   
   (h) is often easily distracted by extraneous stimuli
   
   (i) is often forgetful in daily activities

2. six (or more) of the following symptoms of hyperactivity-impulsivity have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level:

   **Hyperactivity**
   
   (a) often fidgets with hands or feet or squirms in seat
   
   (b) often leaves seat in classroom or in other situations in which remaining seated is expected
   
   (c) often runs about or climbs excessively in situations in which it is inappropriate (in adolescents or adults, may be limited to subjective feelings of restlessness)
   
   (d) often has difficulty playing or engaging in leisure activities quietly
   
   (e) is often “on the go” or often acts as if “driven by a motor”
   
   **Impulsivity**
   
   (f) often talks excessively
   
   (g) often blurts out answers before questions have been completed
   
   (h) often has difficulty awaiting turn
   
   (i) often interrupts or intrudes on others (e.g., butts into conversations or games)

B. Some hyperactive-impulsive or inattentive symptoms that caused impairment were present before age 7 years.

C. Some impairment from the symptoms is present in two or more settings (e.g., at school [or work] and at home).

D. There must be clear evidence of clinically significant impairment in social, academic, or occupational functioning.

E. The symptoms do not occur exclusively during the course of a Pervasive Developmental Disorder, Schizophrenia, or other Psychotic Disorder and are not better accounted for by another mental disorder (e.g., Mood Disorder, Anxiety Disorder, Dissociative Disorder, or a Personality Disorder).
For individuals (especially adolescents and adults) who currently have symptoms that no longer meet full criteria, “In Partial Remission” should be specified.


**Similarities and Differences between Child and Adult AD/HD**

There are more similarities than differences when comparing children with AD/HD to adults with AD/HD. Both children and adults show similar cognitive and neuropsychological profiles, with difficulties in attention, response inhibition, memory and executive functioning (Hervey, Epstein, & Curry, 2004; Seidman et al., 2004; Woods, Lovejoy, & Ball, 2002). They exhibit similar difficulties in psychological functioning, with low frustration thresholds, labile moods, chronic irritability and comorbid depression, anxiety, and conduct disorders (Ellison, 2002). Finally, both groups share similarities in outcome measures, achieving lower educational levels, underachieving in academic and occupational settings, demonstrating chronic impulsivity, and exhibiting deficits across the social, educational and occupational domains (Biederman, et al., 1998; Mannuzza & Klein, 1999).

Adults with AD/HD have higher rates of comorbidity than children, with Antisocial Personality Disorder, depression, substance use and anxiety the most common (McGough et al., 2005). Much of this information is based on studies of self-referred adults and clinically referred adults first diagnosed in adulthood. This population seems to exhibit lower conduct disorder rates and higher intelligence and educational achievement levels than their child counterparts (Barkley, 2006).
The Development of Adult AD/HD

Three main factors that moderate the impact of AD/HD on child development have been identified. The first is child-specific, and includes variables such as AD/HD symptom severity, the presence of comorbid disorders, and the child’s intellectual capacity. The second relates to family environment, and includes variables such as socio-economic status, parents’ divorce and/or separation, parental psychopathology, alcoholism, family cohesion, and parental support. The third factor is treatment specific, with a multimodal treatment program combining several treatment options such as appropriate medication, family/parenting training, school accommodation, and behavioural and psychosocial intervention predicting the best adjustment over time (Ellison, 2002).

Epidemiology of Adult AD/HD

Prevalence. It is estimated that 30% to 70% of children diagnosed with AD/HD continue to be impaired in adulthood (Barkley, Fischer, Edelbrock, & Smallish, 1990; Spencer et al., 1998). This wide range is due in part to the variation in diagnostic criteria used (Wolf & Wasserstein, 2001). For instance, when persistence of symptoms into adulthood was defined by meeting full criteria, Faraone, Biederman and Mick found 15% at age 25 (2006). However when persistence of symptoms into adulthood was defined to include those in partial remission (those with symptoms but not enough to meet full criteria) the percentage increased to 60% (Faraone, Biederman, & Mick, 2006).

A worldwide prevalence of 3.4% for adult AD/HD has been estimated from data collected in 10 countries in the Americas, Europe and the Middle East (Fayyad et al., 2007). The World Health Organization estimated a base rate of 4.4% for adult AD/HD in a population survey utilising a screen for adult AD/HD in a probability
subsample (N=3,199) of 18-44-year-old respondents in the USA. This nationally representative household survey used a lay-administered diagnostic interview to assess a wide range of DSM-IV-TR disorders (Kessler et al., 2006).

**Gender.** Kessler and colleagues (2006) reported a 1:6 female-male ratio in adults with AD/HD. This was based on a sample of 3,199 18 to 44 year olds. This is comparable to the gender ratio found in studies of children and adolescents, and suggests that there are no gender difference changes in the persistence of AD/HD into adulthood (Biederman, Faraone, Monuteaux, Bober, & Cadogen, 2004).

**Culture.** There has been some debate as to whether AD/HD is best seen as a biological or cultural construct. Rohde and colleagues (2005) demonstrated that in Brazil, prevalence rates, comorbidity, genetic data and treatment outcome statistics are all very similar to the findings from more highly developed countries. Dwivedi and Banhatti (2005) reviewed the literature based on AD/HD and culture. They concluded that although different cultures attach different levels of significance to AD/HD behaviours, once consistent assessment criteria are applied prevalence rates are similar. Polanczyk and colleagues (2007) reviewed 102 studies and surveys from North America, Europe, Africa, Asia, Oceania and the Middle East, using a multivariate meta-regression model. They observed that geography played a limited role in AD/HD prevalence variability, and concluded that worldwide variability was explained by methodological differences. Roessner and colleagues (2007) compared German and Brazilian clinically-referred children with AD/HD and demonstrated similar profiles using one behavioural measure across both populations. Published studies of AD/HD in children and adults have originated from the following countries: Australia, Brazil, Canada, China, Colombia, Finland, Germany, Hong Kong, Iceland, India, Israel, Japan,
The Netherlands, New Zealand, Spain, Sweden, Taiwan, The Ukraine, United Kingdom, and the United States (Faraone, Sergeant, Gillberg, & Biederman, 2003).

**Socio-economic status.** McGough and colleagues (2005) studied adult AD/HD in a large, nonclinical group. Their sample, parents of previously identified AD/HD children who met study criteria for AD/HD, had lower educational and occupational achievement than those who did not meet AD/HD criteria. Rieppi and colleagues (2002) demonstrated that family educational level (but not necessarily family socio-economic status) impacted upon child treatment outcomes. A combined regimen of medication and behavioural treatments was found to be more effective for highly educated families than for families with lower educational attainment. Lasky-Su and colleagues (2007) examined the relationships between socio-economic status, pertinent genetic polymorphisms, and AD/HD symptoms, and found evidence suggesting that socio-economic status may modify AD/HD symptoms. As they observed, this may not be surprising given that low levels of socio-economic status are associated with lower income and decreased health care, which are related to low birth weight. The incidence of low birth weight has been associated with a three-fold increase in the incidence of AD/HD (Mick, Biederman, Prince, Fischer, & Faraone, 2002).

**Intelligence.** A meta-analytic review of 18 studies representing 1,031 adults with AD/HD and 928 non-AD/HD, nonclinical comparison adults using the WAIS Full Scale IQ scores (FSIQ) demonstrated that AD/HD adults scored lower than controls by an average of 2.94 points, a difference not considered clinically meaningful. A closer examination of these differences showed that studies utilising participants first diagnosed in childhood obtained lower FSIQs in AD/HD adults than studies that did not specify this criteria. In addition, comorbidities in the AD/HD groups appeared to account for lower FSIQ, as AD/HD adults without comorbidities achieved FSIQs
comparable to controls. Finally, studies that matched the AD/HD and control groups for education level found no differences in FSIQ (Bridgett & Walker, 2006).

**Comorbidity.** Comorbidity refers to the extent that other psychiatric disorders co-occur with AD/HD beyond that expected by chance alone, or beyond the base rates of other disorders in the general population. Studies show that adults with AD/HD have higher rates of comorbidity than children with AD/HD. Table 2 lists the comorbid disorders most commonly found in clinically referred adults with AD/HD in previous studies. The high frequencies reported may have been related to referral bias, as they were different from the rates from the longitudinal studies that followed diagnosed individuals from childhood. In some cases, such as Oppositional Defiant and Conduct Disorder, reported levels in clinically-referred adults were lower than those in the longitudinal studies, and in other cases, such as Generalized Anxiety Disorder, clinically-referred adult case rates were higher than those found in the longitudinal studies (Barkley & Gordon, 2002).

Table 2

*Rates of Comorbidity Found in Clinically-Referred Adults with AD/HD*

<table>
<thead>
<tr>
<th>Comorbid Disorder</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oppositional Defiant Disorder 1,2</td>
<td>24-35%</td>
</tr>
<tr>
<td>Conduct Disorder 1,2</td>
<td>17-25%</td>
</tr>
<tr>
<td>Antisocial Personality Disorder 1,3</td>
<td>7-18%</td>
</tr>
<tr>
<td>Alcohol Dependence/Abuse 1,2,3</td>
<td>32-53%</td>
</tr>
<tr>
<td>Other Substance Dependence/Abuse 1,2,3</td>
<td>8-32%</td>
</tr>
<tr>
<td>Generalized Anxiety Disorder 1,2,3</td>
<td>24-43%</td>
</tr>
<tr>
<td>Major Depression 1,2</td>
<td>16-31%</td>
</tr>
<tr>
<td>Dysthymia 2,3</td>
<td>19-37%</td>
</tr>
<tr>
<td>Obsessive-Compulsive Disorder 3,4</td>
<td>4-14%</td>
</tr>
</tbody>
</table>

*Note.* Percentages above are taken from the following published studies:
1 Biederman, et al., 1993
2 Murphy & Barkley, 1996
3 Shekim, Asarnow, Hess, & Zaucha, 1990
4 Roy-Byrne et al., 1997
Overall, the comorbidity studies suggest that AD/HD is a general risk factor for mood and anxiety disorders, as well as disruptive behaviour disorders (McGough, et al., 2005). In addition, problems in the regulation of sleep and arousal appear to be an important feature of AD/HD, with a greater variability in sleep patterns, difficulty in falling asleep, and in awakening (Brown & McMullen, 2001). The differential diagnosis of sleep-arousal disorders and AD/HD is important, because of the possibility of a sleep disorder being misdiagnosed as AD/HD, or the possibility of a comorbid sleep disorder being missed (Ball, Wooten, & Crowell, 1999). Ellison reported that motor problems continue into adulthood for many children with AD/HD, specifically hyperactivity, restlessness, difficulties in playing sports, and handwriting difficulties (Ellison, 2002).

Greater impulsivity and risk-taking found among adolescents with AD/HD in the areas of driving behaviour and sexual behaviour has also been found among clinic-referred adults with AD/HD, although to a lesser extent than adolescents. This supports research demonstrating that individuals with AD/HD carry a greater risk of accidents and disease (Barkley & Gordon, 2002). Barkley and other researchers have suggested that this population may not adequately care for themselves physically and mentally, in terms of their physical condition, health consciousness, nutrition, hygiene, and efforts at disease prevention, and thus may predispose themselves to greater risk of cardiovascular disease and reduced life expectancy (Barkley & Gordon, 2002; Pagoto et al., 2009).

To summarise, the prevalence of adult AD/HD in the population is similar to that of childhood AD/HD, and the gender ratio in adults is similar to that of the child AD/HD population. Both developed and developing countries report the presence of the disorder across many disparate cultures, and despite differences in the definition of the disorder between diagnostic systems. Socio-economic status appears to be
implicated more in treatment outcomes rather than in occurrence of the disorder. It appears that any disadvantage in intelligence levels in the adult AD/HD population (as measured by FSIQ scores) may be attributable to comorbid conditions. This point is important because adults with AD/HD demonstrate significant levels of comorbidity for several serious psychiatric disorders.

**Aetiology of AD/HD**

**Genetics of AD/HD.** AD/HD is a highly heritable disorder, demonstrated by studies utilising family, twin, adoption, molecular genetics, and behavioural genetic methodologies. Family studies have found that parents of AD/HD children have a two-to eight-fold increase in risk for AD/HD. Twin studies of AD/HD comparing monozygotic twins to dizygotic twins have attributed about 80% of the aetiology of AD/HD to genetic factors (Faraone, 2004b; Levy, Hay, & Bennett, 2006). Adoption studies have demonstrated that, firstly, adoptive relatives of AD/HD probands had rates of AD/HD similar to the base rate in the population, and secondly, that biological relatives of AD/HD probands had significantly higher rates of AD/HD than the base rate (Faraone, 2004b; Sprich, Biederman, Crawford, Mundy, & Faraone, 2000). Two methodologies used in molecular genetics, the genome scan and the candidate gene approaches, have identified particular candidate genes, both through scanning for linkages and through focussing on genes theoretically implicated by the large pharmacological literature base on AD/HD. These include DRD4, the D4 dopamine receptor gene, DAT1, the dopamine transporter gene, and DRD5, the dopamine D5 receptor gene (Faraone, 2004b; Fisher et al., 2002; Levy, et al., 2006).

The Australian Twin AD/HD Project has shown that genetic influences in AD/HD vary at different stages of development (Hay, McStephen, & Levy, 2001). Although much of the consistency in behaviour during childhood and early adolescence
is due to genetic influence, some of the data suggest that there may be families where the children grow out of AD/HD at adolescence, children whose fathers (or mothers) also followed a similar developmental pattern. Behavioural genetic studies suggest that the persistent form of AD/HD is familial and is more familial than the non-persistent form. This finding could be due to rater bias, in that parents of AD/HD children become more sensitised to AD/HD symptoms in themselves after rating their own children. The possibility of bias in self-report of AD/HD symptoms in parents of children with AD/HD, as opposed to those who did not have children with AD/HD, was investigated by Frick and colleagues. They found no differences between the groups of parents, either in the number of symptoms reported or in the pattern of symptoms (Frick, Lahey, Christ, Loeber, & Green, 1991). Two reviews of genetic studies of AD/HD have shown that the persistent type of AD/HD appears to be more genetically based than the nonpersistent type (Faraone, 2004b; Levy, et al., 2006).

To summarise, behavioural genetic studies using family, twin and adoption methodologies converge with the molecular genetic studies in demonstrating that genes influence susceptibility to AD/HD. Several genes have been implicated, suggesting that the genetic mechanisms predisposing individuals to AD/HD are complex, and are likely to be caused by the combined actions of several genes. However this vulnerability may not be expressed in all environments, and at present it is not known why.

**Risk factors.** Several factors, both common and uncommon, have been investigated as potential risk factors for AD/HD. The less common factors include low birth weight, prenatal alcohol exposure, pre-natal nicotine exposure, pre- and post-natal lead exposure, exposure to other toxins, and early trauma and attachment problems. Common factors are those that may operate powerfully in the population, yet may be
undetected in behavioural genetic studies. These include diet, exposure to electronic media such as computers and TV, and environmental toxins (Nigg, 2006).

**Risk for AD/HD from uncommon factors.** Although studies of low birth weight and AD/HD have a number of important methodological limitations (such as measurement, definition and sampling issues), they suggest that low birth weight may confer a doubling of risk for AD/HD, and that these children may also have motor delays or motor control problems (Nigg, 2006). A number of studies have been conducted investigating the effects of lower-level alcohol exposure during pregnancy. Taken together, the neuropsychological studies in this area suggest that although there may be some parallels in cognitive deficits between the AD/HD and fetal alcohol syndrome groups, their profiles do differ, especially in severity of deficit, with AD/HD more severe (Coles et al., 1997). An association between prenatal exposure to nicotine and AD/HD has been demonstrated, even after controlling for parental AD/HD, Conduct Disorder, low birth weight, and other confounding factors. What remains to be answered, however, is the size of the effect (e.g., the relative risk), and the relative effect of genetic influence (Nigg, 2006).

The recommended safe level of exposure to lead from contaminated house dust, soil and water has been progressively lowered as studies have found even the lowest exposures have dramatic effects on children’s health. Even at lower levels of exposure, cognitive delays, attention problems, executive function difficulties and impulsivity have been found to be associated with lead exposure in children. Because the exposure to lead is so widespread throughout the population, it is plausible that even if the risk for AD/HD is low, it could represent a substantial risk factor for AD/HD (Nigg, 2006). Extreme psychological trauma early in life may cause an AD/HD syndrome involving heightened activity and impulsivity (Glod & Teicher, 1996), while early trauma may
also disrupt neural development, affecting self-regulatory systems through the altered development of the hippocampus, amygdala, and prefrontal cortex (Teicher et al., 2003).

Risk for AD/HD from common factors. Two potential factors show promise as possible contributors to AD/HD symptomatology: 1) dietary shortages of omega-3 fatty acids; and 2) the role of organophosphate pesticide residues in food. The first has the support of one controlled double-blind intervention trial in AD/HD children (Richardson & Puri, 2002), while the second has support from animal studies linking early exposure to animal models of hyperactivity. Thus both possibilities have promise, but no strong research base at present (Nigg, 2006). Initial exploratory studies showed potential links between early television viewing and symptoms of inattention and overactivity. However any link between AD/HD and early television viewing is unknown at present, due to methodological limitations (Christakis, Zimmerman, DiGiuseppe, & McCarty, 2004; Nigg, 2006).

Human and animal studies both suggest that low-level, background exposure to PCBs and related contaminants may disrupt development in executive functions such as working memory and reinforcement response. However, methodological limitations preclude a clear understanding of their possible contribution to AD/HD symptomatology (Nigg, 2006). In summary, prenatal exposure to alcohol and cigarettes, low birth weight, and postnatal exposure to lead may contribute to problems that include AD/HD symptoms. These factors may contribute to a small percentage of AD/HD diagnoses, but at present this percentage estimate is not known. More widespread factors such as diet, television exposure and environmental toxins have proved difficult to study, but may be important focuses of research in the future when
considering the many factors which may contribute to the aetiology of AD/HD, either as an additive effect to genetic predisposition, or on their own (Nigg, 2006).

**Neurology of AD/HD: brain imaging.** Neuroimaging of adults with AD/HD is a new area of research. While there are at least 27 published reports of structural neuroimaging using magnetic resonance imaging (MRI) in children with AD/HD from more than twelve research groups (Seidman, Valera, & Makris, 2005), there are few studies of adults (Hesslinger et al., 2002; Schneider et al., 2010; Seidman et al., 2006). Theories of AD/HD have suggested that it involves structural and functional brain abnormalities in frontal-striatal circuitry (Castellanos, 1997; Faraone, 2004a; Tannock, 1998). A meta-analysis of imaging studies provides support for this hypothesis, however other work suggests that the brain is altered in a more widespread manner than was previously suggested (Schneider, et al., 2010; Seidman, et al., 2006). Well replicated findings on children with AD/HD have demonstrated significantly smaller volumes in the prefrontal cortex, caudate, splenium of the corpus callosum, cerebellum, and in overall cerebral volume. Studies of adults with AD/HD have found significant reductions in the left orbitofrontal cortex (Hesslinger, et al., 2002), in the volume of the anterior cingulate cortex and the prefrontal cortex, and in overall cortical gray matter (Schneider, et al., 2010; Seidman, et al., 2006).

**Event related potential.** Event related potential (ERP) studies rely on repeated measurements of electrophysiological responses to stimuli by the use of EEG to measure electrical activity in the brain. The ERP represents the brain’s response to unpredictable stimuli, and the P300 (or P3) is a positive deflection in voltage that occurs approximately 300 milliseconds after the stimuli are presented. The P300 is understood to reflect a higher cognitive response to unexpected and/or cognitively salient stimuli, or in other words, it represents expectation or attention (Verleger, 2003). One theory of AD/HD postulates that these individuals have altered motivational processes (Sonuga-
Barke, 2002), or a suboptimal motor activation state (Sergeant, Geurts, Huijbregts, Scheres, & Oosterlaan, 2003). This means that individuals with AD/HD have insufficient effortful control and are unable to respond appropriately to stressors such as the ability to allocate extra effort to maintain their attention to stimuli presented at a slow rate. In general children with AD/HD have demonstrated an associated P300 amplitude with a performance decline in slow event rate conditions (Wiersema, van der Meere, Roeyers, van Coster, & Baeyens, 2006). Only one study has looked at adults with ADHD using a similar methodology. In that study these results were replicated in adults (Wiersema, Van der Meere, Antrop, & Roeyers, 2006).

**EEG.** Electroencephalography (EEG) measures the association between intracranial electrical currents and associated voltages on the scalp which reflect certain facets of brain electrical functioning and processing, such as response to stimuli and tasks. Early EEG studies on children with AD/HD demonstrated abnormalities such as excess slow-wave activity, and epileptiform spike and wave activity. These EEG abnormalities have been shown to occur across the lifespan in AD/HD samples (Loo & Barkley, 2005). Cross-sectional design research has shown that theta (slow-wave) activity remained elevated across all age groups, while the characteristic beta activity reduction in AD/HD children diminished with age, so that adults with AD/HD did not differ from controls (Bresnahan, Anderson, & Barry, 1999). Thus adults with AD/HD were thought to differ from their non-AD/HD counterparts by demonstrating elevated theta (slow-wave) EEG activity, a finding that was replicated in a later study (Bresnahan & Barry, 2002).

**Summary: Background to the Study**

AD/HD is one of the most studied childhood conditions. However, not much is known about its expression in adulthood, information that is important for individuals
with the disorder, for the clinicians treating them, and for society at large. The study of
adult AD/HD has been limited by frequent changes to the definition of the disorder, by
inconsistent diagnostic protocols in research studies, and by a lack of agreement among
researchers on the most pertinent variables to study. There has been uncertainty about
symptom remission, about the similarities and differences between the subtypes, and
about what to expect later in life as children with AD/HD pass through normal stages of
development with dysfunctional neurological systems, limited skill sets, and a history of
failure. There is a need to understand why comorbid disorders appear to increase with
age, and what can be done about changing that outcome. AD/HD theory will be
incomplete without an appreciation of its effects over the lifespan.

The study of adult AD/HD is critical to inform child treatment, but is equally
important for the present generation of adults who have not had the benefit of early
diagnosis and treatment during their formative years. It is imperative to find out
whether diagnosis and treatment in adulthood is “better late than never”. There is not
enough known at present to justify treating adults with AD/HD as larger versions of
their childhood selves. Although adult AD/HD it is somewhat uncommon, it is
prevalent enough that medical and mental health professionals, as well as the patients
themselves, need to understand how best to recognise, manage and treat it, and to
differentiate it from other medical, psychiatric or behaviour disorders. Finally, it is
unknown whether the disorder confers any advantages, as research has traditionally
investigated only the negative impacts of AD/HD. The following chapter will examine
the reasons for AD/HD symptoms, how these symptoms develop over an individual’s
lifetime, and what implications these have for AD/HD theory. This will be done
through a comprehensive review of the existing literature, focussing on three main areas
of study: neuropsychological, psychological and functional outcome studies.
Chapter Two

Literature Review

In this chapter, three areas of study relating to adults with AD/HD will be reviewed. They include neuropsychological, psychological and functional outcome studies, with a focus on the main findings and limitations of these three areas. This body of research has developed in an attempt to understand how AD/HD develops over an individual’s life, but also to test or build upon theories of AD/HD. The chapter will conclude with a summary of the key research issues in the area, and a justification and aims of this thesis.

Theories of AD/HD

A number of theories have been advanced to explain the behavioural symptoms of AD/HD, and most have focussed on underlying factors such as deficient inhibitory control (Barkley, 1997a), state regulation deficits (Sergeant, 2000), or reinforcement-response abnormalities and motivational deficits (Sagvolden, Aase, Johansen, & Russell, 2005). Two models of AD/HD had been suggested prior to these. Quay (1988) used Gray’s neuropsychological model of anxiety to explain the origin of poor behavioural inhibition in AD/HD, arguing that the impulsiveness seen in AD/HD arises from an under-functioning behavioural inhibition system less sensitive to conditioned punishment stimuli than those of non-AD/HD individuals. Douglas (1972, 1999) suggested that self regulation deficiencies gave rise to deficiencies in four cognitive domains: 1) the poor investment and maintenance of effort; 2) a deficient modulation of arousal to meet situational demands; 3) a strong inclination to seek immediate reinforcement, and 4) difficulties with impulse control.
Barkley’s theory was based on Bronowski and Fuster’s work on the neuropsychological functions of the prefrontal lobes, and focussed on poor behavioural inhibition as the central deficiency in AD/HD (Barkley, 1997a). Four executive functions were considered to be dependent on behavioural inhibition for their own effective performance, and these executive functions in turn helped to regulate both goal-directed actions and task persistence. They included: 1) self regulation of affect/motivation/arousal; 2) internalization of speech; 3) working memory; and 4) reconstitution. These four executive functions, dependent on behavioural inhibition, predict difficulties for individuals with AD/HD. As a consequence of these deficiencies (or delays), individuals with AD/HD are controlled by the immediate context and its consequences more so than non-AD/HD individuals (Barkley, 1997a, 1999).

Sergeant’s Cognitive Energetic Model proposed that AD/HD deficits occur at three levels, the cognitive, energetic, and management system levels. The model encompasses both top-down and bottom-up information processing approaches. The first level proposes four general stages of attentional mechanisms: encoding, search, decision, and motor organization. These are associated with experimental task variables. The second level is comprised of three energetic pools: effort, arousal, and activation. The effort pool has been linked to the hippocampus and appears to both excite and inhibit the other two energetic pools, arousal and activation. The third level is the executive system, which is an overriding management system, associated with planning, monitoring, and detecting and correcting errors. These are associated with the prefrontal cortex (Sergeant, 2005; Sergeant, Oosterlaan, & van der Meere, 1999).

Sagvolden and colleagues (2005) advanced a dynamic developmental theory of AD/HD to describe two of its subtypes, Hyperactive/Impulsive and Combined. In their theory they argued for two main behavioural processes causing AD/HD symptoms, the
altered reinforcement of novel behaviour and the deficient extinction of previously reinforced behaviour. These are associated with a hypofunctioning mesocortical dopamine system, probably interacting with other hypofunctioning dopamine systems. These dysfunctional dopaminergic systems are believed to be caused by a combination of insufficient glutamate input from the prefrontal cortex to dopamine neurons, and the faulty regulation of dopamine release to these regions. Thus AD/HD behaviours such as impulsiveness and executive functioning difficulties are seen in this model as more fundamental motor problems, such as the timing of starting or stopping responses, the acquisition, retrieval and relearning of programs for sequential motor tasks, and deficient nondeclarative habit learning and memory (Sagvolden, et al., 2005).

These models and theories have had difficulty accounting for the heterogeneity that is recognised as the main obstacle in understanding AD/HD. Coghill and colleagues (2005) proposed that the identification of endophenotypes for AD/HD was crucial to understanding AD/HD. Endophenotypes are mediating factors that sit between the observed manifestations of a disease and its originating causes, and may be neuroanatomical, biochemical, neurophysiological, or neuropsychological in nature. Although many AD/HD endophenotypes have been identified in the research generated by these models (such as working memory and delay aversion), these are not necessarily specific to AD/HD, and remain contentious. It has been suggested that it may be far more useful to investigate potential neuropsychological, rather than behavioural, subtypes of AD/HD (Coghill, et al., 2005). Nigg (2006) observed that investigating AD/HD at the neuropsychological level provides the most likely opportunity of a future breakthrough in establishing a causal mechanism or marker in AD/HD, and from there link this marker to etiological mechanisms.
Neuropsychological investigations have identified three broad areas of disability in adults with AD/HD: attention, memory and executive functions (Boonstra, Oosterlaan, Sergeant, & Buitelaar, 2005; Hervey, et al., 2004; Schoechlin & Engel, 2005; Seidman, et al., 2004; Woods, et al., 2002). These are believed to contribute to the psychological and functional difficulties of this population (Ellison, 2002; Young, 2002).

Research has also been conducted on the psychological conditions that accompany AD/HD in an attempt to extend theory and understanding, but also to try to evaluate treatment outcomes. Large scale treatment outcome studies have shown that early intervention with pharmacotherapy is crucial, but have also demonstrated that psychological factors play an important role and therefore require consideration (Jensen & Members of the M.T.A. Cooperative Group, 2002). It is possible that dysfunctional neurological systems in AD/HD contribute to difficulties in mood regulation which contribute to psychological difficulties (Drevets, Savitz, & Trimble, 2008). Because of this possibility, AD/HD symptoms cannot be considered separately from psychological states when examining the phenomenon of AD/HD (Young & Bramham, 2006).

Research on functional outcomes has also been conducted on adults with AD/HD, both to demonstrate the validity of the diagnosis (which rests upon impairment across settings), and to address the issue of how neuropsychological deficits manifest in day-to-day living. In order to comprehensively examine the literature on adult AD/HD, the following review is organised separately under three broad areas, neuropsychological research, psychological research, and functional outcomes research. These are reviewed separately due to the lack of overlap between these areas in the literature.
Neuropsychological Research in Adult AD/HD

Consistent with the presumed role of the frontal-subcortical systems in the expression of AD/HD, measures of attention and executive functioning have been the primary focus of studies in the area. There are theoretical reasons to disentangle attentional processes from executive processes. For example, Mirsky, Pascualvaca, Duncan, and French (1999) described a model of attentional functioning pertinent to AD/HD drawing upon the human epilepsy, lesion, and electrical brain stimulation studies, as well as animal model studies, and demonstrating that attentional processes originate in the subcortical regions such as the mesopontine brainstem reticular formation, the midline thalamus, and reticular nuclei of the thalamus. This centrencephalic system is believed to be the fundamental organising system for the maintenance of consciousness, arousal and attention, and the platform upon which other functions of attention would have developed through evolution. However, the neuropsychological tests used to measure and delineate these functions have also been shown to require the involvement of pathways connecting the prefrontal region to midline and brainstem regions, as well as the prefrontal regions themselves (Gallagher & Blader, 2001). Although it can be argued that on an anatomical basis attention and executive functioning are theoretically distinct, few mental operations exist which require the use of one without the other, and many of the neuropsychological tests used by researchers and reviewed here reflect that quandary. In this review attention and executive functioning are separately considered, based upon Mirsky’s component model of attention (Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991). Memory is also reviewed, because difficulties with memory play a key role in the inattentive symptoms of the DSM-IV-TR criteria. Memory performance in adult AD/HD has been less well studied. The involvement of the hippocampus and its links to the prefrontal cortex is implied in memory dysfunction (Bower, 2005). Information to be remembered travels
via Papez’s circuit from the hippocampus to the mammillary bodies of the hypothalamus, the anterior thalamic nucleus, the cingulate cortex, the entorhinal cortex, then back to the hippocampus to enable the consolidation of memories (Canadian Institute of Neurosciences, 2010).

**Overview of Attention**

Although attention was once seen as a single process, comparable to a filter or a bottleneck, it is now considered a function of the interaction of at least four component processes, influenced by multiple neural systems. Cohen, Malloy, and Jenkins (1998) describe attention at the functional level:

Patients with attentional dysfunction have an inability to allocate cognitive resources effectively to the task at hand. Clinical examination reveals that the patient fails to perform at optimal levels even though primary cognitive resources, such as sensory registration, perception, memory, and associative functions, are intact. Patients with primary attentional disorders are able to perceive sensory input, comprehend language, form and retrieve memories, and perform other cognitive functions, yet they fail to do so consistently. The performance inconsistency that is a hallmark feature of attentional disturbances stems from the fact that attention consists of a set of dynamic processes that influence the interaction between other core cognitive functions, such as perception and memory, and the external environment. (pp. 541-2)

At the theoretical level, attention is commonly referred to as several different related capacities that regulate how we receive and process stimuli (Lezak, Howieson, Loring, Hannay, & Fischer, 2004). Attention research has generally been restricted to
particular aspects of attention, and has not resulted in any integration of the findings into a common theoretical framework (Posner, 1980; Sanders, 1983; van der Heijden, 1992). Filter theory saw attentional capacity as the transmission capacity of a channel, and selection was performed by a filter that blocked or attenuated the flow of information (Broadbent, 1958). The general processing capacity approach contrasted effortful, capacity-demanding processes with automatic, capacity-free resources (Shiffrin & Schneider, 1977). The concept of capacity included the notion that attention consisted of multiple, specific resources (Allport, Antonis, & Reynolds, 1972). Later theories of attention moved away from focussing on limited capacity and toward the selective and integrative functions of attention, with an emphasis on visual attention (Neumann, 1996; Posner & Petersen, 1990).

More recent theories of attention have viewed attention in terms of its underlying neural mechanisms, such as working memory, top-down sensitivity control, competitive selection, and automatic bottom-up filtering. This neurophysiological approach arose from studies of the monkey prefrontal cortex, functional imaging of human and monkey brains, experimental tasks with humans and monkeys, and electroencephalographic studies of monkeys and humans (Knudsen, 2007). A complementary method of studying attention is the neuropsychological approach, using data obtained from the clinical and experimental study of the cognitive effects of brain injury or neurological diseases, taking models of normal cognitive functioning into account. Mirsky and colleagues’ approach was to administer a wide range of attentional measures to over 600 adults and children, factor analyse the data, and identify the underlying components of attention that underpinned their performances. In turn, they linked these identified factors to neuroanatomy, based on the previously published works of others. Then they administered the tests that loaded onto the attentional factors to three patient groups (complex partial epilepsy, generalised absence
seizures, and head injuries) and demonstrated distinct profile differences between groups (Mirsky, et al., 1991).

Mirsky and colleagues’ model takes the position that attentive functioning results from the coordinated action of several elements linked into a system: focus/execute, sustain, encode, and shift (Mirsky, 1987; Mirsky, et al., 1991; Mirsky, et al., 1999). This is consistent with information-processing studies that identify a variety of functions linked to attention such as selectivity, focusing, sustaining concentration or vigilance, switching attention, distractibility, modulating the intensity of attention and attention to memorial processes such as rehearsal, retrieval, and encoding. Thus attention is a set of processes that can be subdivided into a number of distinct functions. Each function can be assessed with existing measures derived from neuropsychological tests. The functions are thought to be supported by different brain regions which have become specialised for this purpose but which are organised into a system. Therefore, damage or dysfunction in one of these brain regions can lead to specific deficits in particular attentional functions. The organisation of these functions into a system allows for shared responsibility of functions, and implies that the specialisation is not absolute, allowing for the possibility that some structures may substitute for others in the event of dysfunction (Mirsky, et al., 1999). These factors form the organisation of the attentional domains reviewed here, and are described in greater detail in Chapter 3.

**Attentional focus/execute in adult AD/HD.** Mirsky and colleagues (1991) used principal components analyses and factor analyses to identify the elements of attention measured by 13 neuropsychological tests. The Trail Making Test ([TMT]; Reitan, 1958), loaded heavily onto the focus/execute factor in these analyses.

To date, 11 published studies have used the TMT in their research on adults with AD/HD. Only two of these found significant differences between the scores of their
AD/HD and control groups (Lovejoy et al., 1999; Muller, Gimbel, Keller-Pliefsnig, Sartory, & Gastpar, 2007). Both of these studies matched the AD/HD and control groups on age, education, gender and IQ, while the other studies had matched on some aspects, but not all. In terms of screening and inclusion of participants in the clinical group, the earliest studies utilised interviews to identify AD/HD participants (Gansler et al., 1998; Lovejoy, et al., 1999; Riordan et al., 1999). Over time this procedure also included symptom checklists (Johnson et al., 2001; Rapport, VanVoorhis, Tzelepis, & Friedman, 2001; Riordan, et al., 1999), and later, rating scales, although often these were not necessarily comparable (Horton, 1996; Riccio et al., 2005; Walker, Shores, Trollor, Lee, & Sachdev, 2000). By 2007 researchers in this area used a combination of interviews, childhood rating scales, and the Conners Adult ADHD Rating Scales (Conners, Erhardt, & Sparrow, 1998) for self-report and collateral ratings of AD/HD symptomatology (Muller, et al., 2007; Rybak, McNeely, Mackenzie, Jain, & Levitan, 2007; Stavro, Ettenhofer, & Nigg, 2007).

While all studies screened their AD/HD participants for comorbid psychiatric disorders, seven of the studies excluded comorbid AD/HD participants, meaning that the participants as a whole were relatively homogenous. Three of the studies matched the control group to the AD/HD group on age, education, gender and IQ (Lovejoy, et al., 1999; Muller, et al., 2007; Riordan, et al., 1999). In addition the AD/HD participants in all of the studies were recruited from clinical sources, thus, they are believed to represent the more severe end of the AD/HD continuum (Barkley, 2006; Nigg, 2006). Although other methodological issues might have impacted on the studies, it is important to note that two studies that matched the groups on age, education, gender and IQ found group differences in TMT performance, as TMT performance is known to be affected by these factors (Lezak, et al., 2004).
One issue that complicates the AD/HD neuropsychological literature is the grouping of the two disparate diagnostic subtypes into one AD/HD group for research purposes (Schoechlin & Engel, 2005). This could potentially account for the two studies that found significant differences between their AD/HD and control groups on the TMT, if the majority of the samples were comprised of one subtype poorer on the TMT than the other subtype. Muller and colleagues, who reported a significance level of <.001 on both Part A and B of the TMT, reported that one-third of their AD/HD sample were of the AD/HD-Inattentive subtype, but unfortunately this information was not available from the Lovejoy study (Lovejoy, et al., 1999; Muller, et al., 2007). The issue remains unresolved.

Another issue obscuring the research on TMT performance in adults is the use of the appropriate score or scores from the TMT. The test has two parts, Part A and Part B. Visual scanning, perceptual-motor speed, and numerical sequencing are measured by Part A, while alphabetical sequencing and the shift between alphabetic and numeric sets is tapped in Part B. Part B is more difficult due to increased demands in motor speed and visual scanning, as well as a 32% increase in total tracking distance over Part A (LoSasso, Rapport, Axelrod, & Reeder, 1998). Visual scanning for Part B is also more difficult, due to the greater number of visually interfering stimuli present between target stimuli. Therefore, both motor control and visual selection factors influence the differences between Part A and B scores (Arbuthnott & Frank, 2000).

Researchers have attempted to identify the most useful of the TMT scores and have experimented with using a difference (B-A) and a ratio (B/A) score, with varying success (Arbuthnott & Frank, 2000; Corrigan & Hinkeldey, 1987; Drane, Yuspeh, Huthwaite, & Klingler, 2002; Heilbronner, Henry, Buck, Adams, & Fogle, 1991; O'Sullivan et al., 2001; Uc et al., 2006). Mirsky and colleagues’ (1991) factor analysis identified a focus/execute factor derived from the raw score of Part B of the TMT. This
factor was seen as composed of two elements: a visual-perceptual ability to scan stimulus material for a target both rapidly and efficiently, and an ability to make a skilled manual response quickly. Mirsky and colleagues referred to this aspect of attention as focus/execute, in recognition of their inability to separate focussing from the task demand of rapid response (1999). This aspect of attention has been linked to the dorsolateral prefrontal cortex by Zakzanis and colleagues (2005), who evaluated TMT Part B performance in relation to Part A performance in a fMRI study of 12 healthy adults, and found that brain activity for Part B was quite widely distributed in contrast to Part A. Part B appears to be a measure that best captures focus/execute, as it assesses the ability to focus attention on one aspect at a time without separating out processing speed entirely. The predominant region associated with Part B performance was the dorsolateral prefrontal cortex, in addition to those presumed to be involved in the motor control (precentral gyrus, cingulate gyrus, medial frontal gyrus) and the working memory aspects of the task (the middle and superior temporal gyri).

**Sustained attention in adult AD/HD.** In Mirsky and colleagues’ factor analyses the factor identified as sustained attention consisted of scores derived from a continuous performance test (CPT; Mirsky, et al., 1991). This test, designed to assess the ability to sustain attention over an extended period, measures very little of the motor component required to respond, as any responses within 700 milliseconds are considered correct (Mirsky, et al., 1991). This is an acceptable cut-off, as visual go/no-go task responses are known to occur within 500 milliseconds or less (Parasuraman, 1986). Studies utilising CPTs to measure sustained attention in adults with AD/HD have been through the same methodological changes as the TMT studies. Although a number of commercially made CPTs are available and appropriate for research (Riccio, Reynolds, & Lowe, 2001), most adult AD/HD studies have utilised the Conners’ CPT (CCPT), probably due to its extensive normative base (Lezak, et al., 2004).
Eight studies have compared adults with AD/HD to controls on the CCPT, and six found significant differences between groups. These six had utilised clinical samples that were comprised of a number of different subtype proportions (Barkley, Murphy, & Kwasnik, 1996; Egeland, 2007; Epstein, Conners, Sitarenios, & Erhardt, 1998; Epstein, Johnson, Varia, & Conners, 2001; Murphy, Barkley, & Bush, 2001; Walker, et al., 2000). Two studies that did not find group differences utilised community samples comprised of one-half Inattentive and one-half Hyperactive/Impulsive subtype (Advokat, Martino, Hill, & Gouvier, 2007; Riccio, et al., 2005). Each of these researchers reported on a number of CCPT measures, and examination of these components fails to provide any clear indications of whether methodological differences such as comorbidity or subtype makeup of the AD/HD group affected the findings. The omissions (alertness/arousal or selective attention) and commissions scores (response inhibition) show consistent differences between AD/HD and control groups, regardless of the subtype makeup of the AD/HD group, while Hit RT scores (impulsivity or inattentiveness) did not differ in any of the six clinically-based studies. Cohen (1988) has observed that sample size affects the significance level of differences between groups in research studies. However sample sizes ranging from 25 to 105 have shown differences in CCPT measures between adults with AD/HD and controls (Barkley, et al., 1996; Murphy, et al., 2001). The best explanation for inconsistent CCPT performances across studies lies in the origins of the AD/HD groups. Clinically referred AD/HD adults demonstrated poorer CCPT performances than community sourced adults with AD/HD. This supports the contention of many researchers that AD/HD symptomatology lays along a continuum. They suggest that there are individuals with AD/HD in the community who function at a higher level than those who present to clinics (Barkley, 2006; Ellison, 2002; Faraone, Biederman, & Mick, 2006; Gallagher & Blader, 2001; Nigg, 2006; Weiss, Hechtman, & Weiss, 1999).
Attentional encoding in adult AD/HD. This component of attention was identified by Mirsky and colleagues from Digit Span subtest scores (both forward and backward). This test involved the sequential registration, recall, and mental manipulation of numeric information. Although others had suggested that Digits Forward and Digits Backward measured different aspects of behaviour in brain-damaged adults (Black, 1986), they argued that their data from a mixed control/brain-damaged group demonstrated a strong correlation between both measures and thus should be considered together (Mirsky, et al., 1991). Lezak takes the position that the two measures are either the same or highly correlated in normal control subjects, however not in brain-damaged individuals (Lezak, et al., 2004). As Mirsky and colleagues’ factor analyses did not analyse their Digits Forward and Backward scores separately, it is unknown to what extent each contributed to the factor loading (Mirsky, et al., 1991).

Eight published studies have directly compared the performance of adults with AD/HD to controls on Digit Span (Barkley, et al., 1996; Dige & Wik, 2005; Faraone et al., 2006; Kovner et al., 1998; Murphy, et al., 2001; Schweitzer, Hanford, & Medoff, 2006; Seidman, Biederman, Weber, Hatch, & Faraone, 1998; Walker, et al., 2000). Five of these reported Digit Span scores without explicitly defining them, and the assumption is that it was the standard raw WAIS score consisting of Digits Forward correct trials plus Digits Backward correct trials. Three of these five demonstrated significant differences between their AD/HD and control groups (Barkley, et al., 1996; Murphy, et al., 2001; Schweitzer, et al., 2006). One which did not find differences had an AD/HD group comprised predominantly of adults with subthreshold AD/HD symptoms and adults with late onset of AD/HD symptoms, that is, those who met full DSM-IV criteria except for the age of onset criteria (Faraone, Biederman, Doyle, et al.,
The other non-significant result used methodology similar to that of the other researchers (Seidman, et al., 1998).

The remaining three studies considered Digits Forward and Digits Backward scores separately, and found that regardless of sample size, composition or diagnostic protocol, only Digits Backward differed significantly between the AD/HD and control groups (Dige & Wik, 2005; Kovner, et al., 1998; Walker, et al., 2000). Digits Forward did not differ between groups in two studies (Dige & Wik, 2005; Walker, et al., 2000). Both of these studies utilised clinical samples, and one study used controls matched only on age (Dige & Wik, 2005), while the other study matched participants on education, IQ and gender, but not age (Walker, et al., 2000). Dige and Wik’s (2005) Inattentive subtype comprised 67% of the AD/HD group, while Walker and colleagues (2000) did not report on subtype composition. Neither study reported their findings separately by subtype.

It is clear from the results of the studies that separating Digit Span Forward and Backward performances removes the uncertainty about what is being measured. Digit Span Backward taps working memory, while Digit Span Forward taps attentional encoding (Lezak, et al., 2004; Robertson, 1990). However due to the use of widely disparate methodologies, it is not clear whether attentional encoding is compromised in adult AD/HD or not. According to Hale and colleagues (2007), the brain regions supporting the Digit Span Forward task would involve activations of the verbal circuit for number processing, or the left hemisphere angular gyrus and the perisylvian regions.

**Attentional shift in adult AD/HD.** Mirsky and colleagues’ factor analyses identified a fourth attentional component, which they labelled shift. They described this as the “abstract capacity to shift in an adaptive and flexible manner from attending to one aspect or stimulus feature of objects to another aspect” (p. 118, Mirsky, et al.,
This factor was derived from the Wisconsin Card Sorting Test (WCST): Categories, Percent Correct, and Errors (Mirsky, et al., 1991). Ten studies have compared adults with AD/HD to controls on the WCST. Six of these reported no significant differences between their AD/HD and control groups on several scores from the WCST, such as Categories, Perseverative Errors, or Failure to Maintain Set (Gansler, et al., 1998; Johnson, et al., 2001; Rapport, et al., 2001; Riccio, et al., 2005; Seidman, et al., 1998; White, Hutchens, & Lubar, 2005). Three of the remaining four studies that reported differences between their AD/HD and control groups had drawn their AD/HD participants from a community sample, although one was a mix of clinical and community participants, of unknown subtype proportions (Faraone, Biederman, Doyle, et al., 2006; Nigg et al., 2005; Stavro, et al., 2007). The fourth study utilised clinically referred individuals with AD/HD, consisting of 67% Inattentive and 33% Combined subtype participants (Dige & Wik, 2005). Two of these studies accepted AD/HD individuals with comorbidity, two further studies did not describe how they dealt with the issue of comorbidity, and one excluded AD/HD individuals with comorbid conditions.

Altogether a total of seven different WCST scores were reported in these studies, with each study taking a different approach. The number of Categories achieved was the most commonly cited measure, and was mostly non-significant between groups, both in the studies reporting other significant WCST scores and in those that did not. The two studies that reported significantly different Categories scores used community-based, more carefully diagnosed samples (one with comorbidity; one without) and were substantially larger samples than other studies, suggesting that the measure has a relatively small effect size (Nigg, et al., 2005; Stavro, et al., 2007).
Brain imaging work done with PET scans during WCST performance has identified the dorsolateral prefrontal cortex and inferior parietal lobes as essential to successful performance (Berman et al., 1995; Nagahama et al., 1996; Rogers, Andrews, Grasby, Brooks, & Robbins, 2000). Imaging done using fMRI during WCST performance has further shown that the dorsolateral prefrontal cortex is most involved during the early stages of WCST performance (e.g., checking your memory for previous cards, shifting your attention away from those), while shifting to a new response appears to involve the cortical basal loop, consisting of the mid-ventrolateral prefrontal cortex, caudate nucleus, and mediodorsal thalamus (Konishi et al., 1998; Monchi, Petrides, Petre, Worsley, & Dagher, 2001). Receiving feedback and responding appears to involve the posterior prefrontal cortex, while matching after negative (but not positive) feedback involves the putamen (Monchi, et al., 2001).

To summarise, narrowing the focus of this review to studies utilising normed instruments derived from statistical validation to represent theorised components of attention has been useful. According to Mirsky’s model of attentional functions (1999), adults with AD/HD would have no difficulties in focus/execute, meaning that they have no difficulty scanning visual material for a target, or in making a skilled manual response both rapidly and efficiently. However careful matching of AD/HD and control groups may show that there is a difference. For the sustain component, adults with AD/HD have demonstrated difficulties in both alertness/arousal and in response inhibition. The encode and shift components have yielded mixed results in the adult AD/HD literature, and a study utilising stricter diagnostic criteria, more careful matching, and the segregation of subtypes may further clarify this issue. In addition, comparing all four aspects of attention in one study may help to better understand attention in adults with AD/HD.
Overview of Memory

There is a great deal of agreement as to what constitutes the psychology of memory. This knowledge base has emerged from the study of normal memory in the laboratory, as well as the study of memory deficits in brain damaged patients. In the 1960s the concept of a unitary memory process was replaced by models that distinguished between short term memory and long term memory systems, from evidence that arose from the study of patients with brain damage. Information was assumed to flow to the long term memory store via the short term memory store, and the longer it was stored, the more likely it would flow to long term memory. However evidence began to accumulate that holding information in short term memory did not guarantee learning. Thus a levels of processing framework was conceived that suggested that the depth of processing controlled the likelihood of learning (Baddeley, 2004).

The short term memory system was then developed and elaborated upon as a working memory system comprised of a central executive, an attentional control system; the phonological loop, a subvocal rehearsal process; and the visuospatial sketchpad, for the storage and manipulation of visual and spatial information (Baddeley & Hitch, 1974). More recently a fourth component of the working memory system has been proposed, the episodic buffer, which is considered important for chunking information into short term memory, and also in immediate memory for prose (Baddeley, 2000; Baddeley & Wilson, 2002). Long term memory has also been separated into components, distinguishing between explicit (or declarative) and implicit (non-declarative) memory, based on neuropsychological evidence. The various types of implicit memory appear to depend on different parts of the brain. Explicit memory appears to depend on a particular circuit linking the hippocampi to the temporal and
frontal lobes of the brain, and consists of two separate systems, episodic and semantic memory. Episodic memory allows us to recall specific events, while semantic memory consists of our acquired general knowledge of the world. It is believed that the retrieval of these two types of memories involves two different parts of the prefrontal cortex. These regions are believed to be the ventral region of the right prefrontal cortex for episodic retrieval, and the right middle temporal gyrus and the right inferior temporal gyrus for semantic retrieval (Canadian Institute of Neurosciences, 2010; Henson, Shallice, & Dolan, 1999).

In terms of the process of remembering, researchers have established that there are three distinct stages: 1) encoding, the registration of information; 2) storage, the maintenance of information over time; and 3) retrieval, the accessing of information directly by recognition or recall, and indirectly by implicit processes. Encoding is assessed by varying the way that material is processed during learning, for example remembering words more effectively by processing their meanings rather than only their visual characteristics. Storage is measured by forgetting, and it appears to be insensitive to encoding procedures. Retrieval is assessed through either recall or recognition processes. Recognition is believed to place a lighter cognitive load on retrieval than recall, where information must be produced from storage rather than chosen from among a range of items. Free recall is considered the most straightforward recall measure. In free recall a sequence of items, typically words, are presented and the subject must recall as many as possible. In immediate recall conditions, word recall is highly dependent on its position during presentation, with the final words and the first one or two words being most frequently recalled (the recency and primacy effects). Free recall performance is dependent upon long term memory, with many factors impinging on it such as the frequency and associability of the words presented.
Research on the behavioural effects of brain lesions in animals and brain damage in humans, as well as human brain imaging research, has identified a number of regions implicated in memory. Parts of the medial temporal and hippocampus regions are linked to the storage of new memories, while parts of the posterior parietal cortex are involved in mental imagery and visual memory. The left temporal and right parietal cerebral cortices are associated with verbal and visual memory, respectively, while the amygdala and limbic system are implicated in emotional memories. The cerebellum, motor, premotor cortex and basal ganglia are linked to learning and performance of motor skills. The sensory cortices are involved in modality-specific memories, and the frontal and prefrontal cortices appear to serve working memory, with separate parts specialised to types of information. In addition, the prefrontal cortex is associated with the strategic aspects of performance and memory (Bower, 2005).

**Verbal memory.** One variant of verbal memory is free recall, which is commonly measured by presenting groups of words from the same semantic category (such as flowers or colours). Subjects tend to recall these in semantic clusters, demonstrating that they are using meanings as a basis for encoding and retrieval. In addition, unrelated words have been shown to be chunked into clusters that are meaningful to the subject. When asked to remember prose, the initial level of recall appears to be set in terms of the number of word clusters or chunks, rather than the number of words to be recalled. More complex recall tasks include serial recall, when a subject is asked to recall items in order of presentation, and paired associate learning, where subjects are required to recall two linked words, either semantically related or unrelated to each other (Baddeley, 2004).

**Visual memory.** In addition to the study of verbal memory, other researchers have examined the phenomenon of visual memory, conceiving of it as a form of coding
and symbolic representation that was an alternative to the verbal coding system. It was shown that words differed greatly in the extent to which they evoked imagery in subjects that paired associate learning with high imagery words resulted in better remembering than low imagery words, that instructing subjects to use imagery to remember words increased their performance, and finally, that pictures of everyday objects elicited better remembering than the names of objects. Subsequent research demonstrated that two closely connected, yet functionally independent coding systems exist (Bower, 2005).

**Memory and AD/HD.** Research suggests that a variety of factors lead to memory impairment in children with AD/HD, such as difficulty attending, difficulty processing memories, and difficulty with poor strategy selection. These same factors may be implicated in memory performance in adults with AD/HD (Barkley, 1997b; Seidman, et al., 1998). Memory has been less well studied in neuropsychological studies of adults with AD/HD, even though being “forgetful in daily activities” is one of the defining features of the disorder (American Psychiatric Association, 2000). Impairments in memory are particularly disabling for people in their everyday lives (Butters, Soety, & Glisky, 1998), but it is unknown what proportion of functional difficulties adults with AD/HD may be due to deficits in memory functions, rather than attentional functions. A number of studies have examined memory test performance in adults with AD/HD and overall these adults were impaired relative to controls. Although a wide range of tests were used, an overall memory performance deficit was consistent across studies. The memory domains studied have included visual memory for figures, verbal memory and learning for lists, short term memory span and retention, and verbal memory for stories (Dige & Wik, 2005; Downey, Stelson, Pomerleau, & Giordani, 1997; Faraone, Biederman, Doyle, et al., 2006; Gansler, et al., 1998; Hervey, et al., 2004; Holdnack, Moberg, Arnold, Gur, & et al., 1995; Jenkins et al., 1998;
Verbal memory in adult AD/HD. Tests of verbal memory and learning for lists are the most commonly used memory tests in this population. Seven of nine studies reported medium to large effect sizes on the California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987) performance differences of AD/HD adults and controls (Biederman et al., 2006; Downey, et al., 1997; Faraone, Biederman, Doyle, et al., 2006; Holdnack, et al., 1995; Jenkins, et al., 1998; Katz, Wood, Goldstein, Auchenbach, & Geckle, 1998; Lovejoy, et al., 1999; Riordan, et al., 1999; Seidman, et al., 1998). These studies found that adults with AD/HD appeared to show a preference for serial clustering rather than semantic clustering as a strategy for remembering CVLT lists, which was less efficient and accounted for some, if not all, of their difficulty (Hervey, et al., 2004). However in contrast, Roth and colleagues demonstrated that situational anxiety contributed more to poor performance than poor organisational strategies on the CVLT (Roth et al., 2004). Overall most CVLT component measures yielded medium to large effect sizes in these studies (Hervey, et al., 2004).

Story recall test performances have been reported in three studies comparing adults with AD/HD to controls, using the Logical Memory I and II subtests of the Wechsler Memory Scale – Revised (LMI and LMII; Wechsler, 1987). Two of these studies found no differences (Gansler, et al., 1998; Riccio, et al., 2005), and the other reported a significant difference (Johnson, et al., 2001). The subtype composition of these samples was reported by Riccio and colleagues (2005), whose sample consisted of 44% Inattentive and 56% Combined subtype participants. More comprehensive information on the performances of adults with AD/HD on story recall tests is needed,
as these tests are considered a good index of everyday memory, yet are sensitive enough to identify memory deficits (Snyder & Nussbaum, 1998).

**Visual memory in adult AD/HD.** Adults with AD/HD have not shown consistent impairments in visual memory. Using two different tests of visual memory (the Rey-Osterreith Complex Figure and the WMS Visual Reproduction subtest), the effect sizes of the differences found between adults with AD/HD and controls were small (Biederman, et al., 2006; Faraone, Biederman, Doyle, et al., 2006; Gansler, et al., 1998; Johnson, et al., 2001; Muller, et al., 2007; Seidman, et al., 1998). It has been suggested that the differences found were due to difficulties in imposing structure and in encoding information, rather than in consolidation or storage of the memory (Hervey, et al., 2004; Woods, et al., 2002). Other researchers have found no performance deficits in visual memory for figures in adults with AD/HD (Gansler, et al., 1998; Kovner, et al., 1998; Seidman, et al., 1998). However tests of visual memory for figures call for a visuomotor response, usually drawing, which complicates the interpretation of poor performance on these tasks (Lezak, et al., 2004). This issue was highlighted by Schreiber and colleagues, who found, using a qualitative scoring methodology, that adults with AD/HD drew less accurate and neat figures than controls (Schreiber, Javorsky, Robinson, & Stern, 1999). There is no information on subtype differences in visual memory performance.

To summarise, memory research on adults with AD/HD has identified deficits in verbal memory and learning for word lists, and deficits in short term span and retention. The ability to remember verbal information in story form may not have been adequately tested in this population. In visual memory, the use of tests that confound visuomotor deficits with visual memory in adults with AD/HD have obscured the data, and thus no conclusion about visual memory can be reached. In addition, no studies have examined
their adult AD/HD groups on a comprehensive memory battery that allows for comparison between subtypes, as well as in contrast to matched controls.

Overview of Executive Functioning

Executive functioning is used to describe the most complex of behaviours that help individuals respond in an adaptive manner to novel situations, and that form the basis of many cognitive, emotional and social skills. Defective executive functioning typically involves a cluster of deficiencies, yet can easily be missed in highly structured neuropsychological examinations, due to the examiner or the task providing structure for the examinee, rather than the examinee having to impose organization and structure in order to complete the task. However, poor executive functioning is readily apparent in an individual’s behaviour outside of testing situations, with impairments in self-direction, self-regulation, initiative, spontaneity and conceptual flexibility affecting the ability to function independently and effectively. Executive functioning has been associated with dysfunction in the prefrontal cortex, but it is also sensitive to damage in other parts of the brain, with subcortical as well as cortical involvement implicated (Lezak, et al., 2004).

Factor analyses of batteries of executive functioning have suggested that the domain consists of several components (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). Others take the position that it involves a single latent ability after considering the results of studies demonstrating positive and moderate correlations between executive functioning measures (Nigg, et al., 2005). However, executive functioning influences performance in the cognitive, emotional and motor functioning domains, which supports the position that it is not a single entity, but a series of systems. Luria’s functional systems model (1970) described it as a system that plans, organises and monitors behaviour, but this explanation is now seen as an oversimplification. The
prefrontal cortex, mostly associated with executive functioning, contains structural
divisions delineated by the predominance of certain cells, connections with other
structures, and the prevalence of particular neurotransmitters. These executive areas
include the orbital cortex, the dorsolateral prefrontal cortex, the medial area of the
frontal lobe (containing the anterior cingulate gyrus and the supplementary motor area),
and other executive-motor areas outside of the prefrontal cortex, such as the frontal eye
fields, Broca’s area, and the premotor area (Andrewes, 2001).

The orbital cortex has connections to the limbic system, and is therefore
believed to have an important role in regulating and controlling emotions. There is also
evidence that it has an influence on attention, and patients with damage to this area have
a tendency to be easily distracted (Malloy, Bihrlle, Duffy, & Cimino, 1993). There is
also evidence from animal research that the area has a role in motivation by the
association of rewards with behaviour (Rolls, 2000). The dorsolateral prefrontal cortex
is linked with the visual, somatosensory, and auditory sensory areas, and has a
specialised role in organising and integrating incoming sensory information. It contains
a buffer store where information can be kept in mind while we do something else, and
has a key role in selective attention and storing sequences of events into memory
(Milner, Corsi, & Leonard, 1991). The medial area of the frontal lobes is involved in
the preparation and execution of complex motor movements. The anterior cingulate has
connections with the amygdala and other limbic system structures, and is associated
with the attribution of emotion, focussed attention, and storing memories. It is seen as
important for drive, as patients with bilateral damage here are passive and show little
affect or sexual drive (Andrewes, 2001). The other areas associated with an executive
role but not part of the prefrontal cortex have roles in eye movement (frontal eye fields),
the organisation of speech (Broca’s area), and the preparation and organisation of motor
movements (premotor area).
Some theories of executive functioning have suggested that working memory is critical to sequential analysis and to the organisation of behaviour toward a goal. Difficulties with working memory can prevent an individual from keeping a goal in mind, and disrupt temporal relations between items and events. Thus behaviour becomes driven by immediate stimuli, or by recently rewarded behaviour. Disruption in working memory can account for a number of difficulties observed in executive dysfunction (Banich, 2004). Norman and Shallice (2000) suggested a two-pronged system consisting of contention scheduling and the supervisory attentional system. Contention scheduling is a cognitive system that allows relatively automatic processing, which occurs over time with stimuli or situations becoming linked to actions, routines or processing schemes, and groups of routines becoming linked to one another. Once an action is initiated by this system it is active until inhibited by a mutually incompatible process. The supervisory attentional system is a cognitive system that requires an individual to effortfully direct attention and guide action through decision processes. It is active only in novel situations, when a task is technically difficult, when problem solving is required, or when automatic response tendencies must be overcome. Cohen and colleagues’ (2000) theory focussed on the involvement of the anterior cingulate, and they proposed that it was crucial for monitoring and controlling cognitive conflicts. Their model suggested two control systems, one related to the selective attention role of the dorsolateral prefrontal cortex, and another involving the anterior cingulate, monitoring attentional conflicts and modulating by increasing levels of noradrenalin. Along with other structures such as the thalamus and sensory input areas, this system appeared to have a modulating role that maintained an optimal level of cortical arousal depending on task demands (Andrewes, 2001; Cohen, et al., 2000).

Willcutt and colleagues, in reviewing executive function research and theories with regard to AD/HD, agreed with others that existing theories are weakly defined and
overly broad (Pennington & Ozonoff, 1996; Sergeant, et al., 2003) and noted that this is supported by factor analyses of batteries of executive functioning measures. However a meta-analysis of the executive functioning studies has suggested that executive functioning tasks include at least four factors: 1) response inhibition and execution, 2) working memory and updating, 3) set-shifting and task switching, and 4) interference control (Willcutt, et al., 2005). Similarly, Pennington (1997) and Willcutt et al. (2005) identified the following components as important to executive functioning: 1) working memory; 2) interference control; 3) set shifting/task switching; 4) response inhibition; and 5) planning.

Nigg (2006) has applied a model of executive functioning to AD/HD in particular, and describes executive functioning in AD/HD as consisting of two related but conceptually distinguishable areas: control and working memory. Control encompasses components identified by most theorists and consists of firstly, filtering competing information to maintain task response, or cognitive attentional selection, and secondly, the ability to suppress from working memory previously relevant information, or cognitive suppression (Nigg, 2006). Other researchers have identified a third function, that of suppressing, interrupting or cancelling a motor response, known as response inhibition. This is often viewed as analogous to impulsivity, but data to support this view is mixed (Nigg, et al., 2005). A fourth function, the ability to shift response set, is believed to be distinct from response inhibition because of the need to activate another response simultaneously, possibly falling short of a total stop process (Nigg, 2006; Pennington, 1997).

The working memory component of executive functioning is considered a limited-capacity ability closely related to executive attentional selection, however it differs in its need to maintain information in an active state in order to action some
information or plans over others. A second ability dependent upon the working memory domain is identified as planning (Pennington & Ozonoff, 1996), involving mentally organising a series of steps in temporal sequence to solve a complex problem. A third ability that Nigg organises into the working memory domain is that of activation. Although related to vigilance, it is distinguished as the readiness to respond, rather than the readiness to notice something (Nigg, 2006). Although some view it as an executive function (Berger & Posner, 2000), others see it as subsidiary to executive functioning (Sergeant, et al., 1999).

**Executive functioning and AD/HD.** Children with AD/HD have demonstrated weaknesses in executive functioning, defined as the ability to regulate behaviour to context and maintain a response set (Barkley, 1997b; Nigg, 2001; Pennington & Ozonoff, 1996). Whether or not adults with AD/HD display executive functioning deficits is critical to theories about the role of executive functioning in the disorder. Developmental theories would suggest that prefrontal lobe operations, such as executive functioning, continue to become more efficient to early adulthood. Research has suggested that AD/HD symptoms decrease or modify in their expression with maturation into early adulthood (Faraone et al., 2000). For that reason a number of neuropsychological studies of adults with AD/HD have focussed entirely on executive functioning. Nigg (2006) has devised a model of executive functioning in AD/HD that recognises that, although prefrontal cortical regions are closely involved, executive functioning also depends upon structures in the basal ganglia, the thalamus, and the cerebellum. He suggests that this occurs via a series of parallel prefrontal-subcortical neural loops. This organisation scheme for the components of executive functioning borrows from Pennington and Ozonoff (1996), Posner and Petersen (1990), and Casey (2002). What follows is a review of the adult AD/HD literature organised by the four

**Interference control in adult AD/HD.** Most AD/HD research has focussed on this domain by using the Stroop task, which requires individuals to both selectively attend to particular aspects of stimuli while actively suppressing other aspects. The measure has generated debate as to whether it is a pure measure of interference control independent of working memory (i.e., the ability to strategically filter irrelevant information to concentrate on a task), or whether working memory is also being measured as well (Nigg, 2006). Several functional brain imaging studies in adults have established that performing the Stroop task activates the anterior cingulate cortex, a frontal region associated with frontal executive networks (Cabeza & Nyberg, 1997; Posner & DiGirolamo, 1998). Several versions of the Stroop task are commonly used by researchers, and adults with AD/HD have been shown to demonstrate consistent performance deficits compared to controls across several different versions (Woods, et al., 2002). Hervey and colleagues in their meta-analysis found a medium effect size for the Color-Word score on the Stroop among adults with AD/HD, however did not specify which versions were included in their analysis (Hervey, et al., 2004). One of the most commonly used versions in the adult AD/HD literature is the Golden version, and thus will be reviewed here (Golden, 1978).

Eight studies reported their results comparing adults with AD/HD to controls using the Golden version of the Stroop (Corbett & Stanczak, 1999; Dige & Wik, 2005; Johnson, et al., 2001; Rapport, et al., 2001; Riccio, et al., 2005; Seidman, et al., 1998; Stavro, et al., 2007; Walker, et al., 2000). Seven of the eight studies found significant differences between groups. The majority of these found deficits mainly in the Word and Color scores, showing that AD/HD adults were slower than controls in both word
reading and colour naming. This suggested an overall effect of slowed verbal processing speed (Corbett & Stanczak, 1999; Johnson, et al., 2001; Nigg, et al., 2005; Rapport, et al., 2001; Stavro, et al., 2007; Walker, et al., 2000). Three studies found deficits in their AD/HD adults on the Color-Word score, the measure that encapsulates the ability to ward off distraction (Riccio, et al., 2005; Stavro, et al., 2007; Walker, et al., 2000). These three studies did not differ substantially from the others in terms of the sample size, source, diagnostic process or comorbidity status of their AD/HD groups. Only one study found a significant difference between AD/HD and control groups using the interference score (Riccio, et al., 2005). There was no information available about the subtype composition of these studies, other than Riccio and colleagues, whose AD/HD group was comprised of 44% Inattentive and 56% Combined subtype individuals. As the interference score predicts performance in the Color-Word score on the basis of performances on the word reading and colour naming scores, it is not surprising that only one study found significant differences between groups on this score (Hervey, et al., 2004). Taken together this data suggests that although there is evidence for poor performance on the Stroop task in adults with AD/HD, some of this may be attributable to slower verbal processing speeds and not solely to the inability to ward off distraction.

**Working memory in adult AD/HD.** Most research on adults with AD/HD has focussed on verbal working memory as measured by the Digit Span Backward task. Other measures of working memory have been utilised by a small number of researchers, and include the spatial working memory measure of the Cambridge Neuropsychological Test Automated Battery, in which AD/HD adults were impaired (Dowson et al., 2004; McLean et al., 2004; Turner et al., 2005), and unnormed experimental task measures (Valera et al., 2005), in which AD/HD adults were not compared to controls at baseline. As noted previously, three studies utilising the Digit
Span Backward task have demonstrated impairment in AD/HD adults compared to controls (Dige & Wik, 2005; Kovner, et al., 1998; Walker, et al., 2000). Only Dige and Wik (2005) reported the subtype composition of their study (67% Inattentive, 33% Combined), while the other two studies did not. The effect of AD/HD subtype on the working memory performance of adults has not yet been determined.

**Planning in adult AD/HD.** The tower tasks are considered planning measures, although they place a heavy load on visual working memory and sequencing (Nigg, 2006). Four studies have examined Tower of London (TOL) task performance in adults with AD/HD and controls, with mixed results. One found significant differences in Initiation and Total time taken to perform the task, with AD/HD group taking longer both to initiate the first move, and to solve the problem (Muller, et al., 2007). Another found no differences between adults with AD/HD and controls on the Drexel version of the TOL in either time or accuracy based scores (Riccio, et al., 2005). In two other studies, no differences between AD/HD adults and controls were found in the total of moves made to complete the task (Nigg, et al., 2005; Stavro, et al., 2007). Young and colleagues, using a nonstandard computerised TOL task on a predominately Combined subtype group of adults with AD/HD found that the AD/HD group used the same amount of planning time on difficult items as on easier items, whereas the control group took more time to plan the more difficult items (Young, Morris, Toone, & Tyson, 2007).

It has been suggested that the TOL exhibits a ceiling effect in most adult applications and that more complex versions are needed to test adults (Ward & Allport, 1997). Brain imaging studies of normal volunteers performing computerised Tower of London tasks have demonstrated the involvement of areas believed to support verbal working memory, visuospatial working memory, attention and motor processes:
dorsolateral prefrontal cortex, parietal, cerebellar, basal ganglia, striatum, premotor cortex, supplementary motor area, precuneus and inferior parietal cortex (Newman, Carpenter, Varma, & Just, 2003; Schall et al., 2003; van den Heuvel et al., 2003).

**Response inhibition in adult AD/HD.** AD/HD researchers have focussed on the Go/No-Go, Stop, or Antisaccade tasks to measure this ability in children with AD/HD (Barkley, 1999; McLean, et al., 2004). As these tasks are rarely used in adults with AD/HD, they will not be reviewed here. The Commissions score of the CCPT (Conners & MHS Staff, 2002) is also used to measure response inhibition (Hervey, et al., 2004; Nigg, 2006). As noted previously, adults with AD/HD demonstrate deficits on Commissions scores, and it is unknown whether there are any differences in subtype performance. However this deficit may be limited to clinically-referred adults, rather than individuals from the community.

To summarise, executive functioning deficits in interference control using the Stroop interference score are not found in adults with AD/HD, once slowed processing speed is accounted for. Using the Digit Span Backward task to represent working memory, adults with AD/HD have been shown to perform more poorly than controls. Results have been mixed when assessing the performance of adults with AD/HD on planning, as measured by tower tasks. Adults with AD/HD have also demonstrated difficulties with response inhibition using the Commissions score of the CPT paradigm, regardless of subtype. Generally, the previous findings on executive functioning in adults with AD/HD are mixed, and may be attributable to methodological issues, such as the selection and measurement of components, subtype composition, inconsistent matching of groups, and sampling. A study of executive functioning in adults with AD/HD is needed that addresses these methodological limitations, and that examines all of these components simultaneously.
**Summary: Neuropsychological Research in Adult AD/HD**

A systematic review of the neuropsychological literature involving studies of adults with AD/HD has demonstrated that this clinical group has difficulties in several components of attention, memory and executive functioning. In terms of attentional components, they have shown few deficits in the focus/execute component of attention, although that may be due to methodological limitations. In sustained attention, they demonstrated difficulties in both alertness/arousal and in response inhibition. The encode and shift attentional components yielded mixed results in the adult AD/HD literature. In terms of memory, the research has found medium to large effect sizes in AD/HD adults’ verbal memory and learning deficits, and some difficulties with visual memory for figures and verbal memory for stories, although these findings are questionable due to methodological problems. Finally, adults with AD/HD have demonstrated deficits in at least three components of executive functioning in previous studies: working memory, planning, and response inhibition.

Much of the neuropsychological research has yielded mixed results when separate attention, memory or executive functioning components are compared across studies. This is likely due to methodological considerations, as few studies share similar methods in terms of sampling, study criteria, diagnostic criteria, the measures chosen, the identification of subtypes, and matching to control groups. In particular, matching AD/HD groups on age, education, and IQ is crucial when comparing performances on neuropsychological measures (Lezak, et al., 2004). This implies that the findings of studies that have not utilised matching on these variables may be under question, and are likely contributors to the disparate results.
Psychological Research in Adult AD/HD

Comorbidity studies of adolescents with AD/HD foreshadow those of adults with AD/HD, and suggest that many of the psychological and emotional conditions that accompany AD/HD begin early. Adolescents with AD/HD have higher rates of Oppositional Defiant Disorder and Conduct Disorder, as well as mood and anxiety disorders (Biederman, et al., 1998; Chang & Chuang, 2000; Fischer, Barkley, Fletcher, & Smallish, 1993; Murphy, Barkley, & Bush, 2002; Shekim, Asarnow, Hess, & Zaucha, 1990). Two studies utilising the Symptom Checklist 90-Revised, a brief self-report measure of psychological status, reported elevations on all nine indices of the measure: somatisation, obsessive-compulsive, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism (Chang & Chuang, 2000; Murphy, et al., 2002). Although a number of comorbid psychological conditions have been associated with adult AD/HD (as depicted in Table 2, Chapter One), the most prevalent of these are conduct disorder, depression and other mood disorders, and anxiety disorders.

**Conduct disorder in adult AD/HD.** Clinic-referred adults with AD/HD have higher frequencies of conduct disorder (CD) than would be attributable to chance alone (Angold, Costello, & Erkanli, 1999). Seventeen to 25% of them qualify for a CD diagnosis, either currently or previously (Barkley, et al., 1996; Biederman, Faraone, Spencer, Wilens, & et al., 1993; Murphy & Barkley, 1996). This proportion is well below that reported in studies of AD/HD children followed to adulthood, where levels of CD are double those reported for adults with AD/HD (Barkley, et al., 1990; Weiss & Hechtman, 1993). Adults with AD/HD and comorbid CD are considered a qualitatively different group to those without CD, and this group remains an elusive one to study, due to low retention and follow-up rates (Ellison, 2002). Genetic studies are suggesting
that AD/HD and comorbid CD have high heritability and involve the transmission of genes other than those attributed to AD/HD (Levy, et al., 2006).

**Depression in adult AD/HD.** AD/HD in adults is significantly associated with major depression. Estimates range from 16% to 31% of the adult AD/HD population (Barkley, et al., 1996; Biederman, et al., 1993; Murphy & Barkley, 1996; Roy-Byrne et al., 1997). Dysthymia, a milder but longer term form of depression, is estimated to be present in 19% to 37% of the adult AD/HD population (Murphy & Barkley, 1996; Roy-Byrne, et al., 1997; Shekim, et al., 1990). All of these studies utilised clinic-referred adults, and thus may be due partially to the higher rates of depression and dysthymia found among clinic-referred adults (Barkley & Gordon, 2002).

Biederman and colleagues found a 2.5 times greater risk for major depression at late adolescent follow-up among adult females with AD/HD than control group females, even after accounting for psychiatric comorbidity, in a longitudinal group being followed in the USA. This major depression group had an earlier age of onset, greater than twice the duration of illness, and a more severe depressive illness associated with higher suicidality and hospitalisation than those with major depression in the control group (Biederman et al., 2008). Young and Gudjonsson examined the differences between adults with AD/HD, control adults, and adults in full or partial remission of their AD/HD symptoms among participants drawn from a London adult AD/HD clinic. Their data showed a decline in the symptoms of anxiety and depression as AD/HD symptoms declined, with the in full-remission group’s levels of anxiety and depression comparable to those of the control group (Young & Gudjonsson, 2008).

An intriguing difference in mood states between Hyperactive and Inattentive subtype adults with AD/HD was found by Knouse and colleagues, who asked US college students with AD/HD to assess their mood and activities in-the-moment using 50
personal digital assistants for one week. They found that Inattentive subtype individuals had lower moods regardless of social contact, satisfaction with current activities, concentration difficulties, or social context, while Hyperactive-Impulsive subtype individuals did not have lower moods generally, and when they did, these lower moods were associated with being alone versus being with others. The overall results indicated that Inattentive subtype individuals were likely to experience the world as consistently more distressing, while Hyperactive-Impulsive subtype individuals were less likely to be influenced by their current context or their appraisals of their own competence (Knouse et al., 2008).

**Anxiety in adult AD/HD.** Some studies have found that adults with AD/HD have high rates of generalized anxiety disorder, ranging from 24% to 43% of clinic-referred adults (Barkley, et al., 1996; Biederman, et al., 1993; Murphy & Barkley, 1996; Shekim, et al., 1990). Other studies have shown no higher degree of anxiety disorders than occurred in a clinical control group of adults seen at the same clinic without AD/HD (Murphy & Barkley, 1996; Roy-Byrne, et al., 1997). It is possible that referral bias inflated the prior figures, as has been found to be the case with clinic-referred children (Barkley, 1998).

Some studies have found high rates of obsessive-compulsive disorder (OCD) in adults with AD/HD (Shekim, et al., 1990), while others have not (Roy-Byrne, et al., 1997). Spencer and colleagues (Spencer et al., 2001) found higher rates of OCD among adults with AD/HD, but only among those with a comorbid tic disorder. Some researchers have identified a close relationship between OCD and tic disorder in the adult AD/HD population (Barkley & Gordon, 2002; Peterson, Pine, Cohen, & Brook, 2001). Others have argued that OCD may develop in those with AD/HD because it serves as a useful memory strategy for these individuals (van der Feltz-Cornelis, 1999).
No studies have compared the rates of anxiety symptoms or conditions between Inattentive and Combined subtype adults.

**Stress in adult AD/HD.** Families of children with AD/HD reported far greater stress than families of children with other special health care needs in a large scale study examining over 65,000 children and their parents in the United States. (Splete, 2006). Studies that measured cortisol (the stress hormone) after a standardised experimental task that elicits stress response have shown that adults with AD/HD report greater levels of stress even though their measured cortisol levels did not differ from controls (Lackschewitz, Huther, & Kroner-Herwig, 2008). Adults with AD/HD have been found to use less effective coping strategies, and furthermore, their ability to cope with stressful situations was found to be related mostly to their ability to use cognitive strategies, in contrast to a control group, whose coping abilities were related to both cognitive strategies and personality factors. These conclusions were drawn from a study whose AD/HD group were comprised of 2/3 Combined subtype individuals (Young, 2005), and therefore may not necessarily be valid for both AD/HD subtypes.

Coping strategies can also be affected by a lack of social relationships, as social support can act as a stress buffer, providing the opportunity to consult about problems, gain advice and learn from others’ experiences, or from the modelling of others’ methods of coping (Young & Bramham, 2006).

There are robust gender differences in the use of coping strategies for stress, with females more likely to use emotion-focussed and males more likely to use problem-focussed coping (Lazarus & Folkman, 1984). However in adults with AD/HD, both genders have been shown to be less likely to follow this pattern, and females were found to be less likely to confide in others and use social support, while males were less likely to problem solve, instead responding with aggressive or antisocial behaviour.
(Young & Bramham, 2006; Young, Chadwick, Heptinstall, Taylor, & Sonuga-Barke, 2005). No differences or similarities between the AD/HD subtypes have been studied.

**Summary: Psychological Research in Adult AD/HD**

To summarise, AD/HD in adulthood carries a greater risk of comorbid conduct disorder, depression, and dysthymia. Studies investigating the risk of comorbid anxiety disorders have been equivocal, and the relationship between AD/HD and anxiety has not been thoroughly investigated. For reasons not yet clear, adults with AD/HD report greater levels of stress than non-AD/HD adults. Nothing is known about the relationship between AD/HD subtype and psychological or emotional difficulties, although one exploratory study found that Inattentive subtype individuals consistently reported lower moods (Knouse, et al., 2008).

In addition, no studies have investigated the relationship between individual neuropsychological and psychological variables within the same adult AD/HD group. An investigation such as this could help to determine whether particular neuropsychological deficits or strengths are associated with psychological or emotional difficulties. This information would make a significant contribution to clinical service delivery for adults with AD/HD. However it would also be important for the treatment of children with AD/HD to know if particular symptom profiles or subtypes, for instance, are more likely to be associated with psychological or emotional problems in adult life.

**Functional Outcomes Research in Adult AD/HD**

Outcome studies of adolescents with AD/HD suggest that the presence of AD/HD carries with it a risk for poorer functioning in day to day living skills. Academic failure, early pregnancy, substance use, driving accidents and citations, and
problems in social and vocational settings are higher in adolescents with AD/HD, and set the scene for difficulties in adulthood as well (Barkley, 2004; Biederman, et al., 1998; Fischer & Barkley, 2006; Fischer, et al., 1993; Horner & Scheibe, 1997; Mannuzza & Klein, 1999; Molina, Bukstein, & Lynch, 2002; Molina & Pelham, 2003; Weiss & Hechtman, 1993). A number of studies have investigated functional outcomes in adults with ADHD. The same outcomes reported in the adolescent literature continue to plague adults with ADHD, along with several others pertinent to adult life, such as parenting and relationship skill deficits, educational attainment, financial problems, and vocational difficulties. The most prevalent of these in previous studies of adults with AD/HD have been in the areas of social functioning, vocational issues, family difficulties, and financial problems.

**Social functioning in adult AD/HD.** Young and Gudjonsson (2008) compared three groups drawn from a London adult AD/HD clinic: an AD/HD group, a group in partial remission of AD/HD symptoms, and a group in full remission of AD/HD symptoms to a control group on a scale of friendships measure, asking about the number and quality of friendships. They found that all three clinical groups appeared to have friendship problems in comparison to the normal group, with the AD/HD group having the most difficulties. They concluded that the ability to make and manage interpersonal relationships may improve with symptom remission, but the skills may not become as functional as those of individuals without a history of AD/HD. Canu and Carlson conducted an in-vivo experiment involving college men with AD/HD which demonstrated that Inattentive subtype group members had significant difficulties with initiating conversations and asking for dates from the opposite sex, as opposed to those in a Combined subtype group, or controls (Canu & Carlson, 2004).
**Vocational issues in adult AD/HD.** Murphy and Barkley found in a study of 172 clinic-referred adults with AD/HD that, relative to controls, they were more likely to have been fired, have impulsively quit a job, be chronically unemployed, and change jobs more often (Murphy & Barkley, 1996). Adults diagnosed with ADHD in childhood were less likely to continue education after high school compared to controls, an outcome related to lower occupational status in study participants (Biswas, Pelham, Molina, & Gnagy, 2008). Biederman and colleagues found that clinic-referred adults with AD/HD demonstrated significant deficits in an eight-hour simulated workplace experience, with difficulties in reading speed and comprehension, math fluency, and task persistence. The deficits were documented using objective task, observer rated, and self rated measures (Biederman et al., 2005). Barkley, Murphy and Fischer compared two groups of AD/HD adults, those who were clinic-referred in adulthood, and those who were first diagnosed in childhood and followed longitudinally, with clinical and community control groups. Their participants reported significant occupational difficulties, including getting along with others, behaviour problems, being fired, quitting out of boredom, being disciplined by supervisors, performing assigned work, pursuing educational activities, being punctual, using good time management, and managing daily responsibilities. These difficulties were corroborated by employer ratings for both groups (Barkley, Murphy, & Fischer, 2007). Safren and colleagues found that clinician-rated impairments in work and interpersonal functioning were most strongly related to AD/HD symptoms (and not depression or anxiety) in 105 medicated adults presenting for CBT for residual AD/HD (Safren, Sprich, Cooper-Vince, Knouse, & Lerner, 2010). All of these studies did not specify their subtype group composition, nor did they directly compare subtypes on the variables.

**Family difficulties in adult AD/HD.** Murphy and Barkley’s 172 clinic-referred adults with AD/HD were more likely to have been divorced and remarried than
control adults, and tended to report less marital satisfaction in their current marriages (Murphy & Barkley, 1996). Biederman and colleagues found a separation/divorce rate approximately twice that of controls in their study of (Biederman et al., 1998). Barkley and colleagues compared two large groups of AD/HD adults, those who were clinic-referred in adulthood, and those who were first diagnosed in childhood and followed longitudinally. In terms of separation/divorce rates and marital satisfaction, both groups were comparable, and fared poorer than community controls (Barkley, et al., 2007). Robin and Payson, quoted in Canu and Carlson (2004), surveyed 80 married couples about the sources of dissatisfaction in their marriage. Each couple consisted of an AD/HD and a non-AD/HD partner. The most frequently nominated items were poor task management, impulsive communication, inattention to their partner, and emotional outbursts.

Barkley and colleagues’ comparison of clinic-referred and childhood-diagnosed adults with AD/HD found that both groups were highly likely to have children with AD/HD, consistent with the genetic studies, however the data also showed that children with AD/HD had a greater range of psychological problems if their parents also had AD/HD than if they didn’t (Barkley, et al., 2007). Wymbs and colleagues, in a study of 282 families, demonstrated that parents of youths diagnosed with AD/HD were more likely to divorce, and were quicker to do so, than the parents of children without AD/HD (Wymbs, Pelham, Molina, Gnagy, & Wilson, 2008). There is no information on the impact of AD/HD subtype on family functioning.

**Financial problems in adult AD/HD.** No studies investigating financial problems in adults with AD/HD have been published, although clinicians, families and patients themselves report difficulties with handling financial responsibilities in adulthood (Barkley, 2006; Barkley & Gordon, 2002; Harpin, 2005; Robin, 2002;
Safren, Perlman, Sprich, & Otto, 2005). In addition, the economic burden of treating their own or their children’s AD/HD is known to exacerbate financial problems (Harpin, 2005; Matza, Paramore, & Prasad, 2005).

**Summary: Functional Outcome Research in Adult AD/HD**

To summarise, adults with AD/HD experience a range of negative outcomes in day to day living, according to studies that compared them to non-AD/HD adults. In particular, social functioning, vocational issues, and family difficulties have been identified as obstacles for adults with AD/HD. Difficulties with handling finances are reported by clinicians, although no study has confirmed this. One study has found that work and interpersonal impairments are more associated with AD/HD symptoms than with depression or anxiety (Safren, et al., 2010). The researchers have been diverse in the methodologies used to examine outcomes, and there have been a number of disparate measures and methods used. Because of this, the results cannot be compared across studies. In addition, no one has examined all of these outcome measures together in one study. Treatments for adult AD/HD will need to address these difficulties, but to do so requires more knowledge about which aspect/s of AD/HD contribute to these difficulties. This would have implications not only at the individual level, but also at the societal level. Treatments could then be directed at those aspects most strongly associated with poor outcomes.

**Justification for the Study**

Overall, there are three main issues that continue to plague research on adults with AD/HD. The first is the issue of heterogeneity among the adult AD/HD groups studied. This heterogeneity has arisen from methodological issues such as sampling bias, study entry criteria and diagnostic criteria, disagreement on the measurement of
variables, the identification of subtypes, and the matching of clinical and control groups on key demographics known to affect performance. The measurement of key domains, such as attention and executive functioning, has not been systematic and theoretically based, and often the two domains are not examined simultaneously. Tests that are theoretically and psychometrically sound have not always been utilised. The distinction between clinical and community based samples has not been delineated, and the issue of whether to include those with comorbid disorders remains unresolved. Key variables known to affect neuropsychological performance, such as gender, IQ, or educational level, are not always matched between groups. Finally, while AD/HD subtypes are often identified, they are grouped together for statistical reasons, which is likely to obscure any differences.

A second issue is the high incidence of psychological difficulties found in adults with AD/HD. The effects of depression, anxiety, and stress on neuropsychological performance are well documented (Lezak, et al., 2004), however these will also affect outcomes such as social, vocational, family and financial functioning. Researchers have partially addressed this issue by identifying comorbid conditions and covarying these in their analyses. However, a number of studies have reported that adults with AD/HD commonly experience high levels of emotional symptoms that fall short of, or do not fit easily into existing diagnoses of psychological conditions. The relative contribution of these to neuropsychological and functional outcomes is unknown. One way to address this issue would be to measure key psychological variables and examine the associations between these, neuropsychological variables, and functional outcome variables. Researchers have argued against utilising psychological variables as covariates when examining neuropsychological differences, as the procedure masks the actual performance differences found in real world settings and thus limits the usefulness of the research (Barkley & Murphy, 2007).
The third issue is a lack of understanding of the relationships between AD/HD symptoms such as poor attention, hyperactivity, and impulsivity, and psychological and functional difficulties. The implications of this lack of understanding are serious. An understanding of these relationships is vital to deciding whether adult AD/HD is a debilitating condition, and is a disability that requires treatment or accommodation. It is important to know whether there are symptoms that would help identify those who will require ongoing help, and those who will not. A key question is whether adults with AD/HD need their AD/HD symptoms treated, or only require treatment for psychological conditions. This has broad implications for health care at the individual level, and at the level of health care administration for AD/HD populations.

No studies have simultaneously examined objective neuropsychological performance, psychological difficulties, functional outcomes, and their relationships in a group of adults with AD/HD. This is despite the commonly-held view that growing up with disabling AD/HD symptoms is likely to lead to problems in adult life. Previous research has shown that there is an association between symptom counts and objective neuropsychological deficits. One study has shown links between symptom counts and functional outcomes. An investigation of the links between neuropsychological deficits, psychological difficulties, and functional outcomes in one well-defined group of adults with AD/HD would greatly contribute to an understanding of AD/HD over the lifespan. In addition, a direct comparison of whether neuropsychological or psychological factors better predict functional impairments would inform general treatment protocols, as well as support clinician decision-making about where best to direct individual treatment.
Methodology of the Study

This study of adults with AD/HD was drawn from both community and clinical sources to represent a broader range of functional outcomes. Firstly, the study examined attention, memory and executive functioning utilising more comprehensive theory driven neuropsychological measures than those used in many previous studies. Secondly, the study also identified psychological symptoms in this group through a self-report measure of depression, anxiety and stress symptoms. Thirdly, the study measured functional outcomes in the group, also with a self-report measure. The outcomes chosen for study (social, vocational, family/home, and financial functioning) were selected on the basis of their frequency in the adult AD/HD outcome literature. Finally, the study examined the relationships between the neuropsychological measures, psychological symptoms, and functional outcomes.

The study utilised a neuropsychological approach to examine the characteristics of adults with AD/HD at a group level for a number of reasons. Firstly neuropsychological theories of AD/HD have an important role in describing the deficits believed to underlie symptomatic behaviour, and relating these to brain structure and function (Nigg, Blaskey, Huang-Pollock, & Rappley, 2002). Secondly, the neuropsychological findings to date are mixed, and needs to be understood fully to provide a comprehensive picture of the disorder (Nigg, 2006). Thirdly, a neuropsychological approach can help evaluate the validity of the AD/HD subtypes (Pennington, 1997). The study utilised a self-report approach to determining psychological and functional outcomes based on the traditional approach to the measurement of psychological states, in an attempt to prevent interviewer bias and to ensure more candid responses (Babbie, 1995). The study had three aims. These aims,
considered in the context of previous findings, suggest some hypotheses about adults with AD/HD.

**Aim One.** The first aim was to more accurately define the neuropsychological deficits that are believed to contribute to AD/HD symptomatology, using theory-driven measures and more careful sampling. It was expected that both subtype groups of adults with AD/HD would perform poorer than controls on all four attentional components: focus/execute, sustain, and encode, and shift, based upon studies that had utilising careful matching of participants. It was also expected that both AD/HD subtype groups would share this performance deficit due to the shared inattentive symptom set necessary for an AD/HD diagnosis. In addition, AD/HD imaging has found AD/HD dysfunction in the dorsolateral PFC, a region believed to underpin the focus/execute and shift components of attention.

It was expected that adults in both AD/HD subtype groups would exhibit poorer verbal memory, due in part to the diagnostic requirement of memory impairment for both subtype classifications (see Table 1, Inattention symptoms). This was also expected due to the involvement of the temporal and frontal lobes in memory performance, areas shown to be dysfunctional in AD/HD. Visual memory performance in both adult AD/HD subtype groups was expected to be comparable to controls, because the visual memory measure utilised would have partialled out the effect of visuoconstructional factors. This was also expected because the supporting regions of visual memory have not been shown to be involved in AD/HD.

In executive functioning, adults in both AD/HD subtype groups were expected to perform more poorly in interference, due to the shared distractibility (inattention) factor required for classification into both subtypes, as well as to the involvement of the anterior cingulate cortex in this process, a region found to be dysfunctional in AD/HD.
It was expected that the Inattentive subtype group would perform more poorly on the working memory measure than the Combined subtype group, as was found in a previous study with a high proportion of Inattentive participants. In planning ability, both subtype groups were expected to perform more poorly than controls, but for different reasons. For the Combined subtype group, impulsive responding has been observed in a previous study, while in the Inattentive subtype group, difficulties with working memory may impact their performance on this measure. This task also has been linked with the dorsolateral PFC, implicated in AD/HD. Finally, in response inhibition, both subtype groups were expected to exhibit poorer performance than controls. Both the previous literature and the CCPT manual itself do not suggest any performance differences among subtype groups on this measure.

**Aim Two.** The second aim was to more accurately define the psychological and functional outcomes that adults with AD/HD have reported experiencing in their day-to-day lives. Adults with AD/HD were expected to report elevated levels of depression, anxiety and stress symptoms, in line with the findings of a number of previous studies. Those with the Inattentive subtype were expected to report more depressive symptoms than those of the Combined subtype, as has been found in one exploratory study and among children with AD/HD. The effect of subtype on anxiety or stress is unknown, but it was expected that those with hyperactive symptoms (i.e., the Combined subtype) would be likely to report more anxiety and stress than those of the Inattentive subtype.

In terms of social functioning, it was expected that the Inattentive subtype group would report more problems than those in the Combined subtype group, relative to controls, based on previous research comparing the two groups directly. In terms of vocational functioning, both subtype groups were expected to report more problems in this area than controls, with the Combined subtype group affected by both impulsivity
and inattention symptoms, and the Inattentive subtype group affected by inattention symptoms. In terms of family functioning, both subtype groups were expected to report more problems than controls, due to inattention and memory symptoms, which have been shown to adversely affect non-AD/HD spouses and partners. In terms of financial functioning, the Combined subtype group were expected to report more difficulties than either the Inattentive subtype or control groups, due to the presence of symptoms of impulsivity.

Aim Three. The third aim was to determine the extent and direction of any associations between neuropsychological, psychological, and functional outcome variables. There were no previous findings to base hypotheses on, however clinicians have argued that adults with psychological conditions represent a particularly severe subgroup of adults with AD/HD who experience the worst eventual outcomes. Therefore, it was expected that both neuropsychological and psychological variables would contribute to poor functional outcomes in both adult AD/HD subtype groups.

A more detailed methodology and the findings of the study are presented in the following chapters. The neuropsychological findings are presented first, in Chapter Four, while the psychological and functional outcome findings are described in Chapter Five, along with an analysis of the relationships between the neuropsychological, psychological, and functional outcome variables. Finally, general conclusions and implications arising from the findings are presented in Chapter Six. The following chapter, Chapter Three, details the sampling and measurement of the AD/HD and control groups.
Chapter Three

Methodology

This chapter outlines the methodology used to identify, recruit and assess the study participants. It also describes how the variables of interest were measured and analysed statistically to address the aims of the study. The study had three aims. The first was to more accurately define the neuropsychological profiles of adults with AD/HD in contrast to matched controls, focusing specifically on attention, memory and executive functioning variables. The second aim was to more accurately identify the psychological and functional outcomes experienced by adults with AD/HD, again comparing these to matched controls. The third aim was to examine the associations between the neuropsychological, psychological and functional outcomes among the AD/HD adults.

To achieve these aims it was essential to address the limitations of previous studies. These limitations were addressed by: 1) using a more thorough, multipronged approach to assessing AD/HD and control participants for study entry; 2) using a more comprehensive set of neuropsychological tests drawn from sound theoretical bases; and 3) recruiting a control group matched on age, gender, educational level, and estimated full-scale IQ to the AD/HD participants. Control groups need to be matched to clinical groups on these characteristics if neuropsychological performances are to be considered comparable (Lezak, et al., 2004).

Three groups of adults were recruited for this study. One group consisted of adults who met DSM-IV-TR criteria for AD/HD, Combined subtype, and another was comprised of adults who met DSM-IV-TR criteria for AD/HD, Inattentive
subtype, using the Conners Adult ADHD Rating Scale - CAARS (American Psychiatric Association, 2000; Conners, Erhardt, & Sparrow, 1999). These participants were drawn from both community and clinical sources, which was a deliberate strategy to address the limitations of previous studies, where most samples had been drawn from clinical sources. The third group, the control group, consisted of adults who had no AD/HD history or current symptoms according to a screening questionnaire (Conners, et al., 1999), matched by age, gender, educational level, and estimated full-scale IQ to the AD/HD sample. In the AD/HD groups no individuals were found with the Hyperactive/Impulsive symptom profile, although the CAARS did allow for the identification of this group (Conners, et al., 1999). This is the third subtype of AD/HD listed in the DSM-IV-TR (American Psychiatric Association, 2000), and these individuals exhibit symptoms in that domain only, with no (or subclinical levels of) inattentive symptoms. This subtype is rarely identified in research studies and researchers have noted that it has the least empirical support as a valid subtype. It was originally created by the DSM-IV workgroup to encourage research on its validity (Lahey, Carlson, & Frick, 1997; Milich, Balentine, & Lynam, 2001).

Participants with AD/HD and comorbid conditions were included in this sample in recognition of the high degree of comorbidity in AD/HD adults (Katz, Goldstein, & Beers, 2001). The issue of whether neuropsychological performance in adults with AD/HD is affected by comorbid conditions has not yet been resolved. The neuropsychological performances of adults with AD/HD and comorbid mood disorders have not differed from those with only AD/HD in some studies (Katz, et al., 1998; Murphy, et al., 2001). Other studies have found that adults with AD/HD and comorbid anxiety or depression performed more poorly than those with only AD/HD on attentional tasks (Downey, et al., 1997). In this study comorbid
diagnoses were made only for the AD/HD participants as part of the study’s inclusion process. Control participants were not diagnosed, and consequently the groups could not be directly compared on this variable.

**Participants**

A total of 62 adults aged 17 to 63 years participated in this study. They consisted of 32 individuals with AD/HD (mean (SD) age = 37.8 (13.1), and 30 matched controls (mean (SD) age = 39.6 (12.9). The AD/HD group comprised 16 individuals with Inattentive subtype (AD/HD-I, 10 females and 6 males) and 16 individuals with Combined subtype (AD/HD-C, 8 females and 8 males). The control group comprised 21 females and 9 males. Both groups had educational levels ranging from 8 to 19 years of formal education.

AD/HD participants were recruited from local general practitioners and psychiatrists, from a support group for adults with AD/HD and a support group for parents of AD/HD children, and from snowball sampling. AD/HD participants referred from clinical sources comprised 22% of the overall group, while 78% were drawn from the community. Control participants were recruited from family members or friends of AD/HD support group members, from first year psychology classes at Griffith University, and from snowball sampling. All control participants were below the clinical cut-off for adult AD/HD using the CAARS Screener Version (Conners, et al., 1999), and had no history of AD/HD symptoms. Participants in the control group were matched to those in the AD/HD group on gender, age, education level, and estimated full-scale IQ.

All participants were English speaking, had normal hearing, normal or corrected vision, and had full scale IQs of more than 80 (Bradley, Danielson, & Hallahan, 2002;
Participants who were prescribed stimulant medication were advised to be free of medication for at least a 12 hour minimum period prior to testing (Lovejoy, et al., 1999). Using the SCID-IV, 31% of the AD/HD-C and 31% of the AD/HD-I were classified in a current depressive, or mixed anxiety/depressive condition. Six percent of the AD/HD-C group and 19% of the AD/HD-I group were classified in a current anxiety condition. Ethical approval was obtained from Griffith University and the research was conducted in accordance with the approved protocol. Participants were provided with specific information on contacting the University if they had any concerns (see Appendix A), were required to read and acknowledge their informed consent (see Appendix B), and were asked to complete a demographic information form (see Appendix C).

All participants completed substance use measures to screen for drug abuse and alcohol misuse. All three groups (Control, AD/HD-C, and AD/HD-I) achieved mean scores of less than two on the DAST, the recommended cut-off for identifying a drug use disorder. On the AUDIT, four Control participants (14%) reported alcohol use above the cut-off of eight for hazardous drinking; two of these (7%) were above the cut-off of 13 for potential alcohol dependence (Dawe, Loxton, Hides, Kavanagh, & Mattick, 2002). A total of six (40%) participants in the Combined subtype group were above the cut-off of eight, and three (20%) were above the cut-off of 13. In the Inattentive subtype group, five participants (33%) were above the cut-off of eight, and two of these (13%) were above the cut-off of 13.

**Assessment for inclusion into the AD/HD group.** A six-step protocol was developed from the recommendations of previous researchers to confirm each participant’s status for inclusion into the AD/HD group. This resulted in a more detailed and comprehensive procedure than those in previous studies. Participants who
did not meet the AD/HD criteria, based on clinical judgement from the data gathered from these six steps, were excluded from the study:

1. A structured clinical interview (Barkley & Murphy, 1998) to elicit current and past functioning, and to confirm or refute: a) the early onset and persistence of AD/HD symptoms; b) the existence of functional impairment across settings, and c) the existence of other explanations that better accounted for difficulties.

Previous neuropsychological studies of adults with AD/HD with the most stringent methodology have relied on clinical interviews to confirm the early onset and persistence of symptoms, and the presence of clinically significant functional impairments necessary for a DSM-IV diagnosis (American Psychiatric Association, 1994; Johnson, et al., 2001; Lovejoy, et al., 1999; Murphy, et al., 2001; Rapport, et al., 2001; Rashid, et al., 2001; Seidman, et al., 1998; Walker, et al., 2000)

When diagnosing adult AD/HD for clinical (not research) purposes, researchers are also in agreement that the diagnosis is based on clinical judgement utilising information from a number of sources, including a clinical interview (Adler, 2004; American Academy of Pediatrics, 2000; Educational Testing Service, 2008; Gallagher & Blader, 2001; Hallowell & Ratey, 1994; Jackson & Farrugia, 1997; McGough & Barkley, 2004; National Health and Medical Research Council, 2009; Quinlan, 2000; Serfontein, 1994; Weiss & Murray, 2003; Wender, 1995). Adler (2004) has stated that the clinical interview “remains the bedrock of the adult AD/HD diagnosis” (Adler, 2004, p. 1), observing that rating scales and neuropsychological tests gauge symptoms, but a clinical interview enables assessment of all three core features of AD/HD accurately. These core features are 1) symptoms in early childhood; 2) significant impairment in two or more settings; and 3) moderate severity in 6 of 9 possible symptoms.
2. The Structured Clinical Interview for DSM-IV Axis I Disorders, Mood and Anxiety Modules (First, Spitzer, Gibbon, & Williams, 1998) for conditions that rule out AD/HD diagnosis, or for conditions comorbid to AD/HD.

Three previous neuropsychological studies of adults with AD/HD utilised a structured clinical interview (First, et al., 1998) to assess for comorbidities or to screen for other psychiatric conditions that might better account for AD/HD symptomatology (Johnson, et al., 2001; Rapport, et al., 2001; Seidman, et al., 1998). Other researchers relied on either semi-structured or unstructured interviews to elicit this information. Three teams of clinicians have published recommendations advising the use of the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I) as part of the protocol for diagnosing AD/HD in adults for clinical purposes (Adler, 2004; Gallagher & Blader, 2001; Murphy & Gordon, 1998). The use of the research version of the SCID-I (First, Gibbon, Spitzer, & Williams, 2002) in this study ensured reliability and validity to a standard appropriate for diagnosing individuals for clinical purposes (Shear et al., 2000). To rule out conditions that may better account for AD/HD symptoms, the AD/HD group was assessed for the presence of mood and anxiety disorders using the SCID-I Mood and Anxiety modules.


Few researchers have reported using normed, self-report rating scales as part of their diagnostic process, however the use of self-report symptom checklists has increased since adult AD/HD studies were first published in the 1990s (Murphy, et al., 2001; Rapport, et al., 2001; Rashid, et al., 2001; Walker, et al., 2000). The use of collateral information provided by significant others as part of clinical interviews has become common practice in the adult neuropsychological studies (Murphy, et al., 2001;

The Australian National Health and Medical Research Council, the Educational Testing Service, and the American Academy of Pediatrics all recommend the use of rating scales as part of the diagnostic process for determining the presence of AD/HD in adults (American Academy of Pediatrics, 2000; Educational Testing Service, 2008; National Health and Medical Research Council, 2009). In this study, the CAARS was used to assess current symptoms and symptom levels, to assess collateral data, and to identify AD/HD subtype. The CAARS (Conners, et al., 1999) is structured around the current DSM-IV-TR (American Psychiatric Association, 2000) classification of AD/HD symptoms, and yields T-scores which place an individual within one of the three AD/HD subtypes, as well as within clinical range for the disorder (e.g., meeting DSM-IV-TR criteria). It includes a validity scale designed to uncover the inflation or minimisation of symptoms. It offers highly satisfactory internal and test-retest reliability coefficients (from .64 to .91; from .88 to .91, respectively), and correlates moderately with another measure of adult AD/HD (subscale range $r = .37$ to $.67$). In addition, it has demonstrated the ability to discriminate between clinical and nonclinical adults (overall classification rate of 85%; Macey, 2003).

4. Ratings at or above clinical cut-off on a retrospective childhood rating scale (Barkley, 1998; Barkley & Murphy, 1998) completed by participant, and/or a parent or older sibling.

The verification of childhood-onset symptomatology is a criterion for diagnosis within the DSM-IV-TR classification system (Murphy, et al., 2001). A review of the
most methodologically sound published studies revealed that researchers used either
DSM-III-R-keyed instruments (e.g., the WURS or the CHAMPS; (Johnson, et al., 2001;
Rashid, et al., 2001; Walker, et al., 2000), used an instrument normed only to age 18
(Kiddie-SADS; (Seidman, et al., 1998), or used an interview of their own invention
(Murphy, et al., 2001; Rapport, et al., 2001). The only normed, adult, DSM-IV-TR-
based measure that addresses the childhood onset criterion is Barkley & Murphy’s
Childhood Symptoms Scale – Self-Report and Childhood Symptoms Scale – Other
Report, which are components of their adult assessment protocol (Barkley & Murphy,
1998). A further advantage to this measure is its use of age 12 as a cut-off for onset
rather than age 7, as the DSM-IV field trial demonstrated that this is a more appropriate
criterion to include all subtypes (McGough & Barkley, 2004). This study utilised the
Self-Report scale in all cases, and the Other Report scale whenever possible.

5. A thorough history-taking, including health, developmental, academic,
employment and social history to rule out neurological or medical conditions
mimicking AD/HD.

Although published adult AD/HD neuropsychological studies report taking
extensive histories in the course of their screening procedures, as a whole researchers
have not utilised any systematic and standardised historical interview to elicit
participant histories. As studies have suggested that the symptoms of adult AD/HD can
be attributed to a number of other conditions, such as sleep disorders (Ball, et al., 1999),
previous cocaine abuse (Levin, Evans, & Kleber, 1998), borderline personality disorder
(Dowson, et al., 2004), seizure disorders, thyroid disorders, or other medical conditions
(Pearl, Weiss, & Stein, 2001), a methodical, replicable historical interview needs to be
conducted to increase the validity of the diagnosis. In this study a published historical
interview for adult AD/HD was utilised, the Conners Adult AD/HD History Form (Conners, et al., 1999).

6. Other collateral information provided, such as medical, school or neurological reports.

Historical information from these sources can be useful to provide further evidence of childhood onset symptomatology, to document that symptoms were significant enough to attract professional attention, and/or to assess whether the difficulties were present in more than one setting. Only two published neuropsychological research groups reported using this information as part of their diagnostic protocol (Murphy, et al., 2001; Walker, et al., 2000). However, those concerned with the individual clinical evaluation of adult AD/HD are unanimous in their support of the use of this information source as an adjunct to diagnosis (Adler, 2004; Gallagher & Blader, 2001; Hallowell & Ratey, 1994; McGough & Barkley, 2004; Quinlan, 2000; Wender, 1995). In this study information from such sources was requested of participants, and when provided, was used as further evidence of the presence of the disorder.

Demographic, Screening and Equivalence Measures

Demographic measures. Demographic information was obtained at assessment immediately after participants read and signed the informed consent form (see Appendices B and C for the Informed Consent and Demographic information forms, respectively). Age was recorded by the participant twice, in both years of age and their date of birth. Gender and age had been previously noted by the examiner prior to assessment as this information was required for determining an individual’s CAARS score. Educational level was also reported by the participant, and calculated according
to the Australian Standard Classification of Education in years completed (Trewin, 2001). Participants’ postcodes were obtained to calculate socioeconomic status using the Postal Area (POA) Index of Relative Socio-economic Advantage and Disadvantage, 2008 (Australian Bureau of Statistics, 2008). Postcodes were converted to their corresponding decile ranking according to the POA Index, and then grouped into three levels of socioeconomic status for the purposes of data analysis, assigning decile rankings 1 to 3 as the lowest level, decile rankings 4 to 6 as the mid-range level, and decile rankings 7 to 10 as the highest level. Employment status was reported by the participant as either unemployed, employed part time (less than 38 hours per week), or employed full time (38 or more hours per week). Marital status was reported by the participant as either single, married or defacto, divorced, or widowed.

**Drug abuse.** The Drug Abuse Screening Test ([DAST]Skinner, 1982) was developed as a brief screening instrument assessing the use of recreational drugs, physical and medical complications, and emotional and personal problems arising from drug use in the preceding 12 months. This test was chosen because the items ask about previous rather than current recreational drug use in an attempt to increase the candour of the participants (Dawe, et al., 2002). Respondents answer Yes or No to 20 items, and the test is scored by adding the number of Yes responses (except two items where a No response indicates no problem). Raw scores range from 0 to 20. A cut-off score of between 2 and 4 has been shown to support the diagnosis of a drug use disorder. It has demonstrated high internal consistency (alpha .92 to .95) and good construct and criterion-related validity (Dawe, et al., 2002). The appropriateness of this test in adult AD/HD populations was evaluated by McCann and colleagues, who used the DAST on a population of adults with AD/HD and concluded that a raw score of 6 or above provided the optimum cut-off point to detect individuals in active substance use (McCann, Simpson, Ries, & Roy-Byrne, 2000). Yewers and colleagues also used the
DAST in an adult AD/HD population, but specific data from the DAST were not published (Yewers, Hay, & Barton, 2005).

**Alcohol use.** The Alcohol Use Disorders Identification Test (AUDIT) was developed to screen for individuals who are drinking at harmful or hazardous levels (Saunders, Aasland, Babor, de le Fuente, & Grant, 1993). An analysis of drinking patterns, medical history, alcohol-related problems and psychological reactions among 1888 individuals from six culturally diverse countries was undertaken in the creation of this instrument. The AUDIT consists of 10 items selected through statistical analysis and is thought to measure three aspects of alcohol use: consumption, dependence, and related problems. It is scored by adding each of the ten items, with raw scores ranging from 0 to 40. A score of eight or above has been used to indicate the presence of alcohol problems in men, while a lower cut-off score of four has been suggested for women and adolescents. It has yielded good internal reliability within a number of populations (Cronbach alphas .80 to .94), as well as good test-retest reliability ($r$ .88 to .96). It has also demonstrated acceptable construct and predictive validity (Dawe, et al., 2002). McCann and colleagues (2000) used the AUDIT on an adult AD/HD population, and found that sensitivity was better at a lower cut-off of six, with little reduction in specificity, for detecting alcohol abuse. Yewers and colleagues (2005) found no differences in alcohol use levels between their AD/HD and non-AD/HD adults using the AUDIT.

**Intelligence.** The Wechsler Abbreviated Scale of Intelligence (WASI), an abbreviated form of the WAIS, uses the scores of the Vocabulary and Matrix Reasoning subtests to estimate full-scale IQ (The Psychological Corporation, 1999). This is a recommended method for reducing testing time in research (Strauss, Sherman, & Spreen, 2006), and was employed in this study. The two-subtest IQ estimate has good psychometric properties, with a mean reliability of .94. The Vocabulary subtest is
correlated at .88 with the WAIS Vocabulary subtest, and the Matrix Reasoning at .66 with that of the WAIS (Spreen & Strauss, 1998; The Psychological Corporation, 1999). The participants’ estimated full-scale IQs were obtained as a means of assessing the comparability of the control and AD/HD groups.

Neuropsychological Measures

Fourteen scores comprised the set of neuropsychological variables used in this study. Four components of attention, derived from factor analyses and applied to AD/HD models by Mirsky and colleagues (1991; 1999) were used. Three verbal memory measures were utilised that corresponded to everyday recall tasks, and encompassed the immediate, delayed and learning components of memory. A test of visual memory was used that had made no demands on visuoconstructional abilities, and generated scores for overall, delayed, and retention after delay performances. Four executive functioning components were utilised that were suggested by Nigg (2006) as applicable to AD/HD models.

Attentional focus/execute. Mirsky and colleagues found in their factor analyses that the TMT (Reitan, 1958) represented a component of attention they identified as ‘focus/execute’ (Mirsky, et al., 1991). The TMT (Reitan, 1958) consists of two parts, A and B. Part A requires the test taker draw lines connecting consecutively numbered circles, while Part B requires the test taker to draw a line between consecutively numbered and lettered circles, alternating between the two series. The test-retest reliabilities of the TMT have been found to range from .64 to .94, and the test been linked to frontal lobe dysfunction (Spreen & Strauss, 1998). The measure used in this study was the number of seconds taken to successfully complete Part B of the task.
The TMT is believed to tap visual scanning, perceptual-motor speed, and numerical sequencing on Part A of the test. Part B greatly increases the cognitive complexity of the task by requiring alphabetical sequencing and the need to shift between alphabetic and numeric sets. The difficulty of Part B is greater due to increased demands in motor speed and visual scanning, as well as a 32% increase in total tracking distance over Part A (LoSasso, et al., 1998). In addition, visual scanning for Part B is more difficult due to the greater number of visually interfering stimuli present between target stimuli (Arbuthnott & Frank, 2000).

**Sustained attention.** Sustained attention was measured by the use of the CCPT-II, a 14-minute computerised visual CPT test that has been normed on 1,190 individuals from the general population and from clinical referrals for attention problems. The normative group ranged from 4 to 70 years of age, and norms are collapsed into seven age groups (Conners & MHS Staff, 2002). The test generates 13 indices of performance that can be examined for response patterns (Riccio, et al., 2001), and uses the ‘x’ paradigm; that is, test takers must refrain from responding to the letter ‘x’ while responding to all other letters that appear. This paradigm was singled out by Oades (2000) as one requiring less load on working memory than other paradigms that require a response or nonresponse to an ‘x’ after another target, such as an ‘a’. It has obtained split-half reliabilities of between .73 and .95 for the various indices, with test-retest reliabilities ranging between .08 and .92. Validity studies have demonstrated the test’s ability to discriminate between clinical and nonclinical groups (e.g., AD/HD, neurological, or psychiatric diagnoses). In Mirsky and colleagues’ factor analyses, a CPT was used for measuring what was later identified as the sustain factor, using percentages of correct and incorrect responses and reaction times as scores (Mirsky, et al., 1991). In this study, the Attentiveness (d’) score was used to approximate Mirsky and colleagues’ percentages of correct and incorrect responses scores. These scores
appeared to be the most similar to Mirsky and colleagues’ CPT measures because they were based on reaction times, and depended upon the ability to distinguish and detect targets and non-targets over time.

**Attentional encoding.** Digit Span loaded onto the ‘encode’ factor in Mirsky and colleagues’ factor analyses, which they defined as “a mnemonic capacity to hold information briefly in mind while performing some action or cognitive operation on it” (1999, p. 172). Researchers and clinicians have subsequently separated overall Digit Span performance into two separate abilities, encoding the information and holding it in short term memory, and performing an action or cognitive operation upon it. This latter ability is now seen as working memory (Lezak, et al., 2004). For this reason it is more accurate to use the Digit Span Forward score, and not the Digit Span Backward score, to represent attentional encoding. Lezak and colleagues (2004) highly recommend using the raw score of this subtest, as it has a relatively restricted range and does not correlate too highly with other measures. The Digit Span Forward subtest from the Wechsler Memory Scale-III requires an individual to repeat back a random string of digits immediately after hearing them, with a gradual increase in string length on successive correct trials (Wechsler, 1997). This test offers internal consistency reliability coefficients of .88 to .90 averaged across age groups. In addition, test-retest reliabilities of .83 to .87 were obtained in persons aged 30 to 54. The score used in this study was the number of correct trials completed out of a possible 16.

**Attentional shift.** Attentional shifting is the capacity to shift attentional focus from one aspect of a stimulus to another in a flexible, efficient manner (Lezak, et al., 2004). The Categories score of the WCST (Grant & Berg, 1948) was used by Mirsky and colleagues as a measure of this capacity. The Wisconsin Card Sorting Test Computer Version 4 was used in this study, and requires test takers to sort a large
number of cards according to their various aspects (e.g., colour, number or shape). The test requires flexibility in this task, as the sorting rules change without notice, and shift several times over the course of the task. Test-takers must determine the rule change based on feedback from their last attempt. The Categories Completed score represents the number of sequences of 10 consecutive correct matches, and ranges from 0 for someone who never manages to learn the task, to 6, when the task is considered complete. The test is a computerised version of the original manually administered version, and has been shown to be equivalent (Fortuny & Heaton, 1996).

**Verbal memory.** Logical Memory I and II, subtests from the Wechsler Memory Scale-III (Wechsler, 1997), are story recall tasks with a standardised presentation and scoring protocol useful for determining immediate and delayed recall performance, the effect of repetition on learning, and retention of material over time. Scoring requires minimal examiner judgment, and several scores can be derived from the subtest. Logical Memory I and II (LM I and LM II) have obtained internal consistency reliability coefficients of .79 to .88 across age groups, and test-retest reliabilities of .76 to .77 (Wechsler, 1997). The scores used in this study represented immediate, delayed and rate of learning measures, and were: LM I Recall Total, the amount of information recalled immediately after hearing the stories, LM II Recall Total score, the amount of information recalled after a 30 minute delay; and LM I Learning Slope, the rate of learning between the second and third trials.

**Visual memory.** The Shum Visual Learning Test (SVLT) uses Chinese characters as stimuli and a format similar to the word list memory tests, presenting five learning trials and one distractor trial to measure interference, then a recognition trial. In addition, a delayed recognition trial is presented after a 20-minute interval. The SVLT has obtained test-retest reliabilities of .63 to .82 and has been normed for seven
age groups ranging from 17 to 70+ years, based on the scores of 146 Australians. The scores from this test used in this study represented immediate, delayed and rate of learning measures, and included: SVLT Overall Learning Score, SVLT Delayed Retention Score, and SVLT Learning Index.

**Executive functioning: interference.** Nigg (2006) has recommended using the Stroop task for this variable, as it isolates interference control better than most measures do, and yields different results for AD/HD individuals than measures of working memory. The version of this task used in this study was the Stroop Color and Word Test (Golden, 1978). It has obtained test-retest reliability coefficients from .83 to .91 for healthy individuals, and factor analytic studies have suggested that it is related to serial subtraction tasks, as well as reflecting the ability to sustain mental processes and select appropriate features (Shum, McFarland, & Bain, 1990). The test has been effective in distinguishing between psychiatric and brain-damaged samples, and is sensitive to the severity of dementia, however it is also sensitive to depression and anxiety (Spreen & Strauss, 1998). Four raw scores are derived from the task: the Word raw score, the Color raw score, the Color-Word raw score and an Interference score. In this version, examinees are required to name as many items as they can within 45 seconds for each condition (Balint et al., 2009). A number of researchers have argued for a Stroop interference score for this version of the Stroop task that is more accurate than Golden’s original formula, as the original formula does not yield a score independent of general slowing (Troyer, Leach, & Strauss, 2006; Verhaeghen & De Meersman, 1998). Chafetz and Matthews (2003) suggested a formula that assumed that the time to read a Color-Word item consisted of the time to suppress reading a word, plus the time to name a colour. For this reason, in this study the interference score used was Chafetz and Matthew’s (2003) formula: Color - Color-Word.
Executive functioning: working memory. In Nigg’s model, working memory includes both the storage and processing of the information, and he recommends using Digit Span Backward for this variable (2006). Research on working memory performance in adults with AD/HD has been divided between those who use a spatial working memory task (Dowson, et al., 2004; McLean, et al., 2004; Turner, et al., 2005; Valera, et al., 2005) and those who use the Digit Span Backward subtest of the Wechsler tests, which is thought to be more verbally based. This is possibly because many people report that they perform Digit Span Backward by making a mental image of the digits and reading them backward from this image (Lezak, et al., 2004). However Larrabee (2004) has suggested that spatial span working memory tasks load more on a visuospatial factor than on an attentional/working memory factor. Digit Span Backward requires an examinee to repeat back a string of digits immediately after hearing them, with a gradual increase in string length with successive correct trials. The test’s internal consistency is excellent, in excess of .90 and test-retest reliability high, between .80 and .89 (Strauss, et al., 2006). In this study, following the suggestion of Lezak and colleagues, the raw score was used, signifying the number of correct trials completed (2004).

Executive functioning: planning. The Tower tasks have been recommended to measure planning in AD/HD (Nigg, 2006). The Tower of London task used in this study was developed by Tunstall (1999), who increased the number of disks from three to four to address the ceiling effect commonly reported in the original version (Levin et al., 1997). Four coloured disks, each with a centre hole, fit on a three-peg board. Each peg holds two, three, or four disks only. The disks are arranged in a start position, which is where each trial is begun. Subjects are asked to move the disks using a pre-set number of moves in order to match a picture, and are given three attempts in which to do so correctly. There are ten trials worked through from easiest to hardest. Three
points are awarded for correctly completing a trial on the first attempt, two on the second, one on the third, and zero if the problem was not solved within three attempts. Total scores are obtained by summing the scores across the ten trials, with the range of possible scores from 0 to 30. From this information scores can be obtained to identify the total of the first five trials (known as the simple total), which are relatively simpler than the second five, the total for the second five trials (the complex total), and an overall total, using the points system described above. While the subject is solving each problem, the examiner times both the time required to make the first move of the trial, and the time required to complete the trial. Thus, planning time (considered to be the time to make the first move) can be averaged for the first five trials (simple average planning time), the second five trials (complex average planning time), and for all ten trials (average planning time).

In this study a total score, representing successful completion in either one, two or three trials, was used. Therefore, a perfect score would be 30 (3 points on each of 10 trials), and no successful completions within three trials on all 10 problems would earn a score of 0. The use of accuracy scoring was following the convention of previous studies examining adults with AD/HD on this measure (Muller, et al., 2007; Nigg, et al., 2005; Riccio, et al., 2005; Stavro, et al., 2007).

**Executive functioning: response inhibition.** Response inhibition has been defined as the ability to withhold or suppress automatic responses that are incompatible with the goal when the context changes dynamically. This ability has been identified by all AD/HD theorists as central to the difficulties encountered by this population. However, there is a distinction between reactive suppression and strategic suppression of behaviour that is often missed by theorists and explains some of the apparently paradoxical behaviours of AD/HD (Nigg, 2001, 2006). A commonly used measure of
response inhibition is the Commissions score derived from the CPT (Lezak, et al., 2004), which tracks the number of times that an individual responds to nontargets over a 14-minute period. In this study the Commissions score, derived from the CCPT-II, was used as a measure of response inhibition, as recommended by Nigg (2006) and utilised by others in previous studies of adults with AD/HD (Barkley, 1997b; Epstein, et al., 2001).

**Psychological functioning.** In this study, the Depression Anxiety Stress Scale-21 (DASS-21; Lovibond & Lovibond, 1995) was used to assess the most commonly reported psychological symptoms found among adults with AD/HD. The instrument was developed in Australia to meet the need for a depression scale that assessed the full range of core symptoms of anxiety and depression while providing maximum discrimination between anxiety and depression. During psychometric development of the scale a third factor emerged from the items, stress, and was consistently found in further analyses by other researchers as the scale was tested. A 42-item scale emerged, with 14 items each loading onto one of three subscales: depression, anxiety and stress (Brown, Chorpita, Korotitsch, & Barlow, 1997). In 1998 Antony and colleagues demonstrated that a shorter 21-item version of the scale first suggested by its original authors provided a clearer factor structure and smaller interfactor correlations (Antoney, Bieling, Cox, Enns, & Swinson, 1998). Further investigation of its reliability, validity, and applicability to divergent demographic groups using larger samples has supported the usefulness of the DASS-21 (Crawford & Henry, 2003). This instrument is more appropriate for adults with AD/HD as it has no items referring to poor concentration, in contrast to other scales such as the Beck Depression Inventory (Steer, Ranieri, Kumar, & Beck, 2003).
The reliability (internal consistency) of the DASS-21 has been estimated using Cronbach’s alpha, and has ranged from .89 for the Anxiety scale, and .96 for the total score. Convergent validity has been assessed using the Hospital Anxiety and Depression Scale, the Personal Disturbance Scale, and the Positive and Negative Affect Schedule, and the resulting correlations ranged between .62 and .78 (Crawford & Henry, 2003). For this study all three subscales, depression, anxiety and stress, were utilised to sample psychological functioning. Raw scores (ranging from 0 to 21) are obtained by summing the items for each subscale: Depression, Anxiety and Stress. The raw scores can be transformed using $z$ scores into five clinical ranges: Normal, Mild, Moderate, Severe, and Extremely Severe (Lovibond & Lovibond, 1995). There are no published accounts of the use of this scale with an adult AD/HD population.

**Functional outcomes.** The ability to attend and exert self-control is fundamental to healthy adjustment, and individuals with difficulties in these areas will struggle in most life circumstances. While these individuals may not be destined for gross maladjustment, they are a vulnerable group. According to the research, it is probable that AD/HD has the effect of limiting an individual’s coping abilities. Some have argued that what characterises adults with AD/HD is that they cannot handle the commonplace aspects of their lives as well as most, and their impairments are evident not only in challenging environments, but in coping with everyday routine tasks and day to day living (Barkley & Gordon, 2002). This study utilised a self-report measure of day to day functioning that covered a number of areas important to successful adult living.

**Social, vocational, family and financial problems.** The Personal Problems Checklist for Adults (PPCA; Schinka, 1985) is a 208-item screen for problems of everyday functioning in adults 18 to 60 years of age. The instrument is written at the
seventh grade reading level and encompasses 13 areas of functioning: social, appearance, vocational, family and home, school, finances, religion, emotional, sexual, legal, health and habits, attitudes, and crises. Each area contains from 10 to 34 items each, and individuals are asked to read through the list and tick the items that apply to them currently. The instrument was not designed to be a multi-scale inventory, but rather items were selected for content coverage on the basis of expert judge panels. It serves as a clinical checklist designed to provide an actuarial index of the number of problems or stressors being encountered in everyday life. It has acceptable reliability ($a = .43 - .80; r = .49 - .61$) and has demonstrated convergent and predictive validity (Piedmont, Sherman, & Barrickman, 2000). One published study has demonstrated significant associations between the types of personal problems nominated on this checklist pre-treatment and corresponding psychological distress indices on the Brief Symptom Inventory (Derogatis, 1993; Piedmont, et al., 2000).

For this study, four areas of functioning were chosen to correspond with the most commonly reported functional difficulties of adults with AD/HD (Barkley & Gordon, 2002; Goldstein, 2002; Kilcarr, 2002; Robin, 2002; Young & Bramham, 2006): Social functioning (raw score range 0-18); Vocational functioning (raw score range 0-18); Family/Home functioning (raw score range 0-34); and Financial functioning (raw score range 0-12). The following describes each of the four areas of functioning in greater detail.

**Social problems.** The social problems section of the PPCA consists of 18 items that individuals tick if it is a “problem that they are now having” (Schinka, 1985). The social problems score is obtained by summing the number of items nominated. The items in the social domain include statements such as “not getting along with other
people”, “not fitting in with peers”, “feeling uncomfortable in social settings”, and “feeling different from everyone else”.

**Vocational problems.** The vocational problems section of the PPCA consists of 18 items that individuals tick if it is a “problem that they are now having” (Schinka, 1985). The vocational problems score is obtained by summing the number of items nominated. The items in the vocational domain include statements such as “not having a job”, “being afraid of failing on the job”, “boss being critical or unfair”, and “being bored on the job”.

**Family/home problems.** The family/home problems section of the PPCA consists of 34 items that individuals tick if it is a “problem that they are now having” (Schinka, 1985). The family/home problems score is obtained by summing the number of items nominated. The items in the family/home domain include statements such as “children misbehaving”, having problems with in-laws”, spouse having different interests”, and “not getting along with neighbors”.

**Financial problems.** The finance problems section of the PPCA consists of 12 items that individuals tick if it is a “problem that they are now having” (Schinka, 1985). The finance problems score is obtained by summing the number of items nominated. The items in the finance domain include statements such as “budgeting money”, having unpaid bills”, depending on others for financial support”, and spouse being careless with money”.

**Procedure**

Participants in both the AD/HD and control groups were assessed individually in a one-on-one testing situation, in a quiet, well lit room for a period of two to three hours. They were encouraged to take breaks and refreshments. The time of day for
testing was not controlled as participants were free to choose the time that suited them best. Testing order was counterbalanced, so that half of the participants completed Parts 1, 2, then 3, and the other half of the participants completed Parts 1, 3, then 2 (see Table 3). This was to ensure that systematic fatigue effects did not affect the results.

Table 3

*Testing Protocol for Control and AD/HD groups*

**Part 1**

Wechsler Abbreviated Scale of Intelligence (2 Subtest Form)

**Part 2**

California Verbal Learning Test II (Part 1)
Shum Visual Learning Test (Part 1)
California Verbal Learning Test II (Part 2)
Trailmaking Test Parts A & B
Controlled Oral Word Association Test
California Verbal Learning Test II (Part 3)
Shum Visual Learning Test (Part 2)
WMS-III Digit Span Forward & Backward
Tower of London-4

**Part 3**

WMS-III Logical Memory I
Conners Continuous Performance Test II
Wisconsin Card Sorting Test
WMS-III Logical Memory II
Stroop Colour & Word Test

After completing the neuropsychological assessment protocol, participants were given a self-addressed, stamped envelope in which the DASS-21, DAST, AUDIT and PPCA were to be returned by mail after completion in privacy. Each instrument was briefly outlined, along with a general explanation provided on how to answer the items (i.e., what time period each instrument covered, and the qualitative meaning of the scale
items). The administrative procedures taken to ensure anonymity were explained and emphasised. Two participants out of 62 failed to return the post-assessment questionnaires.

Summary

This chapter outlined the methodology used to obtain a comprehensive assessment of attention, memory, executive functioning, psychological and functional outcomes in three groups of adults. The following chapter describes the findings of the first aim of the study, where relative group performances on attention, memory and executive functioning variables are presented and discussed.
Chapter Four

Neuropsychological Results

This chapter presents detailed findings on the attention, memory and executive functioning performances of three groups of adults. They consisted of one group with AD/HD Combined subtype (AD/HD-C), one group with AD/HD Inattentive subtype (AD/HD-I), and a matched control group. The groups were administered a comprehensive battery of neuropsychological tests to fulfil the first aim of the study. This aim was to clarify neuropsychological performance differences between adults with AD/HD and controls, by resolving many of the methodological limitations of previous studies. Both AD/HD subtype groups were expected to perform poorer on all four attentional components: focus/execute, sustain, encode, and shift, based upon the studies that had utilised careful matching of controls. This was predicted because both subtypes share a common inattention symptom set that would likely affect performance on these attentional components. This was also predicted from previous evidence of dysfunction in the dorsolateral PFC in AD/HD, a region supporting several aspects of attention.

It was expected that both AD/HD groups would perform poorly on the verbal memory measures, due in part to the inattention section of the diagnostic criteria describing memory impairment. However this was also predicted from studies demonstrating the involvement of temporal and frontal lobe systems in verbal memory processes, as these regions have been shown to be dysfunctional in AD/HD. Visual memory performance in both adult AD/HD groups was expected to be comparable to controls, in contrast to previous studies. This was predicted because previous studies had not partialled out the effect of visuoconstructional factors in previous tests of visual
memory. Studies that had used visual memory tests with a large visuoconstructional component had resulted in equivocal findings, perhaps due to this issue. This was also predicted because the supporting regions of visual memory have not been shown to be dysfunctional in AD/HD.

Lastly, the AD/HD groups were expected to perform poorer than controls on a number of executive functioning components. In interference, this was predicted due to the shared distractibility (inattention) symptom set, as well as due to the involvement of the anterior cingulate cortex in interference performance, a region found dysfunctional in AD/HD. In working memory, it was expected that the AD/HD-I group would perform poorer than the AD/HD-C group, as poor performance was found previously in a study with a high proportion of AD/HD-I participants. In planning, both AD/HD groups were expected to perform poorer than controls, but for different reasons: the AD/HD-C group due to impulsivity, and the AD/HD-I group due to working memory dysfunction. This task has also been linked to the dorsolateral PFC, known to be dysfunctional in AD/HD. However, subtype differences in dorsolateral PFC dysfunction have not been studied. In response inhibition, both AD/HD groups were expected to perform poorer than controls, as this is a robust finding in AD/HD. However, neither previous studies nor the CCPT manual suggest that there are subtype differences in response inhibition performance.

**Data Analysis**

Prior to analysis, all variables were examined using SPSS 17.0 to evaluate their distributions and the assumptions for univariate and multivariate analysis. Two cases in the control group had missing values for the psychological and functional outcome variables, and these were excluded from the analyses pertinent to these variables (the psychological and functional outcome variables are summarised in Chapter 5). Using a
A z score of three or more as the criterion, 31 outlier values were identified by examining the variable distributions for each group on every dependent variable. These were transformed by assigning a value one unit larger (or smaller) than the next most extreme score in the distribution (Tabachnick & Fidell, 1996).

Participant characteristics. One-way independent group ANOVAs were conducted to test for differences between the control, AD/HD-C and AD/HD-I subtype groups on age, years of education completed, and estimated full-scale IQ. As shown in Table 4, there were no significant differences between the three groups for age, years of education completed, or estimated full-scale IQ.

Table 4

Control and AD/HD Subtype Group Averages: Age, Years of Education and Estimated Full-Scale IQ

<table>
<thead>
<tr>
<th>Demographic Variable</th>
<th>Control (n=30)</th>
<th>AD/HD-C (n=16)</th>
<th>AD/HD-I (n=16)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>39.6 (12.9)</td>
<td>35.0 (12.9)</td>
<td>40.7 (13.2)</td>
<td>0.91</td>
<td>.41</td>
</tr>
<tr>
<td>Years of Education</td>
<td>13.7 (2.3)</td>
<td>12.5 (2.3)</td>
<td>13.5 (2.2)</td>
<td>1.44</td>
<td>.25</td>
</tr>
<tr>
<td>Estimated Full Scale IQ</td>
<td>113.9 (10.8)</td>
<td>113.8 (12.6)</td>
<td>116.6 (15.2)</td>
<td>0.29</td>
<td>.75</td>
</tr>
</tbody>
</table>

Chi-square tests of independence found no significant differences between the three groups for gender, socioeconomic status, marital status, or employment status, as shown in Table 5.
Table 5

Control and AD/HD Subtype Group Differences: Gender, SES, Marital & Employment Status

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Values</th>
<th>Control</th>
<th>AD/HD-C</th>
<th>AD/HD-I</th>
<th>$\chi^2$ (df,N)</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>21</td>
<td>8</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>1.79 (2,62)</td>
<td>.41</td>
<td></td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>22</td>
<td>11</td>
<td>10</td>
<td>0.87 (4,62)</td>
<td>.93</td>
<td></td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married/Defacto</td>
<td>17</td>
<td>7</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Divorced</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Widowed</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Separated</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>9.29 (8,62)</td>
<td>.32</td>
<td></td>
</tr>
<tr>
<td>Employment Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not employed</td>
<td>8</td>
<td>6</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part Time$^a$</td>
<td>12</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Time$^b$</td>
<td>10</td>
<td>6</td>
<td>4</td>
<td>6.72 (4,62)</td>
<td>.15</td>
<td></td>
</tr>
</tbody>
</table>

Note. $^a$Employed less than 38 hours per week, $^b$Employed 38 or more hours per week.

**Attention: control vs. AD/HD-C vs. AD/HD-I groups.** A between-subjects MANOVA was conducted on four dependent variables representing the attentional components of the Mirsky model (Mirsky, et al., 1991; Mirsky, et al., 1999) to examine group differences. The independent variable was group membership: control, AD/HD-C, and AD/HD-I. Using Wilks’ criterion, the combined DVs were significantly affected by group, $F(8, 112) = 2.31$, $p = .025$. To further examine the results for each of the dependent variables, a series of four univariate $F$ tests were carried out, as shown in Table 6. Focus/execute (TMT Part B) was significantly different between groups, with a large effect size, partial $n^2 = .19$ (see Kittler, Menard, & Phillips, 2007 for effect size classifications). The sustain, encode, and shift variables were not significantly different between groups.
Table 6

Means and Standard Deviations of Four Attention Variables for the Control and AD/HD Subtype Groups

<table>
<thead>
<tr>
<th>Attention Variable</th>
<th>Control M (SD)</th>
<th>AD/HD-C M (SD)</th>
<th>AD/HD-I M (SD)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus/Execute Trailmaking Test B</td>
<td>49.3 (11.5)</td>
<td>65.9 (31.7)</td>
<td>76.5 (31.3)</td>
<td>7.29</td>
<td>.001</td>
</tr>
<tr>
<td>Sustain CCPT-II Attentiveness ‘d’</td>
<td>0.9 (0.4)</td>
<td>0.6 (0.5)</td>
<td>0.7 (0.3)</td>
<td>1.58</td>
<td>.21</td>
</tr>
<tr>
<td>Encode WMS-III Digits Fwd Corr Trials</td>
<td>11.7 (2.6)</td>
<td>10.9 (2.1)</td>
<td>12.1 (2.7)</td>
<td>0.95</td>
<td>.39</td>
</tr>
<tr>
<td>Shift WCST Categories</td>
<td>5.9 (0.2)</td>
<td>5.6 (0.9)</td>
<td>5.6 (0.9)</td>
<td>2.18</td>
<td>.12</td>
</tr>
</tbody>
</table>

A Mann-Whitney U test was carried out as a post-hoc evaluation of the differences between groups on the focus/execute measure. This test is a nonparametric alternative to the between-subjects t-test, and was used due to uneven samples sizes (Diekhoff, 1992). A significant difference was found only between the control and AD/HD-I groups (the mean ranks were 18.4 and 33.0, respectively; $U = 87.5$, $Z = -3.52$, $p = .000$). There was no significant difference between the control and AD/HD-C groups, or between the AD/HD-C and AD/HD-I groups. These results indicated that the Inattentive subtype group was poorer than controls on focus/execute, while the Combined subtype were comparable to controls.

**Verbal memory: control vs. AD/HD-C vs. AD/HD-I groups.** A between-subjects MANOVA was performed on three dependent variables representing three domains of auditory verbal memory: immediate memory (Logical Memory I Recall Total Score), delayed memory (Logical Memory II Recall Total Score), and learning (Logical Memory I Learning Slope). Using Wilks’ criterion, the combined DVs were
significantly different between groups, $F(6, 114) = 5.21, p = .000$. A series of univariate F tests were conducted to examine the results of each dependent variable separately, as shown in Table 7. Significant between groups differences were found for immediate memory (with a large effect size, partial $n^2 = .24$), delayed memory (with a large effect size, partial $n^2 = .29$), and for learning (with a medium effect size, partial $n^2 = .13$).

Table 7

Means and Standard Deviations of Three Verbal Memory Variables for the Control and AD/HD Subtype Groups

<table>
<thead>
<tr>
<th>Verbal Memory Variable</th>
<th>Control M (SD)</th>
<th>AD/HD-C M (SD)</th>
<th>AD/HD-I M (SD)</th>
<th>$F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate$^a$</td>
<td>50.6 (7.6)</td>
<td>38.7 (13.7)</td>
<td>40.4 (9.8)</td>
<td>9.45</td>
<td>.000</td>
</tr>
<tr>
<td>Delayed$^b$</td>
<td>33.6 (6.6)</td>
<td>22.7 (8.6)</td>
<td>25.9 (8.6)</td>
<td>11.98</td>
<td>.000</td>
</tr>
<tr>
<td>Learning$^c$</td>
<td>5.0 (2.7)</td>
<td>4.1 (2.4)</td>
<td>6.7 (2.2)</td>
<td>4.43</td>
<td>.02</td>
</tr>
</tbody>
</table>

Note. $^a$Logical Memory I Recall Total Score, $^b$Logical Memory II Recall Total Score, $^c$Logical Memory I Learning Slope.

A series of Mann-Whitney $U$ tests were carried out as post-hoc evaluations of the differences between groups on the verbal memory measures. A significant difference between groups was found between the control and AD/HD-C groups on immediate memory (the mean ranks were 27.6 and 15.8, respectively; $U = 117.5, Z = -2.83, p = .005$), and also between the control and AD/HD-I groups (the mean ranks were 2.82 and 14.6, respectively; $U = 98.0, Z = -3.28, p = .001$). There was no significant difference between the two AD/HD subtype groups on immediate memory. On delayed memory, a significant difference between groups was found between the control and AD/HD-C groups (the mean ranks were 28.9 and 13.2, respectively; $U = 75.5, Z = -3.79, p = .000$), and between the control and AD/HD-I groups (the mean ranks were 27.7 and 15.7, respectively; $U = 115.0, Z = -2.89, p = .004$). There was no significant difference between the two AD/HD subtype groups on delayed memory. On the learning measure,
there was no significant difference between the control and AD/HD-C groups. There was a significant difference between the control and AD/HD-I groups (the mean ranks were 20.7 and 28.8, respectively; $U = 155.5$, $Z = -1.97$, $p = .049$), and there was also a significant difference between the AD/HD-C and AD/HD-I groups (the mean ranks were 12.1 and 20.9, respectively; $U = 58.0$, $Z = -2.68$, $p = .007$). These findings indicate that both AD/HD subtype groups performed poorer on the immediate and delayed verbal memory measures than controls. On the learning measure, the AD/HD-I group was poorer than the controls and the AD/HD-C subtype group, but the AD/HD-C group was comparable to controls.

**Visual memory: control vs. AD/HD-C vs. AD/HD-I groups.** A between-subjects MANOVA was performed on three dependent variables representing visual memory: SVLT Overall Learning Score, SVLT Delayed Retention Score, and SVLT Learning Index. Using Wilks’ criterion, the combined DVs were significantly affected by group membership, $F(6, 110) = 3.83$, $p = .002$. A series of univariate F tests were conducted to examine the results of each dependent variable separately. As shown in Table 8, the SVLT Overall Learning Score was significantly different between groups, yielding a medium effect size, partial $n^2 = .12$. The other two visual memory variables did not differ between groups.

**Table 8**

*Means and Standard Deviations of Three Visual Memory Variables for the Control and AD/HD Subtype Groups*

<table>
<thead>
<tr>
<th>Visual Memory Variables</th>
<th>Control M (SD)</th>
<th>AD/HD-C M (SD)</th>
<th>AD/HD-I M (SD)</th>
<th>$F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVLT Overall</td>
<td>31.9 (5.2)</td>
<td>31.0 (6.6)</td>
<td>26.3 (7.5)</td>
<td>4.04</td>
<td>.02</td>
</tr>
<tr>
<td>SVLT Delayed</td>
<td>0.9 (0.2)</td>
<td>0.8 (0.2)</td>
<td>0.8 (0.4)</td>
<td>0.95</td>
<td>.39</td>
</tr>
<tr>
<td>SVLT Learning</td>
<td>1.7 (0.8)</td>
<td>1.7 (0.7)</td>
<td>1.4 (0.5)</td>
<td>1.10</td>
<td>.34</td>
</tr>
</tbody>
</table>
A Mann-Whitney U test was carried out as a post-hoc evaluation of the differences between groups on the SVLT Overall Learning Score. A significant difference between groups was found between the control and AD/HD-I groups (the mean ranks were 26.7 and 15.6, respectively; \( U = 113.5, Z = -2.69, p = .007 \)). There were no differences between the control and AD/HD-C groups, or between the AD/HD-C and AD/HD-I groups. This indicated that the AD/HD-I group were poorer than controls on visual memory, while the AD/HD-C group were comparable to controls.

**Executive functioning: control vs. AD/HD-C vs. AD/HD-I groups.** A between-subjects MANOVA was conducted on four dependent variables representing executive functioning: interference (Stroop interference score), working memory (WMS-III Digits Backward Correct Trials), planning (TOL4 Total Score All Trials), and response inhibition (CCPT-II Commissions Score). Using Wilks’ criterion, the combined DVs were close to being significantly affected by group membership, \( F(8, 112) = 1.92, p = .065 \). A series of univariate F tests were conducted to examine the results of each variable separately. As shown in Table 9, response inhibition (CCPT-II Commissions Score) was significantly different between groups, yielding a large effect size, partial \( n^2 = .14 \).

A Mann-Whitney U test was carried out as a post-hoc evaluation of the differences between groups on the response inhibition measure. A significant effect of group was found between the control and AD/HD-C groups (the mean ranks were 20.1 and 29.9, respectively; \( U = 137.0, Z = -2.38, p = .017 \)). There was no significant difference between the control and AD/HD-I groups, or the AD/HD-C and AD/HD-I groups. This indicated that the AD/HD-C group were poorer in response inhibition than controls, while the AD/HD-I group were comparable to controls.
Table 9

Means and Standard Deviations of Four Executive Functioning Variables for the Control and AD/HD Subtype Groups

<table>
<thead>
<tr>
<th>Executive Functioning Variables</th>
<th>Control M (SD)</th>
<th>AD/HD-C M (SD)</th>
<th>AD/HD-I M (SD)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interference Controla</td>
<td>25.1 (8.6)</td>
<td>26.1 (8.0)</td>
<td>26.1 (8.5)</td>
<td>0.64</td>
<td>.53</td>
</tr>
<tr>
<td>Working Memoryb</td>
<td>7.6 (2.3)</td>
<td>6.6 (1.9)</td>
<td>7.5 (2.1)</td>
<td>1.15</td>
<td>.33</td>
</tr>
<tr>
<td>Planningc</td>
<td>23.2 (2.3)</td>
<td>24.1 (2.9)</td>
<td>22.1 (4.9)</td>
<td>1.49</td>
<td>.23</td>
</tr>
<tr>
<td>Response Inhibitiond</td>
<td>9.9 (5.6)</td>
<td>16.4 (9.1)</td>
<td>12.6 (6.3)</td>
<td>4.62</td>
<td>.01</td>
</tr>
</tbody>
</table>

Note. aStroop interference Score, bWMS-III Digits Backward Correct Trials, cTOL4 Total Score All Trials, dCCPT Commissions.

Discussion

The neuropsychological results suggest several findings that support and extend current knowledge about attention, memory and executive functioning in adult AD/HD. Comparing the two AD/HD subtype groups’ performances directly against one another, and against a control group, has identified qualitatively different neuropsychological profiles between the AD/HD subtypes. The AD/HD-I group was poorer than both controls and the AD/HD-C subtype group in attentional focus/execute, in the learning slope of immediate verbal memory, and in visual memory. In contrast, the AD/HD-C subtype group were poorer than both controls and the AD/HD-I subtype group in response inhibition. Both AD/HD subtype groups were poorer than the controls in immediate and delayed verbal memory performances.

Findings: Attention

For attention, the prediction that all four attentional component performances (focus/execute, sustain, encode and shift) would be poorer in both AD/HD groups was not supported. Instead, the only component of attention in which an AD/HD group
performed worse than controls was in focus/execute, and this was true only for the AD/HD-I group. Poorer AD/HD performance on this measure has been found in six previous studies but subtype group performances were not examined separately (Dige & Wik, 2005; Johnson, et al., 2001; Lovejoy, et al., 1999; Muller, et al., 2007; Rapport, et al., 2001; Stavro, et al., 2007) Three other studies did not find performance differences between AD/HD and control groups, and also did not examine subtype differences (Gansler, et al., 1998; Riccio, et al., 2005; Walker, et al., 2000).

Brain imaging and lesion studies have shown that TMT-B performance is linked to the left dorsolateral frontal areas, and that patients with inferior medial and polar lesions were not impaired on the TMT (Stuss, Bisschop, Alexander, Levine, & Katz, 2001; Zakzanis, et al., 2005). Some researchers assert that AD/HD subtype differences are due to the effects of two separate subsystems of frontal functions, the dorsolateral prefrontal system and the inferior frontal/limbic system. Combined subtype individuals are believed to have deficits in the dorsolateral prefrontal system, while Inattentive subtype individuals are believed to have deficits in the inferior frontal/limbic system (Dinn, Robbins, & Harris, 2001; Gansler, et al., 1998).

Other researchers assert that the subtype differences are due to differences in levels of neurotransmitters (which may or may not be in conflict with the above theory), with Combined subtype individuals having dysfunctional dopamine systems, and Inattentive subtype individuals demonstrating norepinephrine dysfunction (Barkley, 1998). This study’s focus/execute findings do not easily fit into this division of the brain regions affected by AD/HD subtype. The findings suggest that if the dorsolateral prefrontal system supports focus/execute performance, then the Inattentive subtype may also have either structural or functional differences in dorsolateral prefrontal cortex functioning.
It has been suggested that TMT Part B performance is indicative of executive function, and that difficulty with the task might indicate impaired executive control or the ability to flexibly shift the course of an ongoing activity (Arbuthnott & Frank, 2000). Others have suggested that it requires the ability to maintain two response sets simultaneously (Eson, Yen, & Bourke, 1978). Kortte and colleagues (2002) maintain that TMT Part B appears to be a unique construct that is not well captured by other measures. In this study, the uniqueness of this finding in the context of negative findings across a broad range of other attention and executive functioning measures supports their contention. The clinical implications of this finding are important. Individuals with problems on the focus/execute task would have difficulties effectively responding to a visual array of any complexity, following a sequence mentally, dealing with more than one stimulus or thought at a time, or in flexibly shifting the course of an ongoing activity (Lezak, et al., 2004).

The lack of differences between the two AD/HD subtype groups and controls on the other three attentional components was not expected, considering that previous studies had reported these. This may indicate that more rigorous matching of participants has eliminated the performance differences, which would not be surprising in view of the known associations between IQ and demographic factors and attentional performance (Lezak, et al., 2004).

**Findings: Verbal and Visual Memory**

For verbal memory, the hypothesis that both AD/HD subtype groups would perform poorer than controls was generally supported. Both AD/HD subtype groups were poorer in the immediate and delay conditions, and on the learning slope measure of the immediate condition, the AD/HD-I group was poorer. This demonstrated that both AD/HD subtype groups exhibited difficulties with verbal memory performance,
even though the material had an inherent structure, and was similar in nature to everyday conversation. This study also demonstrated that the AD/HD-I group were poorer in the initial learning of verbal material. This supports and extends previous studies showing that children with this subtype have greater learning difficulties than children with the AD/HD-C subtype (Milich, et al., 2001).

Two previous studies reported that their adult AD/HD groups performed significantly worse on this measure than controls (Johnson, et al., 2001; Riccio, et al., 2005), while one did not find group differences on this measure (Gansler, et al., 1998). Gansler and colleagues used the Logical Memory subtests in a smaller sample, and using age-based percentage scores, found no differences between AD/HD and control groups (Gansler, et al., 1998). Riccio and colleagues found significant differences between AD/HD and control groups on this measure, using index scores and a sample size comparable to this study (Riccio, et al., 2005). Using raw scores and a larger sample, Johnson and colleagues found a significant difference between AD/HD and control groups in both the immediate and delayed conditions. Their relative performances on the learning score were not reported (Johnson, et al., 2001). The large effect sizes found in this study on both the immediate and delayed verbal memory measures indicates that differences would be found even in relatively small sample sizes, such as in this study. Although the Gansler study had a sample size comparable to this study’s, its recruitment and diagnostic procedures were not as rigorous. In the Gansler study, diagnosis was by interview only, control participants were drawn from the same clinic as AD/HD participants, and thus the two groups may have been similar. Unfortunately, previous studies have not directly compared subtype group performances, either against one another, or against control group performances on this measure. Although the Gansler study identified two separate subtype groups, a
Hyperactive/Impulsive group and Inattentive group, statistical tests were applied to the AD/HD group as a whole, possibly obscuring subtype differences.

The fact that this AD/HD group were as poor in their immediate memory performance as well as in their delayed performance suggests that encoding may play a role in their memory difficulties. However, attentional encoding (as measured by immediately repeating of strings of digits) was not a weakness for the AD/HD groups in this study. But memory for digits does not necessarily parallel memory for words, as the classic case of brain-injured patient HR demonstrated (Wagner, 1996). There is evidence for encoding deficits in the child AD/HD literature, but only in the AD/HD-C subtype. For instance, in a study of children with AD/HD-C subtype it was shown that their poor memory for visuospatial material was due entirely to problems with encoding and not to storage or retrieval (Barnett, Maruff, & Vance, 2005).

The brain areas believed to be involved in verbal memory encoding, storage and retrieval include the posterior parietal and prefrontal cortices for initial story recall, as well as the anterior medial parietal/posterior cortex for the recall of the second presentation of a story (Jansen et al., 2009; Maguire, Frith, & Morris, 1999). Structural brain imaging work on adults with AD/HD is sparse, but child and adolescent AD/HD imaging studies have identified temporal lobe volume reductions, in addition to alterations in the prefrontal cortex and cerebellum, striatum, anterior cingulate cortex, and posterior parietal cortex (Schneider, Retz, Coogan, Thome, & Rosler, 2006; Seidman, et al., 2005). At present the main finding in adults is that of hypoactivity (and the subsequent use of alternative networks, relative to controls) of the dorsal anterior cingulate cortex, a network known to subserve emotional and memory processes (Ernst et al., 2003).
This finding has theoretical and practical implications for this population. Individuals with poor verbal memory functioning have, at the very least, difficulty with recalling conversations or verbal instructions (Snyder & Nussbaum, 1998). The importance of this to functioning in educational, social, or vocational domains is significant. Meltzer has documented the far-reaching effects of his own poor verbal memory after an anoxic episode, describing the disorientation, feelings of incompetence, general reticence and overwhelming anxiety that this condition produces (1983). Poor verbal memory is predictive of an inability to function in the community for psychiatric outpatients (Fisher, Holland, Merzenich, & Vinogradov, 2009), and is predictive of poor medication adherence (Incalzi et al., 1997). Poor verbal memory limits the effectiveness of verbally-based psychological therapies, such as cognitive behavioural therapy (Wild & Gur, 2008), which suggests that it may compromise the effectiveness of cognitive behavioural therapy for adult AD/HD (Morgan, 2000; Safren, et al., 2005). It is noteworthy that the ability to recall passages of prose was poorer in the AD/HD groups, as this task has been associated most strongly with the report of memory problems in everyday life (Sunderland, Harris, & Baddeley, 1983). Verbal memory problems in this population may represent the most disabling aspect of the disorder, and deserve further investigation.

In terms of visual memory, the hypothesis that both AD/HD subtype groups would be comparable to controls was not supported. Instead, the AD/HD-I subtype group were poorer than the control and AD/HD-C subtype groups at remembering visual material. This finding is new, as no published studies have reported this result. Previous studies using other visual memory measures did note deficits in composite AD/HD groups (with a small effect size). The contribution of subtype to these findings is unknown (Schoechlin & Engel, 2005). In addition, the visual memory measures utilised in these previous studies may have confounded visual memory with
visuoconstructional ability, so it is also not clear which processes were disrupted. Theoretically speaking, it is possible that visual memory deficits are related to working memory deficits, as Baddeley’s working memory model posits that working memory partially depends upon access to the visuospatial scratch pad, a function devoted to the aspects of visual material (Baddeley, 2004). A more recent model of visual working memory (Ranganath, 2006) proposes that it requires a distributed network of frontal and posterior cortical areas, with contributions from other areas depending upon the requirements of the visual stimuli, for example the relative novelty of the object (served by the hippocampus and medial temporal cortex), the need to maintain activation of the object’s characteristics (related to the inferior temporal cortex), or the need to inhibit distracting information (supported by the caudal/ventral prefrontal regions). Given that a number of functional networks, rather than specific brain regions, are known to be affected in AD/HD, and some of these are networks that subserve memory, this finding is expected (Ernst, et al., 2003; Schneider, et al., 2006), however the relative poor performance of the AD/HD-I subtype group is a novel finding.

Visual memory impairment may place significant limitations on adult life, as it has been shown to be an important predictor of general employability post-brain injury. It is also important in day to day functioning, for example, remembering where objects are, or finding your way around a new environment (Shum, Harris, & O'Gorman, 2000). In addition, visual memory plays a crucial role in reading, comprehension and spelling (Orenstein, 2000).

**Findings: Executive Functioning**

Contrary to hypotheses, the only executive function performance deficit found was that of response inhibition. Interference, working memory and planning performances were comparable among the AD/HD and control groups. In this study,
the response inhibition performance deficit was attributed to the AD/HD-C group, a finding documented previously in an AD/HD-C group, but not via direct comparison to an AD/HD-I group (Boonstra, Kooij, Oosterlaan, Sergeant, & Buitelaar, 2010). Response inhibition has been linked to the subthalamic nucleus, part of the basal ganglia, using a different response inhibition task (the Stop-signal task) via fMRI (Aron & Poldrack, 2006). Dysfunction in the basal ganglia, both in perfusion and in dopamine transporter levels, has been shown in both children and adults with AD/HD (Raz, 2004).

Poor response inhibition is often viewed as impulsivity and overactivity. The correctness of this assumption is still under consideration, but it is seen as a process that keeps behaviour goal directed from moment to moment. Automatic behaviours cued by the environment must be suppressed at times, and the inability to delay or interrupt such a response has long been seen as central to AD/HD (Barkley, 1997a; Nigg, 2006). The impact of this inability on independent adult living is enormous, and is believed to underlie difficulties in the educational, occupational and social domains, in addictions, in family instability and financial instability, and in emotional lability, poor driving outcomes, and poor sexual health outcomes (Barkley & Gordon, 2002; Ellison, 2002).

Previous studies of interference, using the Stroop task, have shown that adults with AD/HD performed poorer due to slowed processing (Corbett & Stanczak, 1999; Nigg, et al., 2005; Seidman, et al., 1998; Walker, et al., 2000). However these studies used T scores rather than raw scores, and some utilised non-normal controls (e.g., psychiatric controls). One study utilising the Stroop interference score did not find deficits in adults with AD/HD using matched normal controls, and a more rigorous diagnosis of AD/HD participants (Riccio, et al., 2005). Previous studies of children and adolescents with AD/HD have found deficits in Stroop performance, however it has been unclear whether the problem lies in the interference processes or in a generalised slowing, and studies that corrected for response speed by utilising the interference score
did not find a true interference effect (Nigg, 2006). A meta-analysis of the pooled studies found a small overall effect size, indicating that the weakness may not be of clinical significance (van Mourik, Oosterlaan, & Sergeant, 2005). Newer methodologies utilising computers to administer the Stroop task have attempted to more closely examine the cognitive processes by eliminating the paper and pencil part of the task. These have yielded mixed results, with one study of adults finding no interference deficit, and another of children demonstrating interference deficits (Bush et al., 1999; Carter, Krener, Chaderjian, Northcutt, & Wolfe, 2005). Interference performance using the Stroop task has been shown to be supported by the anterior cingulate cortex, although the region appears to be specialised for an evaluative function only, that is, to provide an online conflict signal indicating the need to engage brain regions such as the dorsolateral prefrontal cortex and left inferior parietal cortex to implement the strategic processes required to complete the task (Carter et al., 2000; Macdonald, Cohen, Stenger, & Carter, 2000).

Some studies of working memory using Digits Backward have found group differences in adults with AD/HD, while others have not. An analysis of the methodological differences between these two groups of findings revealed that those studies with higher proportions of AD/HD-C subtypes within their AD/HD groups were those that found no differences between AD/HD and control groups (Boonstra, et al., 2010; Schweitzer, et al., 2006). Conversely, those studies with higher proportions of AD/HD-I subtype within their AD/HD groups demonstrated significant differences in working memory (Dige & Wik, 2005; Kovner, et al., 1998; Walker, et al., 2000). It was unexpected that this AD/HD-I group did not differ from the AD/HD-C and controls groups on working memory, but these findings may be due to a small effect size for working memory, given this study’s small sample size. Digits Backward performance has been linked to the bilateral dorsolateral prefrontal cortex, left inferior parietal
cortex, and Broca’s area in functional imaging studies (Gerton et al., 2004). Dysfunction in these areas has been shown in adult AD/HD.

Previous studies of planning utilising the TOL4 have demonstrated differences in adult AD/HD groups on the time-based scores of this measure (Muller, et al., 2007; Riccio, et al., 2005), but have not found differences on the performance-based scores of the measure (Nigg, et al., 2005; Stavro, et al., 2007). One study did find significant differences between groups on both time and performance measures. This study had a larger number of participants than the other studies, and reported small effect sizes on the TOL measures (Riccio, et al., 2005). This implies that Tower task performance may be affected by adult AD/HD status, but possibly not to a large extent. Brain imaging studies utilising modified TOL tasks have highlighted the role of the dorsolateral prefrontal cortex, with the right side involved in planning and the left side in execution of the plan. In addition the inferior and superior parietal systems are believed to support attentional and visuospatial workspace functions needed to complete the TOL task (Newman, et al., 2003; Schall, et al., 2003; van den Heuvel, et al., 2003). This study’s small sample sizes may have contributed to the lack of a difference between the AD/HD subtype groups and the control groups on this measure.

The issue of whether there are executive functioning deficits in adults with AD/HD has been extensively discussed. Schoechlin and Engel, in their meta-analysis of 24 adult neuropsychological studies, reached the conclusion that “executive functions, as measured by planning and flexibility tasks, are not the strongest predictors of the distinction between ADHD and normal controls...” (Schoechlin & Engel, 2005, p. 739). This position was supported by Boonstra and colleagues, in their meta-analysis of 13 studies of executive functioning in adults with AD/HD. They observed that the data did not suggest a specific deficit in the executive functioning realm for adults with
AD/HD, but rather that in comparison with controls, adults with AD/HD show disabilities in various areas of cognitive functioning, including executive functioning. They further noted that although executive functioning problems are part of AD/HD in adults, they are not found in every study and every sample. Although a number of theories have been suggested that explain the presence of executive functioning difficulties in adults with AD/HD, Boonstra and colleagues noted that the data in their meta-analysis only supported two of these, a general deficit in processing speed (Aldenkamp et al., 2000), and a general variability in performance possibly due to cerebellar dysfunction (Castellanos & Tannock, 2002).

This study’s findings are consistent with those of recent researchers and authors, lending further support to the premise that executive functioning is not the central deficit in adult AD/HD. The relative contribution of subtype to the executive functioning performance of adults with AD/HD may have been overlooked in previous studies, and may help explain the disparate findings. Given the significant impact of intact memory processes on adaptive functioning (Lezak, et al., 2004), it may be that the day-to-day difficulties reported by this population arise from an inability to adequately encode, store and retrieve everyday memories, abilities believed to be dependent on both attention and memory processes. In addition, as the majority of the executive functioning abilities were intact in this study’s adult AD/HD group, it is unlikely that their difficulties with memory are due to the poor allocation of executive resources to memory tasks.

**Summary: Neuropsychological Results**

The overall neuropsychological findings of this study can be summarised as follows: the AD/HD-I subtype group was poorer in focusing attention, and in remembering visual information. The AD/HD-C subtype group was poorer in
performing a response inhibition task. Both subtype groups were poorer than matched controls in immediate and delayed verbal memory. These are all crucial cognitive skills that enable adults to navigate their world, meet their obligations, and cope successfully with day to day living. The question of how these skills link up with psychological and functional outcomes will be addressed next, in Chapter Five.
Chapter Five

Psychological and Functional Outcome Results

The second aim of this study was to explore the psychological profiles and functional outcomes of the two AD/HD subtype groups, and compare these to the control group, using a more rigorous approach. No previous studies have compared the psychological profiles and functional outcomes of AD/HD and non-AD/HD adults who have been matched on age, gender, educational achievement and estimated IQ. Given the effects of demographic and IQ variables on these outcomes, this procedure should increase the validity of the findings (Young & Bramham, 2006).

In studies that examined the psychological status of adults with AD/HD, the approaches that were taken have had some methodological limitations. In some cases (e.g., Biederman, et al., 2008), interview data alone were used to determine psychological status. Interview data are less accurate and detailed than psychometric data, and do not capture differences in symptom levels between groups quantitatively. In other cases, although psychometric measures were used, the instruments did not yield informative data. For example, one study that used the Symptom Checklist, Revised with an adult AD/HD group found a characteristic profile in which all indices were elevated, indicating high levels of general distress but not identifying the presence or absence of particular diagnoses or symptom subsets (Barkley, et al., 1996; Murphy, et al., 2002). In addition, some instruments (e.g., Beck Depression Inventory) are known to overlap with core AD/HD symptoms such as poor concentration (Solanto, Etefia, & Marks, 2004; Steer, et al., 2003), and thus may result in falsely elevated symptom
counts. Finally, the sampling procedures for inclusion into the adult AD/HD groups in these studies were less thorough than those utilised in the current study.

In this study, both AD/HD subtype groups were expected to report elevated levels of depression, anxiety and stress compared to the control group. However, the AD/HD-I group were expected to report higher depressive symptoms, while the AD/HD-C group would report higher anxiety and stress symptoms. These hypotheses were based on one previous study suggesting that those of the AD/HD-I subtype report consistently lower moods. Anxiety and stress symptoms were predicted to be higher in the AD/HD-C group due to the hyperactivity/impulsivity that forms a part of their diagnostic criteria.

Social, vocational, family/home and financial functioning were examined in the two AD/HD subtype and control groups in this study. This was because these four areas were the most commonly reported difficulties observed by clinicians and researchers (Barkley & Gordon, 2002). The AD/HD-I group were expected to report more difficulties with social functioning than the AD/HD-C group, based on the results of a previous study comparing the two directly (Canu & Carlson, 2004). Both subtype groups were expected to report greater difficulties with vocational functioning, due to impulsivity and inattention in the AD/HD-C group, and inattention in the AD/HD-I group. In terms of family functioning, both subtype groups were expected to report more difficulties, due to inattention and memory symptoms, which were central to the complaints of non-AD/HD partners in one previous study (Robin & Payson, 2002). The AD/HD-C subtype group were expected to report more difficulties than either the AD/HD-I subtype or control groups in financial functioning, due to impulsivity.

The third aim of this study was to examine the relationships between neuropsychological, psychological, and functional outcome variables in the AD/HD
groups. There is a high incidence of psychological symptoms among adults with AD/HD, and a key issue is the extent to which these symptoms contribute to AD/HD symptoms, as well as to functional outcomes. An increased understanding of the relationships between these domains will contribute considerably to clinical treatment, and would also make a meaningful contribution to theories of AD/HD. With comorbidity the rule and not the exception among adults with AD/HD, it may be that poor functional outcomes result more from psychological conditions than from underlying neurological deficits. Previous outcome studies have focussed solely on prevalence rates, but have not related these to other features of the disorder, such as subtype or psychological status. However, one study (Safren, et al., 2010) has shown that poor work and social outcomes were associated with AD/HD symptom severity, but were also partially associated with depression and anxiety symptoms.

In this study, both neuropsychological and psychological variables were expected to contribute equally to functional outcomes in the adult AD/HD group. This premise was based on the work of Safren and colleagues (2010), although others have inferred this from clinical experience (Ellison, 2002; Fischer & Barkley, 2006; Marks, Newcorn, & Halperin, 2001). Some clinicians have taken the position that comorbid disorders are a significant predictor of the persistence of AD/HD into adulthood (Ellison, 2002). If this is the case, both psychological symptoms and neurological symptoms would predict functional outcomes in adults with AD/HD.

**Data Analysis**

**Psychological functioning: control vs. AD/HD-C vs. AD/HD-I groups.** A between-subjects MANOVA was conducted on three dependent variables: depression (DASS-21 Depression subscale score), anxiety (DASS-21 Anxiety subscale score), and stress (DASS-21 Stress subscale score). Using Wilks’ criterion, the combined DVs
were significantly affected by group, $F(6, 106) = 5.51, p = .000$. The means and standard deviations reported by the groups on these measures are displayed in Table 10. A series of univariate F tests were conducted to examine the results of each variable separately. All psychological functioning variables differed significantly between groups. The depression, anxiety and stress variables had large estimated effect sizes (partial $n^2$ of .32, .23, and .20, respectively).

Table 10

<table>
<thead>
<tr>
<th></th>
<th>Control M (SD)</th>
<th>AD/HD-C M (SD)</th>
<th>AD/HD-I M (SD)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression$^a$</td>
<td>4.0 (3.9)</td>
<td>9.2 (9.6)</td>
<td>16.5 (10.5)</td>
<td>13.05</td>
<td>.000</td>
</tr>
<tr>
<td>Anxiety$^b$</td>
<td>3.6 (4.6)</td>
<td>10.7 (9.6)</td>
<td>11.3 (7.9)</td>
<td>8.00</td>
<td>.001</td>
</tr>
<tr>
<td>Stress$^c$</td>
<td>12.1 (7.9)</td>
<td>22.0 (12.4)</td>
<td>20.4 (8.1)</td>
<td>6.95</td>
<td>.002</td>
</tr>
</tbody>
</table>

Note. $^a$DASS-21 depression score, $^b$DASS-21 anxiety score, $^c$DASS-21 stress score.

A series of Mann-Whitney $U$ tests were carried out as post-hoc evaluations of the differences between groups on the psychological measures. As noted in Chapter Four, this nonparametric procedure was used to control for different sample sizes. For depression, a significant group difference was found between the control and AD/HD-I groups (the mean ranks were 16.3 and 32.7, respectively; $U = 49.0$, $Z = -4.14$, $p = .000$), and between the AD/HD-C and AD/HD-I groups (the mean ranks were 12.0 and 19.0, respectively; $U = 60.0$, $Z = -2.19$, $p = .029$). Thus, the AD/HD-I group mean depression score was highest, placing them in the moderate clinical range for depression as a group. Although the AD/HD-C group mean depression score was higher than that of the control group (placing them in the mild clinical range), this difference was not statistically significant. For anxiety, a significant group difference was found between the control and AD/HD-C groups (the mean ranks were 18.6 and 28.4, respectively; $U = 114.5$, $Z = -2.49$, $p = .013$), and between the control and AD/HD-I groups (the mean
ranks were 17.2 and 30.9, respectively; \( U = 76.5, Z = -3.46, p = .001 \). The difference between the two AD/HD subtype groups was not significant. Thus, both subtype groups were significantly higher in anxiety symptoms than the controls (placing them both into the moderate clinical range), but they were similar in these symptoms to each other. For stress, a significant group difference was found between the control and AD/HD-C groups (the mean ranks were 18.6 and 28.4, respectively; \( U = 114.0, Z = -2.46, p = .014 \), and between the control and AD/HD-I groups (the mean ranks were 17.9 and 29.5, respectively; \( U = 97.5, Z = -2.88, p = .004 \)). The difference between the two AD/HD subtype groups was not statistically significant. Thus, similar to anxiety, both subtype groups reported higher stress symptoms than controls (placing them into the moderate clinical range), and were comparable to each other.

**Predicting group membership: neuropsychological vs. psychological variables.** Because of the considerable psychological differences found between the AD/HD and control groups, an investigation of the relative impact of psychological and neuropsychological variables on AD/HD group status was undertaken. Some researchers have suggested that psychological factors play a crucial role in the persistence of AD/HD into adulthood (Ellison, 2002). This could be because depression, anxiety and stress increase symptoms of inattention, disorganisation, impulsivity, and forgetfulness to the point of directly contributing to the likelihood of continued diagnosis of the disorder in adulthood. For this reason psychological factors were compared to neuropsychological factors, to determine which best characterised the AD/HD control groups.

A sequential logistic regression was conducted to assess the contribution of neuropsychological functioning to the prediction of group membership once psychological functioning was accounted for. A total of nine predictor variables were chosen from the neuropsychological and psychological domains by identifying all
variables with significant differences between the AD/HD and control groups. The regression was conducted to predict membership in either the composite AD/HD group (AD/HD-C and AD/HD-I) or the control group, first on the basis of three psychological variables, and then after the addition of six neuropsychological variables. The psychological predictor variables were the depression, anxiety, and stress scores. The neuropsychological predictor variables were: attentional focus/execute (TMT Part B), verbal memory (Logical Memory I Total Raw Score, Logical Memory II Total Raw Score, and Logical Memory I Learning Slope), visual memory (SVLT Overall Score), and response inhibition (CCPT Commissions Raw Score).

There was a good model fit (discrimination among groups) on the basis of the three psychological predictors alone, $\chi^2 (3, N = 57) = 19.98, p = .000$. The subsequent addition of the six neuropsychological predictors contributed significantly to the classification of group membership, $\chi^2 (6, N = 57) = 16.69, p = .01$. The full model incorporating both psychological and neuropsychological predictors resulted in a good fit, $\chi^2 (9, N = 57) = 36.68, p = .000$. As shown in Table 11, although both psychological and neuropsychological variables contributed to the correct classification of cases into AD/HD or control groups, the six neuropsychological variables increased the accuracy of the classification rates substantially.

Table 11

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>Classification Rates by Group</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AD/HD</td>
<td>Control</td>
</tr>
<tr>
<td>Psychological*</td>
<td>62.1%</td>
<td>78.6%</td>
</tr>
<tr>
<td>Neuropsychological**</td>
<td>82.8%</td>
<td>85.7%</td>
</tr>
</tbody>
</table>

*Note.* DASS-21 Depression score, DASS-21 Anxiety score, DASS-21 Stress score.

**TMT Part B, Logical Memory I Total Raw Score, Logical Memory II Total Raw Score, Logical Memory I Learning Slope, SVLT Overall Score, and CCPT Commissions Raw Score.
Functional outcomes: control vs. AD/HD-C vs. AD/HD-I groups. A between-subjects MANOVA was conducted on four dependent variables: social problems, vocational problems, family/home problems, and financial problems. Using Wilks’ criterion, the combined DVs were significantly affected by group, $F(8, 104) = 2.74, p = .009$. Table 12 displays the means and standard deviations obtained by the groups on these variables. A series of univariate F tests were conducted to examine the results of each variable separately. Social problems were significantly different between groups (with a large effect size of partial $n^2 = .15$), while vocational, family/home, and financial problems were not, although financial problems was close to being significantly different.

Table 12

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>AD/HD-C</th>
<th>AD/HD-I</th>
<th>$F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social$^a$</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social$^a$</td>
<td>2.5 (2.3)</td>
<td>4.2 (4.4)</td>
<td>6.1 (4.9)</td>
<td>4.81</td>
<td>.01</td>
</tr>
<tr>
<td>Vocational$^b$</td>
<td>2.1 (2.3)</td>
<td>3.2 (2.9)</td>
<td>3.3 (3.1)</td>
<td>1.21</td>
<td>.31</td>
</tr>
<tr>
<td>Family$^c$</td>
<td>3.1 (2.9)</td>
<td>2.8 (2.1)</td>
<td>3.1 (2.7)</td>
<td>0.08</td>
<td>.93</td>
</tr>
<tr>
<td>Finances$^d$</td>
<td>2.3 (1.4)</td>
<td>4.0 (2.3)</td>
<td>2.8 (2.9)</td>
<td>3.01</td>
<td>.06</td>
</tr>
</tbody>
</table>

Note. $^a$PPC social problems, $^b$PPC vocational problems, $^c$PPC family/home problems, $^d$PPC financial problems.

A series of Mann-Whitney $U$ tests were carried out as post-hoc evaluations of the differences between groups on the social problems scores. A significant effect of group was found between the control and AD/HD-I groups (the mean ranks were 18.7 and 28.1, respectively; $U = 118.0, Z = -2.37, p = .018$). There were no significant differences between the control and AD/HD-C groups, or between the two subtype groups. Thus, the AD/HD-I group reported more social problems than either the AD/HD-C or control groups.
A series of Mann-Whitney U tests were carried out as post-hoc evaluations of the differences between groups on the financial problems scores. A significant effect of group was found between the control and AD/HD-C groups (the mean ranks were 18.9 and 27.8, respectively; \( U = 122.5 \), \( Z = -2.27 \), \( p = .023 \)). There were no significant differences between the control and AD/HD-I groups, or between the two subtype groups. Thus, the AD/HD-C group reported more financial problems than either the AD/HD-I or control groups.

**Predicting social functioning in the composite AD/HD group.** Four indices of neuropsychological and psychological functioning were calculated by summing the z scores of the attention variables (TMT-B (reversed), CCPT \( d \), Digits Forward Correct Trials, and WCST Categories Score), the memory variables (Logical Memory I Recall Total Score, Logical Memory II Recall Total Score, Logical Memory I Learning Slope, SVLT Overall Score, SVLT Delayed Retention, and SVLT Learning Index), the executive functioning variables (Stroop Interference Score (reversed), Digits Backward Correct Trials, TOL4 Total Score, and CCPT Commissions Score[reversed]), and the psychological variables (depression, anxiety, and stress scores from the DASS-21).

A hierarchical multiple regression was conducted to determine if addition of information regarding neuropsychological performance and psychological profile improved social functioning beyond that predicted by AD/HD subtype group status. The dependent variable was social functioning, and AD/HD subtype group was entered first as a predictor, followed by attention, memory, executive functioning, and psychological profile. Table 13 displays the correlations between the variables, the unstandardised regression coefficients (B), the standardised regression coefficients (\( \beta \)), the semipartial correlations (\( sr^2 \)) and \( R^2 \), and adjusted \( R^2 \) after entry of all five IVs. \( R \) was not significantly different from zero at the end of Step 1. After step 2, with all IVs in the equation, \( R = .25 \), \( F (1, 24) = 8.52 \), \( p = .008 \). Only one IV, the psychological
index, contributed significantly to predicting social functioning in the composite AD/HD group. Altogether, 38% (25% adjusted) of the variability in social functioning was predicted by knowing the scores on the five IVs.

Table 13

Hierarchical Multiple Regression of Group, Neuropsychological and Psychological Variables on Social Functioning for the Composite AD/HD Group

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable</th>
<th>Social (DV)</th>
<th>Group</th>
<th>Attn</th>
<th>Mem</th>
<th>Exec. Funct.</th>
<th>Psychol</th>
<th>B</th>
<th>β</th>
<th>sr² (unique)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Group</td>
<td>.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.19</td>
<td>0.13</td>
<td>.13</td>
</tr>
<tr>
<td>2</td>
<td>Attention</td>
<td>-.26</td>
<td>.03</td>
<td></td>
<td></td>
<td>.63</td>
<td></td>
<td>0.16</td>
<td>0.10</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td>Memory</td>
<td>-.34</td>
<td>-.02</td>
<td>.63</td>
<td></td>
<td></td>
<td></td>
<td>-0.35</td>
<td>-0.19</td>
<td>-.15</td>
</tr>
<tr>
<td></td>
<td>Exec. Funct.</td>
<td>-.14</td>
<td>.04</td>
<td>.40</td>
<td>.32</td>
<td></td>
<td></td>
<td>-0.09</td>
<td>0.05</td>
<td>.05</td>
</tr>
<tr>
<td></td>
<td>Psychol</td>
<td>.58</td>
<td>.13</td>
<td>-.48</td>
<td>-.41</td>
<td>-.32</td>
<td></td>
<td>0.92</td>
<td>0.56</td>
<td>.47</td>
</tr>
<tr>
<td></td>
<td>Means</td>
<td>5.17</td>
<td>1.50</td>
<td>-9.1</td>
<td>-1.55</td>
<td>-1.49</td>
<td>1.35</td>
<td></td>
<td></td>
<td>R² = .38</td>
</tr>
<tr>
<td></td>
<td>Std Dev</td>
<td>4.71</td>
<td>.51</td>
<td>2.96</td>
<td>2.59</td>
<td>2.48</td>
<td>2.85</td>
<td></td>
<td></td>
<td>Adjust. R² = .25</td>
</tr>
</tbody>
</table>

Predicting vocational functioning in the composite AD/HD group. A hierarchical multiple regression was conducted to determine if addition of information regarding neuropsychological performance and psychological profile improved vocational functioning beyond that predicted by AD/HD subtype group status. The dependent variable was vocational functioning, and AD/HD subtype group was entered first as a predictor, followed by attention, memory, executive functioning, and psychological profile. Table 14 displays the correlations between the variables, the unstandardised regression coefficients (B), the standardised regression coefficients (β), the semipartial correlations (sr²) and R², and adjusted R² after entry of all five IVs. R was not significantly different from zero at the end of Step 1. After step 2, with all IVs in the equation, $R = .73, F(5, 24) = 5.49, p = .002$. Although the attention and memory variables were correlated with vocational functioning, these did not contribute significantly to the regression. Only one IV, the psychological index, contributed significantly to predicting vocational functioning in the composite AD/HD group.
Altogether, 53% (44% adjusted) of the variability in vocational functioning was predicted by knowing the scores on the five IVs.

Table 14

Hierarchical Multiple Regression of Group, Neuropsychological and Psychological Variables on Vocational Functioning for the Composite AD/HD Group

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable</th>
<th>Vocat (DV)</th>
<th>Group</th>
<th>Attn</th>
<th>Mem</th>
<th>Exec. Funct.</th>
<th>Psych</th>
<th>B</th>
<th>β</th>
<th>Sr² (unique)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Group</td>
<td>.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.38</td>
<td>-0.07</td>
<td>-0.07</td>
</tr>
<tr>
<td>2</td>
<td>Attention</td>
<td>-0.50</td>
<td>.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.16</td>
<td>-0.16</td>
<td>-0.12</td>
</tr>
<tr>
<td></td>
<td>Memory</td>
<td>-0.45</td>
<td>-0.02</td>
<td>.63</td>
<td></td>
<td></td>
<td></td>
<td>-0.15</td>
<td>-0.13</td>
<td>-0.10</td>
</tr>
<tr>
<td></td>
<td>Exec. Funct.</td>
<td>-0.23</td>
<td>.04</td>
<td>.40</td>
<td>.32</td>
<td></td>
<td></td>
<td>0.86</td>
<td>0.07</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>Psychol</td>
<td>0.69</td>
<td>.13</td>
<td>-.48</td>
<td>-.41</td>
<td>-.32</td>
<td></td>
<td>0.61</td>
<td>0.59</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>Means</td>
<td>3.23</td>
<td>1.50</td>
<td>-0.91</td>
<td>-1.55</td>
<td>-0.49</td>
<td>1.35</td>
<td>R²</td>
<td>.53</td>
<td>Adjust, R² = .44</td>
</tr>
<tr>
<td></td>
<td>Std Dev</td>
<td>2.96</td>
<td>.51</td>
<td>2.96</td>
<td>2.59</td>
<td>2.48</td>
<td>2.85</td>
<td>R</td>
<td>.73</td>
<td></td>
</tr>
</tbody>
</table>

Predicting family/home functioning in the composite AD/HD group. A hierarchical multiple regression was conducted to determine if addition of information regarding neuropsychological performance and psychological profile improved family/home functioning beyond that predicted by AD/HD subtype group status. The dependent variable was family/home functioning, and AD/HD subtype group was entered first as a predictor, followed by attention, memory, executive functioning, and psychological profile. Table 15 displays the correlations between the variables, the unstandardised regression coefficients (B), the standardised regression coefficients (β), the semipartial correlations (sr²) and R², and adjusted R² after entry of all five IVs. R was not significantly different from zero at the end of step 1. After step 2, with all IVs in the equation, R = .72, F (5, 24) = 5.26, p = .002. The attention and memory variables correlated significantly with family/home functioning. Both the neuropsychological variables and psychological profile contributed significantly to predicting family/home functioning in the composite AD/HD group. Altogether, 52% (42% adjusted) of the
variability in family/home functioning was predicted by knowing the scores on the five IVs.

Table 15

Hierarchical Multiple Regression of Group, Neuropsychological and Psychological Variables on Family/Home Functioning for the Composite AD/HD Group

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable</th>
<th>Fam (DV)</th>
<th>Group</th>
<th>Attn</th>
<th>Mem</th>
<th>Exec. Funct.</th>
<th>Psych</th>
<th>B</th>
<th>β</th>
<th>Sr² (unique)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Group</td>
<td>.07</td>
<td></td>
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<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>Attention</td>
<td>-.51</td>
<td>.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.29</td>
<td>-0.36</td>
<td>-0.26</td>
</tr>
<tr>
<td></td>
<td>Memory</td>
<td>-.40</td>
<td>-.02</td>
<td>.63</td>
<td></td>
<td></td>
<td></td>
<td>-0.07</td>
<td>-0.07</td>
<td>-0.06</td>
</tr>
<tr>
<td></td>
<td>Exec. Funct.</td>
<td>.01</td>
<td>.04</td>
<td>.40</td>
<td>.32</td>
<td></td>
<td></td>
<td>0.33</td>
<td>0.34</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>Psychol</td>
<td>.60</td>
<td>.13</td>
<td>-.48</td>
<td>-.41</td>
<td>-.32</td>
<td></td>
<td>0.42</td>
<td>0.51</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>Means</td>
<td>2.97</td>
<td>1.50</td>
<td>-.91</td>
<td>-1.55</td>
<td>-.49</td>
<td>1.35</td>
<td>R²</td>
<td>.52</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Std Dev.</td>
<td>2.37</td>
<td>.51</td>
<td>2.96</td>
<td>2.59</td>
<td>2.48</td>
<td>2.85</td>
<td>R</td>
<td>.72</td>
<td></td>
</tr>
</tbody>
</table>

Predicting financial functioning in the composite AD/HD group. A hierarchical multiple regression was conducted to determine if addition of information regarding neuropsychological performance and psychological profile improved financial functioning beyond that predicted by AD/HD subtype group status. The dependent variable was financial functioning, and AD/HD subtype group was entered first as a predictor, followed by attention, memory, executive functioning, and psychological profile. Table 16 displays the correlations between the variables, the unstandardised regression coefficients (B), the standardised regression coefficients (β), the semipartial correlations (sr²) and R², and adjusted R² after entry of all five IVs. R was not significantly different from zero at the end of step 1. After step 2, with all IVs in the equation, R = .69, F (5, 24) = 4.34, p = .006. The attention variable correlated significantly with financial functioning, with both the neuropsychological variables and psychological profile contributing significantly to predicting family/home functioning.
in the composite AD/HD group. Altogether, 48% (37% adjusted) of the variability in financial functioning was predicted by knowing the scores on the five IVs.

Table 16

_Hierarchical Multiple Regression of Group, Neuropsychological and Psychological Variables on Financial Functioning for the Composite AD/HD Group_

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable</th>
<th>Fin (DV)</th>
<th>Group</th>
<th>Attn</th>
<th>Mem</th>
<th>Exec. Funct.</th>
<th>Psych</th>
<th>B</th>
<th>β</th>
<th>Sr² (unique)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Group</td>
<td>-0.23</td>
<td>-1.50</td>
<td>-0.29</td>
<td>-0.28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Attention</td>
<td>-0.45</td>
<td>-0.38</td>
<td>-0.42</td>
<td>-0.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Memory</td>
<td>-0.28</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exec. Funct.</td>
<td>0.11</td>
<td>0.45</td>
<td>0.41</td>
<td>0.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Psychol</td>
<td>0.44</td>
<td>0.39</td>
<td>0.42</td>
<td>0.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td></td>
<td>3.40</td>
<td>1.50</td>
<td>-0.91</td>
<td>-1.55</td>
<td>-0.49</td>
<td>1.35</td>
<td>R² = .48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Std Dev</td>
<td></td>
<td>2.69</td>
<td>0.51</td>
<td>2.96</td>
<td>2.59</td>
<td>2.48</td>
<td>2.85</td>
<td>Adjust. R² = .37</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R = .69</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Discussion**

The psychological and functional outcome results have supported and extended previous findings on adults with AD/HD. Examination of the AD/HD subtype groups separately has identified interesting similarities and differences between the subtype groups in terms of psychological profiles and functional outcomes. The AD/HD-I group were more depressed than their AD/HD-C counterparts, but both AD/HD subtype groups were more anxious and stressed than controls. The AD/HD-I subtype group were the only group to report significantly more difficulties in functional outcome domains, and these difficulties were found only in the area of social functioning. Investigation of the relationships between the neuropsychological and psychological variables in both AD/HD subtype groups revealed the importance of neuropsychological factors in predicting AD/HD status. An examination of both
AD/HD subtypes revealed the importance of both psychological and neuropsychological factors in predicting functional outcomes.

**Findings: Psychological Profiles**

For depression, the prediction that the AD/HD-I subtype group would report higher levels of depression symptoms than the AD/HD-C subtype group was supported. However, higher levels of depression in the AD/HD-C, relative to controls, were not found. This is a unique finding, as there is no published research comparing levels of depressive symptoms between AD/HD subtype groups using a psychometric measure. Although AD/HD in adults has been associated with significant levels of depression, most studies have utilised clinical samples, while this study’s sample consisted of 78% community-based participants. As community-based individuals are assumed to be higher functioning than clinically-based individuals, this implies that even more highly functioning adults with AD/HD have a higher risk of comorbid mood disorders. One previous study of adults found a difference between the self-reported mood states of AD/HD-C and AD/HD-I subtypes, showing that regardless of context or situation, the AD/HD-I subtype individuals reported depressive moods (Knouse, et al., 2008). Carlson and Mann (2002) identified a subset of AD/HD-I children who were high in sluggish cognitive tempo (SCT) items from a child rating scale, and showed that those high in SCT had higher levels of anxiety/depression, were more withdrawn in their behaviour, had more social dysfunction, and were more unhappy in general. This AD/HD-I group might be the adult extension of that high SCT group, and this possibility needs investigating.

Both AD/HD group means were above clinical cut-off for the DASS-21 Depression subscale, while the control group mean was below clinical cut-off. This clinically significant level of depression in adults with AD/HD has complex
implications for treatment. One widely available set of treatment recommendations advises physicians to consider which condition is the most impairing (e.g., AD/HD or depression) and to prescribe for that disorder alone (Surnam, 2010). This leaves individuals with AD/HD and depression without treatment for their depression if their AD/HD symptoms are judged to be most impairing. The current Australian guidelines for the treatment of AD/HD and depression in adults are unclear about this issue, taking no particular position (The Royal Australasian College of Physicians, 2009). It is therefore unknown whether individuals with both AD/HD and depression are receiving adequate treatment in the community. Further research on this issue is also of vital importance.

For anxiety, the prediction that the AD/HD-C group would be more likely than the AD/HD-I group to be anxious was not supported. Instead, both AD/HD subtype group means were significantly higher on the anxiety subscale, placing them within the moderate clinical range on the DASS-21. This is consistent with previous studies, although no studies have differentiated between AD/HD-I and AD/HD-C subtype adults’ rates of anxiety symptoms. In this study, the finding of similar rates of anxiety between the subtype groups argues against the idea that hyperactivity contributes to anxiety. Higher rates of anxiety, encompassing several types of anxiety disorders, are found in both children and adults with AD/HD (Ramsay & Rostain, 2005). Some researchers have argued that AD/HD and anxiety may represent a particular subtype, possibly caused by perinatal or birth complications (Sprich-Buchminster, Biederman, Milberger, Faraone, & Lehman, 1993). Others have argued that anxiety arises from the negative experiences of growing up with AD/HD (Young & Bramham, 2006).

These findings imply that it is important to conduct a comprehensive assessment of anxiety symptoms when assessing adult AD/HD, given the potential overlap between
AD/HD symptoms and anxiety symptoms. Treatment with cognitive behavioural procedures has been shown to be successful with this population, and is especially recommended for individuals with AD/HD and comorbid anxiety (Goldstein & Ellison, 2002; Ramsay & Rostain, 2003; Safren, et al., 2005; Stevenson, Whitmont, Bornholt, Livesey, & Stevenson, 2002; Young & Bramham, 2006).

For stress, it was anticipated that the AD/HD-C subtype group would report greater stress than the AD/HD-I subtype group, due to their hyperactive symptoms. This prediction was partially supported, as stress symptoms were significantly higher in both AD/HD subtype groups than in controls. Both AD/HD subtype group means were within the moderate range for stress on the DASS-21, while the control group mean was within the mild range. The higher report of stress symptoms by AD/HD participants was expected, based on previous work showing that adults with AD/HD report subjective stress regardless of whether physiological stress markers are present (Lackschewitz, et al., 2008). This study’s findings are unique, as no previous studies have examined relative stress levels between these two subtype groups, or between any subtype groups. These findings suggest that hyperactivity and subjective stress (as well as anxiety) are not as closely related as it would seem. It may be that stress and anxiety are natural outcomes of poorly functioning verbal memory, or that they are the long term consequence of emotional lability, or some combination of these and other unknown factors (Young & Bramham, 2006). These findings highlight the importance of treatment strategies designed to help adults with AD/HD enhance their ability to cope with stress. In addition, treatment strategies that help them to examine and change their beliefs about their own coping abilities may help increase their capacity to manage stress (Young, 2005).
Differentiating AD/HD and Control Groups

A direct comparison of the contribution of neuropsychological factors to psychological factors in determining AD/HD status demonstrated that objectively measured key neuropsychological differences underpin the AD/HD diagnosis, even though the diagnosis was made using self-report instruments and clinical interview. Neuropsychological variables alone were the best predictors of AD/HD group membership, while neuropsychological and psychological variables both were important predictors of control group membership. This indicates that neuropsychological tests and tasks can capture the symptoms of AD/HD in adults, even in the presence of clinically significant psychological symptoms. The finding that both neuropsychological and psychological variables contributed to the identification of control group members highlights the importance of competency in both of these sets of skills to successful adult living.

This finding underlines the primary importance of neuropsychological deficits to the core symptoms of AD/HD. It also emphasises the secondary position of psychological symptoms when diagnosing AD/HD in adults. It implies that psychological conditions require assessment and consideration in treatment planning, but may not be as essential in diagnostic classification. The DSM-IV-TR criteria for AD/HD states that the symptoms must not be better accounted for by another mental disorder such as a mood or anxiety disorder, and that these can be differentiated from AD/HD by an onset after age seven, or by a lack of history of disruptive behaviour in school, or teacher complaints of inattention, hyperactivity or impulsivity. These findings suggest that an AD/HD diagnosis could easily be missed by attributing symptoms to depression or anxiety, and that diagnostic validity could be improved by directly assessing core symptoms using neuropsychological testing.
Findings: Functional Outcomes

For social functioning, it was predicted that the AD/HD-I subtype group would report more difficulties than the AD/HD-C subtype group, based on previous research comparing the two subtypes directly. This hypothesis was supported, as social functioning problems were significantly higher in the AD/HD-I subtype group, while the AD/HD-C subtype group was comparable with controls. It may be possible that the elevated depressive symptoms of the AD/HD-I group were related to poorer social functioning. However, poorer social functioning has also been demonstrated in children with AD/HD-I compared to AD/HD-C children whose levels of depressive symptoms were similar. Previous studies have suggested that while both subtypes are actively rejected by peers and are socially impaired, the AD/HD-I group react with social withdrawal, while the AD/HD-C group do not (Milich, et al., 2001). If this pattern continued to adulthood, then the use of a self-report measure in this study could have contributed to the findings. That is, the greater difficulties reported by AD/HD-I subtype adults could have been due to heightened interpersonal sensitivity. This implies that the subtype differences in social functioning may or may not reflect social functioning as perceived by peers. As there are no published studies of adult AD/HD social functioning utilising measures other than self-report, this possibility remains unexplored.

A further exploration of social functioning is needed, accounting for the effect of subtype, as the sources and nature of these difficulties are likely to be diverse. Alternative methods of measuring the construct would also be useful, as self-report may not necessarily convey an accurate depiction of social functioning. Specific treatments for adults with AD/HD to help them address their social difficulties are available, yet a comprehensive description of social functioning in adults with AD/HD has not yet been
established. Nevertheless, clinicians have highlighted the need to be aware of this potential gap in treatment for adults with AD/HD (Young & Bramham, 2006).

The hypothesis that both AD/HD subtype groups would report greater problems with vocational functioning was not supported, as both groups were comparable to controls. Previous studies examining vocational outcomes in adults with AD/HD have found that underemployment, rather than unemployment, is a common outcome in AD/HD individuals. However, no other studies have approached the topic via self-report of actual occupational problems (Biswa, et al., 2008; Goldstein, 2002). These findings are novel, and may indicate that adults with AD/HD are more satisfied with occupational outcomes than is believed. The similarity of the two subtype groups diverges from previous work, where poorer employment outcomes were linked to AD/HD-C subtype groups, but not to AD/HD-I subtype groups (Torgersen, Gjervan, & Rasmussen, 2006). However, a more probable explanation is that the participants in this study were a relatively higher functioning group, a known bias in community-based volunteer samples (Babbie, 1995).

The prediction that both AD/HD subtype groups would report more difficulties in the family/home domain was also not supported, as there were no significant differences in family/home functioning between the AD/HD subtype groups and controls. Previous researchers have often cited the underlying neuropsychological deficits in AD/HD as central to difficulties in the family and home domain (Barkley & Gordon, 2002; Canu & Carlson, 2004). No previous research has assessed family functioning from the point of view of the adult with AD/HD; consequently there is no basis for comparison with previous studies. Researchers have found comparable divorce rates between AD/HD and non-AD/HD marriages, although some studies have demonstrated that AD/HD is associated with decreased levels of satisfaction in marriage (Canu & Carlson, 2004; Eakin et al., 2004; Murphy & Barkley, 1996). Clinicians
working in this area support this assertion (Kilcarr, 2002; Young & Bramham, 2006). It may be that any assessment of this functional domain is best done using collateral information as well as self-report, to capture the full extent of the situation.

The hypothesis that financial functioning would be poorer in the AD/HD-C subtype group than in the AD/HD-I or control groups was supported. Clinicians have suggested that symptoms of impulsivity contribute to many difficulties in meeting adult responsibilities, with financial responsibility a key deficit. It is believed that part of the problem lies in the proneness to choose short-term rewards that involve less effort than over choosing longer term rewards that involve greater effort. This proneness in AD/HD-C has been well studied in children but not in adults (Young & Bramham, 2006).

Few previous studies have examined the relative financial functioning of adults with AD/HD. One study examined young adults with AD/HD aged 19 to 25 and found no differences in their financial functioning relative to controls, other than having a higher income than controls because they were in full time employment rather than studying at university (Fischer & Barkley, 2006). In this study the adults with AD/HD were a substantially older group than Fischer and Barkley’s, and it would be expected that difficulties with financial functioning would become apparent with age. These researchers assert that having AD/HD affects an adult’s ability to handle their finances responsibly, suggesting that impulsivity contributes substantially to this problem (Fischer & Barkley, 2006).

**Predicting Functional Outcomes in the AD/HD Group**

The hypothesis that both neuropsychological and psychological variables would contribute to functional outcomes in the AD/HD subtype groups was supported. There were some differences between the functional outcome domains, with social and
vocational functioning predicted better by psychological variables, and family/home and financial functioning predicted by a combination of attention, memory and psychological variables. These are findings that have not been previously reported in the literature, as no previous studies have directly examined the relationships between neuropsychological, psychological and functional outcomes in adults with AD/HD. The findings may imply that psychological functioning plays a role as a mediator in the relationship between neuropsychological performance and some functional outcomes. A mediation analysis was considered for this study to evaluate this possibility, but the basic assumptions of the procedure were not met by the data due to a lack of correlation between variables (MacKinnon, Fairchild, & Fritz, 2007).

However these findings may imply that neuropsychological performance contributes only to a certain extent to functional outcomes in adulthood, through some process of maturation not yet specified. For instance, clinicians have observed that many adults with AD/HD develop useful strategies over time to overcome neuropsychological deficits and function more successfully in their communities (Goldstein, 2002; Ramsay & Rostain, 2005; Young & Bramham, 2006). It is also possible that this sample were higher functioning, as difficulties with functional outcomes are not as prevalent in community-based AD/HD samples, samples that are believed to consist of higher functioning individuals in terms of adaptive functioning (Barkley & Gordon, 2002; Barkley, et al., 1996; Stavro, et al., 2007).

The practical implications of these findings are that the identification and consideration of AD/HD subtype may be a critical factor in determining long term outcomes for individuals with AD/HD. In addition, the identification of AD/HD subtype may be important in ensuring the effectiveness of treatments for AD/HD, by tailoring treatments to encompass the relative strengths and weaknesses of the two
subtype groups. This study’s findings also imply that the treatment of psychological symptoms plays a crucial role in improving functional outcomes for adults with AD/HD.

Summary: Psychological and Functional Outcomes

These findings have significantly extended previous research. Differences between the subtypes have been highlighted, and it was found that the AD/HD-I group are clinically depressed, anxious and stressed, and report more difficulties with social functioning. The AD/HD-C group are clinically anxious and stressed, and report more difficulties with financial functioning. Although the sample was identified and classified through the self-report of behavioural symptoms, neuropsychological performance was found to be a good predictor of group membership for both AD/HD groups. This highlighted the validity of the diagnosis, and the central importance of neurological factors to the symptoms of AD/HD, supporting the neural basis of this condition. An examination of the relative roles of neuropsychological and psychological factors in predicting functional outcomes in both AD/HD subtype groups found that for social and vocational functioning, psychological factors predicted outcomes, while both neuropsychological and psychological factors played a part in predicting family/home and financial functioning. The following chapter, Chapter Six, discusses the study’s findings more generally, details its limitations, and makes suggestions for future research. The clinical and theoretical implications of the findings are also discussed.
Chapter Six

General Discussion and Conclusions

The current understanding of AD/HD in adults has been based upon knowledge of the disorder in children and adolescents. Because the impact of development is likely to affect the expression of AD/HD in adults, the similarities and differences between child and adult presentations of AD/HD have been a topic of intensive research over the past two decades. Although the field of cognitive psychology has drawn some general conclusions about the normal development of cognitive processes over the lifespan, how closely normal cognitive development might apply to individuals with AD/HD is not known. Previous neuropsychological investigations of adult AD/HD have made tentative conclusions, but these have been limited by the inconsistent application of diagnostic criteria, the use of atheoretical assessment protocols, the use of non-matched control groups, and by approaches that examine outcomes without accounting for the impact of related factors.

Research on adults with AD/HD has shown that they experience a wide range of negative outcomes in addition to neuropsychological dysfunction, and to some degree these have been linked with AD/HD symptom severity or remission. There is an important gap in the literature, because very few studies have examined the psychological and functional outcomes of adults with AD/HD. Furthermore, no study has directly examined the associations between neuropsychological deficits and psychological and functional outcomes. There are known links between symptom counts and objective neuropsychological deficits, and there are suggestions of links between symptom counts and functional outcomes. What is lacking is an understanding of the links (if any) between neuropsychological functioning and functional outcomes.
This study sought to address these gaps, and had three main aims. The first aim was to more accurately measure neuropsychological performance in adults with AD/HD using careful sampling and design, and a theory-driven measurement protocol. Secondly, this study aimed to better define the psychological and functional outcomes that adults with AD/HD experience, using psychometrically sound measures appropriate for this population. The third aim was to examine the nature of the relationships between neuropsychological performances, psychological and functional outcomes in this sample of adults with AD/HD.

**Aim One**

Using a factor-analytic model of attention defined by Mirsky and colleagues (1991), poorer attention performance was found on the TMT-B, the measure used for the focus/execute component in this study. However, this difference was found only in the AD/HD-I subtype group. The AD/HD-C subtype group performed at a comparable level to controls on this and all other attentional components. This was despite the fact that both subtype groups met the DSM-IV-TR criteria for inattention symptoms required by both subtypes (American Psychiatric Association, 2000).

AD/HD subtype performances on the other three attentional components, sustain, encode, and shift, were comparable to controls. Previous studies of the sustain component had confounded sustained attention with response inhibition by using the commissions or omissions scores from continuous performance tests, and found differences between the subtypes. However, studies that used the attentiveness score of the CCPT, ‘d’, did not find differences between the subtypes, consistent with the findings of this study. The subtypes have not previously been compared on the measures used for either the encode component of attention in this study, Digits
Forward, or the shift component (WCST categories score) and therefore this study has contributed to previous findings in the literature.

Both AD/HD subtype groups were poorer than controls in the immediate and delayed remembering of verbal material presented in a short story format. Difficulties with verbal memory have been found previously, whether the material consisted of word lists or stories, and whether or not demographic variables were matched between participants. One of the largest effect sizes in a meta-analysis of neuropsychological findings in adult AD/HD was for verbal memory (Schoechlin & Engel, 2005). In addition, the AD/HD-I subtype group exhibited a poorer learning slope in the learning of this material when it was repeated, while the AD/HD-C group was comparable with controls on this index. One previous study found no significant difference between an AD/HD group and controls in learning slope on a word list test, and did not report separate subtype performances (Holdnack, et al., 1995). The AD/HD-I group had difficulty with learning verbal material presented repeatedly, and this is a novel finding.

The AD/HD-I subtype group were poorer in the visual memory task, while the AD/HD-C subtype group were comparable to controls. This is also a novel finding, as no other studies have used this visual memory measure on adults with AD/HD. Researchers examining composite adult AD/HD groups have found differences (with small effect sizes) in visual memory using design reproduction and recognition measures (Schoechlin & Engel, 2005). Otherwise, most researchers have obtained negative findings, whether using design recall, visual recognition, or complex design recall measures (Woods, et al., 2002). If the AD/HD-I subtype group in particular does have visual memory difficulties, this has important implications for the remediation of memory, as transferring auditory memories to visual ones is a common strategy employed to enhance memory performance (Burt, Parks-Charney, & Schwean, 1996; Safren, et al., 2005; Young & Bramham, 2006). However, it is possible that this
group’s poorer visual memory performance was due to slowed processing, as the measure utilised a computerised format where the length of presentation time for the visual stimuli was limited, and not under the control of the examinee.

Executive functioning performance was comparable to controls for all measures except response inhibition, where the AD/HD-C subtype group were poorer than either the AD/HD-I or control groups. This finding is a robust one in the literature, for both children and adults with AD/HD, and response inhibition difficulties have previously been attributed to the AD/HD-C subtype group in adults (Egeland, 2007; Milich, et al., 2001). Boonstra and colleagues (2010) argued that adult ADHD is mainly a disorder of inhibition, after assessing adults with AD/HD and controls matched for age, gender and IQ in five domains of executive functioning (inhibition, fluency, planning, working memory, and set shifting). Without differentiating between subtypes, their AD/HD group showed deficits only in response inhibition (CCPT-II Commission score) and set shifting (WCST Perseverative Errors).

The comparable performances on interference control, working memory, and planning were all consistent with studies that utilised careful matching of participants on demographic and IQ variables. Analyses of executive functioning in adults with AD/HD have shown that the poor performances found in children with AD/HD are not found in adults with AD/HD, once key demographic and IQ variables are accounted for (Boonstra, et al., 2010; Boonstra, et al., 2005; Willcutt, et al., 2005).

**Aim Two**

The second aim of the study was to examine the psychological and functional outcomes of adults with AD/HD, using valid and reliable instruments shown to be appropriate for this population. The findings both replicated those of some previous studies, and in some instances provided new insights. The AD/HD-I subtype group
were significantly more depressed than controls, falling within the moderate range on the DASS-21, while the AD/HD-C subtype group were more similar to controls on this measure, falling within the mild range of the DASS-21. Depression in adults with AD/HD has been well documented, but studies have not differentiated between subtypes. If future studies agree that AD/HD-I subtype adults are indeed at greater risk for depression than AD/HD-C subtype adults, this would indicate that prospective outcome studies of children with AD/HD need to place a greater emphasis on differentiating between subtypes. Treatment evaluation research on adults with both depression and AD/HD is also needed to investigate the possibility of any interactions between treatment efficacy, treatment outcomes, and subtype.

Both AD/HD subtype groups reported significantly more symptoms of anxiety than controls, reporting symptom levels in the moderate clinical range of the DASS-21. The high incidence of anxiety in adults with AD/HD has been well documented, but no studies directly comparing the subtypes have been published. Elia and colleagues reported on subtype differences in children with AD/HD and found differing rates of anxiety disorders in the subtypes, with higher rates occurring in the AD/HD-C subtype (Elia, Ambrosini, & Berrettini, 2008). These findings would appear to refute this subtype difference in adults with AD/HD.

Both AD/HD subtype groups reported significantly more symptoms of stress than the control group. One reason for more stress symptoms in this study’s AD/HD groups could be that some of the DASS-21 stress items are also symptoms of hyperactivity, such as “I find it hard to wind down”, “I felt that I was using a lot of nervous energy”, and “I found it difficult to relax”. However, the fact that there were no differences in stress levels between the AD/HD-I and AD/HD-C groups, whose only diagnostic difference lies in the hyperactivity/impulsivity symptoms of the AD/HD-C group, argues against this possibility. The phenomenon of subjective stress in adults
with AD/HD needs further study, and will require that researchers examine the varying contributions of subtype, gender, demographics, cognitive coping, and neuropsychological profile to inform treatment recommendations for adults with AD/HD.

The self-report of difficulties with social functioning were significantly higher in the AD/HD-I group. This supports the contention of several researchers that this subtype carries with it a risk of social inhibition, as the self-report of poor social functioning may be due to social anxiety, rather than to overall poor social functioning as observed by others (Carlson & Mann, 2002; Milich, et al., 2001; Young & Bramham, 2006). It is possible that individuals with the AD/HD-C subtype, due to hyperactivity and impulsivity, would be rated poorly in the social domain by others but not by themselves (Ramsay & Rostain, 2005). Given the close relationship between depression and social dysfunction (Beck & Alford, 2009), it is possible that poorer social functioning could be related to greater depression in the AD/HD-I group. However, no items on the DASS-21 specifically relate to social functioning, making this link one not easily identified. Further research on the relationships between AD/HD subtype and social functioning is warranted.

No differences were found between the AD/HD subtype groups and controls in vocational and family/home functioning. There is not yet a body of empirical evidence on functional outcomes in adults with AD/HD, and methodological differences between the studies make the findings difficult to evaluate as a whole. Most studies have utilised clinically-referred adults, whose outcomes may not be comparable to that of community-based adults. Previous studies of vocational functioning in adults with AD/HD have used younger groups with higher rates of conduct disorder, and a higher proportion of hyperactive/impulsive subtypes (Biederman, et al., 2005; Murphy & Barkley, 1996). Previous studies of family/home functioning in adults with AD/HD
have focussed almost entirely on marital satisfaction and outcome (Barkley, et al., 2007; Biederman, et al., 1998; Canu & Carlson, 2004).

The self-report of difficulties with financial functioning were significantly higher in the AD/HD-C group. No published studies have examined the possibility that adults with AD/HD may have difficulty with handling finances, although clinicians have often made this observation (Barkley & Gordon, 2002; Fischer & Barkley, 2006; Ratey, 2002). Clinicians have suggested that this functional deficit is due to the propensity to choose easier, short-term gains over more difficult long-term gains, a trait well documented in the literature on children with AD/HD-C (Young & Bramham, 2006). A more detailed study of financial functioning in adults with AD/HD is needed that accounts for AD/HD subtype, symptom profile and severity, neuropsychological profile and psychological comorbidity. Treatment could then be tailored to focus on those aspects that contribute most to this outcome.

**Aim Three**

The third aim of this study was to examine the nature of the relationships between neuropsychological performance and psychological and functional outcomes in adults with AD/HD. This aim was designed to investigate the claims of researchers and clinicians that deficits in attention, memory and executive functioning lead to poorer functional outcomes in AD/HD. An examination of the relationship of psychological variables to these factors was also undertaken in view of their potential impact on functional outcomes.

In this study, neuropsychological variables were shown to better predict AD/HD group membership than were psychological variables. This highlighted the key role of neurological deficits in this disorder, and provided objective support for the symptoms of the disorder in adulthood. It also highlighted the need for adult treatments aimed at
the remediation of attention, memory and executive functioning deficits. These findings also implied that psychological symptoms play a secondary role in the expression of the disorder, and support the continuation of a diagnostic classification system that permits the inclusion of comorbid conditions in adulthood.

Psychological variables alone were the best predictors of social and vocational functioning in the composite AD/HD group, while attention, memory and psychological variables were the best predictors of family/home and financial functioning. This only partially supports the contention of clinicians that underlying neurological deficits lead to negative outcomes in the day to day functioning of adults with AD/HD. Instead, this study found that psychological symptoms also play an important role in functional outcomes, and this finding has important consequences for the treatment of AD/HD in adults. Firstly, in some areas of adult living, long term prognosis may be more affected by psychological factors than by neurological deficits. Secondly, this would indicate that psychological treatment is an important adjunct to the treatment of adults with AD/HD.

In conclusion, the use of a more thorough and theoretical approach to assessing neuropsychological performance in adults with AD/HD has been productive. Firstly, it has shown that poor attention is not a main feature of adult AD/HD. Secondly, it has provided a more detailed picture of attentional functioning in this population, and has shown that, although the AD/HD-C and AD/HD-I subtypes are believed to share a common inattention symptom set, they differ in one attentional component, focus/execute. The use of Mirsky’s approach (1991) has helped to more closely identify attentional differences, and has highlighted the key roles of the dorsolateral prefrontal cortex (DLPFC), cortical basal loop, and supporting motor areas in adult AD/HD-I. As dopamine is known to play a key role in the DLPFC (Zelazo & Muller,
2003), this implies that medications that normalise dopamine levels are appropriate for adults with AD/HD-I.

Thirdly, the extent and significance of verbal memory deficits in both subtype groups of adults with AD/HD was highlighted by the finding of shared deficits in both immediate and delayed recall. The use of a more structured test reduced the possibility that failures of memory were due to failures of strategy use. The use of a measure considered more ecologically valid (Lezak, et al., 2004) has highlighted the clinical significance of these findings. In addition, the AD/HD-I subtype group were found to be poorer in the immediate learning of verbal material than the AD/HD-C subtype group, and further investigation of this finding is warranted.

Fourthly, the AD/HD-I subtype group’s poorer visual memory suggests differences between the subtypes in the functioning of brain regions. These potential differences could partially account for known differences, such as higher rates of specific mathematics disabilities in the AD/HD-I subtype (Milich, et al., 2001), as difficulties in visual working memory are related to mathematics deficits (Lezak, et al., 2004). This finding, if replicated, suggests a promising new area of research. It also suggests that current remediation protocols may need adjustment to include strategies that take the possibility of poor visual memory into account.

Finally, these findings support and extend work demonstrating that executive functioning is not the key deficit in adults with AD/HD (Willcutt, et al., 2005). The use of Nigg’s approach to examining executive functioning has been productive, as it provided a more comprehensive approach with measures that had minimal overlap with Mirsky’s attention measures (Mirsky, et al., 1999; Nigg, 2006). A central criticism of neuropsychological studies of adults with AD/HD has been the confusion of attentional and executive functioning measures (Woods, et al., 2002). Several of the executive functioning measures used here have been suggested by researchers and reviewers as
possible areas of deficit in adult AD/HD, such as the Tower of London (Boonstra, et al., 2005), and the Stroop interference score (van Mourik, et al., 2005). The lack of an AD/HD deficit on these measures supports Boonstra and colleagues’ analysis that executive functioning measures were no more deficient in adult AD/HD than were other neuropsychological measures (Boonstra, et al., 2005).

The findings of this study have suggested some interesting differences between subtype groups. These findings challenge the contention of Nigg that the AD/HD-I subtype is merely a milder form of the AD/HD-C subtype (Nigg, 2006). Similarities were found as well between the subtype groups, which suggest that the subtypes share a common area of overlap. However, the subtypes also appear to have specific distinguishing characteristics. Milich and colleagues (2001) have suggested that more information is needed on the specific attentional problems of the AD/HD-I subtype group, and that a theoretical model is needed that addresses the development and dysfunction of this subtype. Barkley has also argued for a better understanding of this subtype, for the need to more clearly define its attentional deficits, and for evidence that it poses significant deficits relative to the normal population (Barkley, 2001). This study’s findings address some of these needs.

This study’s findings implicate the DLPFC and motor control areas, the cortical basal loop, the hippocampus, medial and left temporal cortices, and the rhinal and posterior parietal cortices as areas of likely dysfunction in the AD/HD-I subtype. The AD/HD-C subtype results also suggest the involvement of the right inferior PFC. A number of researchers support the contention that dopaminergic pathways play a key role in AD/HD, and that dysfunctional levels of dopamine, rather than particular structural or functional regions are the basis of AD/HD symptoms and deficits (Castellanos, 1997; Levy, 2001; Swanson et al., 2000). Three dopaminergic circuits in particular have been suggested. Firstly, the DLPFC circuit, supporting working
memory, maintaining stimulus set, and therefore supporting the planned or deliberate control of action. Secondly, an orbitolateral prefrontal circuit, controlling behavioural output and therefore behavioural inhibition. Thirdly, the anterior cingulate/orbitomedial frontal circuit, supporting emotional regulation and motivational response, as well as attentional control and conflict detection (Nigg, 2006). One question raised by the current study is how poor verbal memory (and possibly, visual memory in AD/HD-I) fits into this theory. Further research is needed to pull apart adult AD/HD memory performance to determine how and why failures occur, both for theoretical and practical reasons.

This study has also made a contribution to an understanding of psychological and functional outcomes in adults with AD/HD. The findings showed that while both AD/HD subtype groups shared clinically significant symptoms of anxiety and stress, the AD/HD-I group were significantly more depressed. Given that this sample consisted mainly of community-based participants, clinical referral bias alone cannot account for these results. These findings suggest that the AD/HD-I subtype group may be at greater risk of depression than the AD/HD-C subtype group. The robust relationship between AD/HD and depression has generated much discussion, and the links between the two have been variously attributed to the difficulties of growing up with disabling AD/HD symptoms (Halmoy, Fasmer, Gillberg, & Haavik, 2009; Weiss & Hechtman, 1993), the possibility that comorbid AD/HD and depression may represent an etiologically distinct familial subtype of AD/HD (Mick, Biederman, Santangelo, & Wypij, 2003), or the possibility of an unrecognised sluggish cognitive tempo subtype with depressive-like symptoms (Carlson & Mann, 2002; McBurnett, Pfiffner, & Frick, 2001). These findings provide tentative support to the latter theory. Further research is needed to determine whether depressive symptoms in adults with AD/HD can be better accounted
for by symptom severity, by AD/HD subtype, by family psychiatric history, by
cognitive schemas about their histories, or some combination thereof.

This study’s findings on functional outcomes have been mixed, but overall have
only partially identified the difficulties reported in the literature (Barkley & Gordon,
2002; Goldstein & Ellison, 2002; Stavro, et al., 2007). Difficulties with social
functioning were predicted in the AD/HD groups, however the effect of subtype was not
expected. Further research is needed to identify whether methodological reasons are
behind this difference. For instance, the self report nature of this measure may have
contributed to the AD/HD-I group’s greater report of difficulties. The self-report
measure may have tapped social anxiety cognitions or perceptions, rather than actual
social performance in real-world situations. The measurement of social functioning is
complex and is best defined multidimensionally (Goldman, Skodol, & Lave, 1992).
Clinicians report a significant need for the treatment of social difficulties in adults with
AD/HD, and have designed targeted interventions to do so (Ramsay & Rostain, 2005;
Safren, et al., 2005; Young & Bramham, 2006). However there is a need for more
comprehensive research to inform these approaches, as the small body of research done
thus far has depended upon self-report, and may not reflect true social functioning as
observed by others. Social skills deficits in adults with AD/HD have not been
disentangled from social anxiety, and research clarifying social difficulties in greater
detail is needed to better inform the design and delivery of treatment.

Difficulties with financial functioning were also predicted for both AD/HD
subtype groups based on the literature, and again subtype differences emerged that were
unexpected. However, the link between the impulsivity of the AD/HD-C group and
difficulties with financial responsibility is a logical one. These findings imply that
treatments for adults with AD/HD need to be targeted differently, depending upon
subtype.
Finally, this study has also shown that neuropsychological performance best predicted membership in the AD/HD group, effectively capturing the essential difference between this group and a carefully matched control group. In addition, performance on neuropsychological tests predicted some functional domains, family/home and financial functioning. Psychological deficits were found to best predict social and vocational functioning, but also contributed to the family/home and financial functioning.

The use of a neuropsychological approach to examine adult AD/HD has provided a structure for investigating presumed deficits, and afforded a more informative picture of adult AD/HD symptomatology. This study has found that at least three neuropsychological domains contribute to the profile of adults with AD/HD, rather than executive functioning alone, which has implications for theories that place executive function deficits central to AD/HD. The findings, viewed in tandem with previous lesion and imaging studies of the specific tests and tasks used, lend support to the dopaminergic pathway theories of AD/HD. Using more carefully defined definitions of attention, memory, and executive functioning, based on factor analyses of test batteries, has shown that specific components of these domains can be considered separately, and while some are deficient in adult AD/HD, others are not. This has also meant that the study’s findings have diverged from previous work, in part because different tests were used to represent the constructs. It has also meant that clinically significant deficits in adult AD/HD have been identified through more systematic investigation, for example visual versus verbal memory.

These findings suggest that differences between the AD/HD subtypes, although diagnosed by subjective self-report, are supported by objective neuropsychological testing. The AD/HD-C subtype group appear to exhibit continued impulsivity at the most basic level of responding, contrary to suggestions that hyperactivity/impulsivity
diminishes in adulthood, exhibit poorer verbal memory, are more anxious and stressed, and report more difficulties with handling their finances. The AD/HD-I subtype exhibited poor attentional focus/execute, deficits in verbal and visual memory, elevated depression, anxiety and stress symptoms, and difficulties in social functioning. These subtype differences need further study in order to deliver appropriate, effective treatments, rather than the one size fits all approach suggested by the current diagnostic classification system.

This study found partial support for the contention that neuropsychological deficits contribute to functional outcomes, but also suggested that psychological factors contribute as well. Only some of the poor functional outcomes that were expected were demonstrated in this mixed clinical and community sample. This supports the contention that AD/HD symptoms in childhood can predict a number of pathways along a continuum, ranging from severe to minimal impairment. This has implications for the assumptions of clinicians that elevated AD/HD symptoms necessarily lead to functional impairments that preclude satisfactory adult living. These findings suggest that there are some adults with AD/HD who are able to develop living skills enabling them to take part in meaningful family life, obtain and keep appropriate employment, pay their bills and manage money satisfactorily, all while exhibiting clinically significant levels of AD/HD symptoms.

Implications for Theory

This study has supported the contention that executive functioning deficits are not central to AD/HD in adults (Boonstra, et al., 2010; Boonstra, et al., 2005; Nigg, et al., 2005). Instead, these findings support theories of AD/HD that emphasise the central role of dopaminergic (and noradrenergic; see Levy, 2009) systems in AD/HD. Dopaminergic theories of AD/HD are supported by neuroimaging, genetic and
medication studies that verify an inhibitory dopaminergic effect at the striatal/prefrontal level. Noradrenergic systems are also important in prefrontal regulation (Levy & Swanson, 2001). In this study, AD/HD performance deficits were found in neuropsychological tests which have been linked through lesion and imaging studies to the mesolimbic, mesocortical and nigrostriatal dopaminergic pathways in children and adults. A hypofunctioning mesolimbic dopamine system will alter the reinforcement of novel behaviours and the extinction of previously reinforced behaviours. A hypofunctioning mesocortical dopamine system has been associated with poor attention and behavioural organisation, and a hypofunctioning nigrostriatal dopaminergic system has been linked to impaired motor functions and poor nondeclarative learning. These are broad functional areas, serving a number of structures, and are seen as the key neurological disorder underlying AD/HD, and the cause of core behavioural deficits.

These findings also provide evidence from both the neuropsychological and psychological domains that two AD/HD subtype groups, the AD/HD-I and AD/HD-C, are not one disorder that differs in severity. Instead, the two subtypes have different but partially overlapping profiles. Differences and similarities in their neuropsychological profiles suggest that some underlying neural dysfunctions are shared, while there are unique areas of dysfunction that require more accurate identification, perhaps through neuroimaging studies separating the subtype groups. Differences and similarities in their psychological profiles are suggestive of the impact of underlying neurological differences, for example slowed processing and poor attentional focus may contribute to depressive symptomatology.

In comparison to the AD/HD-I group, the AD/HD-C subtype group appeared to be relatively high functioning, despite the diagnostic requirement of impairments in both inattention and hyperactivity/impulsivity domains. Poor response inhibition did not appear to be linked with functional outcomes, although it has been suggested that
impulsivity would predict poor financial functioning. Further research on neuropsychological performance considered separately by subtype is needed to identify the important contributing factors. The AD/HD-C subtype group did share higher levels of anxiety and stress with the AD/HD-I subtype group, but the fact that these were shared argues against the impact of hyperactivity/impulsivity contributing to anxiety and stress to any great extent.

The differences between the AD/HD subtype groups demonstrated in this study suggest that the Inattentive criteria of the DSM-IV-TR diagnostic classification system confounds inattention with both memory and impulsivity factors. The inattention criteria items are the main area of overlap between the subtype groups, as these are their only shared symptoms. If the inattention and hyperactivity/impulsivity items were separated and elaborated into inattention, memory and impulsivity domains, the shared portion of the diagnosis may no longer apply, and two (or more) separate diagnoses may result. The results of this study indicate that poor verbal memory, anxiety and stress are the only features shared between these two subtype groups.

The results of this study also suggest a need to re-examine the previously-identified sluggish cognitive tempo subtype of AD/HD. Given that this study’s two subtype groups shared the Inattentive criteria of the diagnostic classification system, it is intriguing that they do not share any similarities in attentional performance. The neuropsychological, psychological and functional outcome profile of this study’s AD/HD-I group suggest a group of adults who struggle to bring their cognitive resources to the task at hand quickly enough to meet the performance demands of attention and memory tasks, who report significantly more depressive symptoms (even though their rates of comorbid mood disorders were the same as the AD/HD-C group), and who reported greater difficulties with social functioning. Previous research has shown that the AD/HD-I subtype exhibit slower processing speeds than AD/HD-C
subtype groups (Adams, Derefinko, Milich, & Fillmore, 2008; Nigg, et al., 2002; Querne & Berquin, 2009). Slower processing speed in the AD/HD-I group and not in the AD/HD-C group was also found in this sample’s TMT Part A performance, though this was not reported because TMT Part A was not included in the attentional component model used. In addition, a meta-analysis has shown that the AD/HD-I subtype consists of two subgroups who are both distinct from, and similar to, those with the AD/HD-C subtype (Stawicki, Nigg, & von Eye, 2006).

**Implications for Clinical Policy and Practice**

This study’s findings confirm the chronic nature of difficulties in inattention, memory and impulsivity by demonstrating relative performance deficits via objective neuropsychological tests in a group of adults with AD/HD. The study showed that neuropsychological factors best predicted AD/HD status, regardless of the presence of psychological symptoms, suggesting that there is a role for neuropsychological testing in confirming AD/HD status, or in differentiating between subtypes in adults.

These findings imply that even among a relatively highly functioning sample drawn from the community, there is a need for the remediation of functional outcomes. Problems with financial functioning were found in the AD/HD-C group. Problems with social functioning were found in the AD/HD-I subtype group, but for both subtype groups social functioning was predicted by psychological, rather than by neuropsychological factors. As both subtype groups were depressed (although the AD/HD-I group were more depressed than the AD/HD-C group), it is clear that it is important to assess and treat depression in this population, and not attribute depressive symptoms to AD/HD symptomatology. Both subtype groups were higher in anxiety and stress than controls, indicating that both need psychological support for these problems as well.
These findings indicate that some of the heterogeneity of adults with AD/HD is likely to be due to the effects of combining two substantially different subtype groups. This study has drawn attention to the possibility that the two subtypes have substantially different treatment needs. In terms of neuropsychological profiles, the AD/HD-I subtype group needs treatment for slow processing speed, focussed attention, and verbal and visual memory. The AD/HD-C subtype group needs treatment for poor response inhibition, problems with verbal memory, and difficulties with financial functioning.

In general, clinical policies and practices need to be identified and disseminated to professionals in the mental health field that draw attention to the need for specialised, comprehensive identification and treatment for this population. In addition, several crucial research questions still require attention. Research on treatment and treatment effectiveness needs to account for subtype differences and for specific factors that may be barriers to effective treatment, such as poor verbal memory, poor response inhibition, depression, anxiety, or difficulties coping with stress.

Limitations of the Study

One of the main weaknesses of this study was the relatively small number of participants, given the number of neuropsychological, psychological and functional outcome variables being examined. This weakness was partially addressed by the use of the MANOVA procedure in an attempt to minimise Type 1 error, however this remains an important limitation to the validity of the results, and caution must be exercised in interpreting these findings. This weakness was also addressed by the use of a control group matched to the AD/HD participants more comprehensively than those in previous studies. Many previous studies of adults with AD/HD have also utilised relatively small numbers of participants, while those with larger numbers generally have drawn their participants from the clinical populations of large urban centres in the
United States. There was a great difficulty in recruiting participants for this study, as the diagnosis of adult AD/HD was not yet familiar to many local psychiatrists. Although they were interested in the topic, many had not identified patients with the diagnosis, or did not feel familiar enough with the diagnosis to apply it to their own patients.

A second limitation of the study is the possibility that this sample is a relatively high functioning sample, given the presumed limitations of AD/HD symptomatology. To be included in this study, participants needed to be able to respond to advertisements about the study, complete and return diagnostic instruments, present for assessment, and complete and return post-assessment questionnaires. Although a great deal of data collection time was spent chasing up and rescheduling participants who had difficulty meeting these conditions, this set of data represents those who were eventually able to do so (albeit with assistance), and does not represent those who could not. There is some support for this in the groups’ average estimated full-scale IQ, which was higher than most reported in the literature on adults with AD/HD. It may be the case that this sample represents the least affected portion of the adult AD/HD population, a contention supported also by the low report of difficulties in functional outcomes.

Another limitation of the study was its dependence on a self-report measure of functional outcome. It is possible that individuals may feel incompetent in an area of functioning, yet not necessarily have difficulties in comparison to others, or from the point of view of others. This issue has been partially addressed by researchers on social functioning in studies of children by using classroom-based ratings of popularity or parent ratings of social success (Nixon, 2001). For obvious reasons this is not possible with adults, and it is for this reason that researchers in adult AD/HD have relied on personal data sources, such as the number of jobs participants have been fired from, or whether the participant has been divorced, as crude estimates of functioning. This study
has therefore made a unique contribution to our understanding of adaptive functioning in a group of adults with AD/HD by utilising a detailed self-report measure, which has increased the precision of assessment, but it is still a possibility that the constructs may not have been satisfactorily assessed.

In addition, the effect of comorbidities (both known and unknown) on participants’ neuropsychological performances were not comprehensively analysed, and may restrict the generalisability of the findings from this sample to other community samples. Finally, this study was limited by its use of a cross sectional rather than a longitudinal design. Cross sectional data can only be used to infer developmental changes over the course of individuals’ lifetimes (Babbie, 1995), and cannot capture potential predictive factors that precede abnormal development in adulthood.

**Suggestions for Further Research**

A number of issues identified in this study suggest future directions for research. Firstly, there is a pressing need for more detailed information regarding adult AD/HD subtype groups, further identifying points of similarities and differences in neuropsychological profiles, in psychological symptoms, in functional outcomes, and in the relative effectiveness of treatments. Most theoretical accounts of AD/HD focus on explaining the symptomatology of the Hyperactive/Impulsive and Combined subtypes, to the detriment of the Inattentive subtype. The dopaminergic and noradrenergic theories of AD/HD only partially account for the characteristic profiles of the Inattentive subtype, and debate continues about whether this condition is a form of AD/HD or a different condition entirely.

Secondly, there is a need for more comprehensive research into memory processes in AD/HD, identifying relative strengths and weaknesses, but also in
identifying where in the process of remembering the deficit lies. It is possible that early
encoding processes are disturbed, which could account for poor performance in both the
immediate and delayed conditions, but there could be other reasons for poor
performance, such as verbally-based retrieval deficits. The use of the SVLT in this
study has showed promise for identifying visual memory difficulties in this population,
as it overcomes the previous limitations of alternative measures, such as organisational
and motor abilities. Although this study found that the Inattentive subtype were poorer
on this measure, this possibility needs further exploration before reaching any firm
conclusions.

Thirdly, research on functional outcomes in adults with AD/HD could be greatly
improved by identifying subgroups based on the severity of AD/HD symptoms. If more
severe symptom ratings (or higher symptom counts) were correlated with poorer
functioning, this would support the argument that the two are related. The identification
of subtypes in future research on functional outcomes would also prove informative for
both treatment design and theoretical understanding. Fourthly, the developmental
course of AD/HD can only be accurately captured by longitudinal studies that account
for the childhood and adolescent symptoms that precede adult AD/HD.

Finally, functional outcomes research directly comparing adults with AD/HD
only to adults with AD/HD and depressive or anxious symptoms would extend this
study’s findings, and could help to better identify any functional outcome difficulties in
AD/HD. The assertions of researchers and clinicians that adults with AD/HD have
significant difficulties with everyday living skills have only been partially supported by
the results of this study.
Conclusions

This study compared the performances of adults with AD/HD and a control group matched on age, gender, education, and estimated full-scale IQ on theoretically derived attention, memory and executive functioning tasks. The AD/HD group was comprised of two subtype groups: Inattentive and Combined. Contrary to the executive functioning theories of AD/HD, the only deficit found in executive functioning was in response inhibition, and this was found only in the Combined subtype group. The only attentional deficit found was in focus/execute, and this was found only in the Inattentive subtype group. Deficits were found in both subtypes in immediate and delayed verbal memory performances, while only the Inattentive subtype group demonstrated poorer visual memory performance. It was shown that performance on neuropsychological tasks could reliably differentiate between the AD/HD and control groups. It was shown that the Inattentive subtype group reported significantly more depressive symptoms, while both subtype groups reported significantly more anxiety and stress symptoms. The study also found that, among four self-report measures of functional outcome, social and financial functioning were significantly found to be poorer among the AD/HD adults, with AD/HD-I subtype adults reporting poorer social functioning, and AD/HD-C adults reporting poorer financial functioning.

These findings support the dopaminergic and noradrenergic theories of AD/HD that predict neuropsychological deficits based on hypofunctioning mesolimbic, mesocortical, and nigrostriatal pathways. The results further extend the work of previous studies by demonstrating attentional deficits and visual memory deficits only in the Inattentive subtype, and by identifying deficits in verbal memory for both AD/HD subtype groups. Previous research on psychological impairments in AD/HD were supported and extended, demonstrating that while higher levels of anxiety and stress are
reported by adults with AD/HD, higher levels of depressive symptoms were found only in the Inattentive subtype group. Some support was found for the contention that neurological symptoms predict poor functional outcomes in adults with AD/HD, but psychological symptoms were also shown to contribute to functional outcomes.

This study has contributed to a greater understanding of the neuropsychological and psychological profiles of two subtype groups of adults with AD/HD by using a more careful and thorough methodology. The study has also highlighted important gaps in knowledge about adult AD/HD. In particular, the AD/HD-I subtype group is not well studied or understood, and may in fact be the most disabled portion of the AD/HD population, in terms of neuropsychological, psychological, and functional outcomes. Further research on the identification, assessment and treatment of this subtype group is needed urgently. Future research on AD/HD in adults must consider subtype groups separately in order to disentangle the relative strengths and weaknesses of the AD/HD subtypes and to better inform theory and practice.
Appendix A

INFORMATION SHEET
Cognitive and Adaptive Functioning in Adults with AD/HD

Who is conducting the research?

Roberta Dobson-Patterson, PhD Candidate
School of Applied Psychology
Griffith University, Mt Gravatt Campus
Phone 3875-3341
Email R.Dobson-Patterson@griffith.edu.au

Ms Dobson-Patterson has completed all classroom and practical components of the PhD in Clinical Psychology program and is a psychologist with experience in treating a variety of clinical concerns, as well as neuropsychological and alcohol and drug use issues. She previously completed research at Griffith University on the prospective memory abilities of children with traumatic brain injury.

Professor David Shum, Principal Supervisor
School of Applied Psychology
Griffith University, Mt Gravatt Campus
Phone 3875-3333
Email D.Shum@griffith.edu.au

Professor Shum conducts research on the effects of brain injury on cognitive processes (e.g., attention, memory, executive functions), the development of neuropsychological tests (e.g., memory and learning, prospective memory, execution functions), the effects of normal ageing on cognitive processes (e.g., attention, memory, executive functions, prospective memory), and on neuropsychological rehabilitation.

Why is the research being conducted?

Recently scientists have discovered that many children with AD/HD do not “grow out of it”, and enter adulthood with many of the same problems they had as children. Problems such as difficulty concentrating, paying attention, remembering things, and being able to get organised can prevent adults from succeeding in jobs, school, and relationships. Scientists have also found that these adults have more than the usual problems with handling their emotions, with handling stress, with the use of drugs and alcohol, with driving safely, and in their relationships with others. This study is being conducted to identify adults with AD/HD, to test their attention, concentration, memory
and thinking abilities, to check for emotional or other difficulties of living, and to see if these are related. The results of this study will contribute to our understanding of the problem, and to theories about what causes it and what can be done about it.

What will you be asked to do?

You will be asked to complete a series of tests of your attention, concentration, memory, and thinking abilities during one-on-one testing in the Griffith University Psychology Clinic. You will also be asked to complete some questionnaires about your emotions, your alcohol and drug use, and any problems or stresses you experience.

On what basis will participants be selected?

AD/HD participants who volunteer will be asked to complete an adult AD/HD rating scale and to have a partner, a parent or someone else close to them complete a similar scale. They will also be interviewed about their personal, health, education and vocational history. Based on these, on their history, and also on the results of the personal interview, participants will be included in the AD/HD group for the study.

Control participants who volunteer will be asked to complete a short screening questionnaire for adult AD/HD.

What are the expected benefits of the research?

The research will benefit participants by giving them a clear picture of their current strengths and weaknesses. The research will benefit the scientific community by addressing important issues in AD/HD research.

What are the risks to you?

There are no known risks that can occur to you as a result of participating in the research. If during the course of the research, or after your participation in the research, you become concerned about an issue, you are encouraged to contact one of the following for help:

Your General Practitioner
Australian Psychological Society (for referral to psychologist) 1-800-333-497
Alcohol & Drug Information Service (24 hour information) 3236-2414
   Outside Brisbane 1-800-177-833
Lifeline (24 hour crisis counselling) 13-11-14
Relationships Australia 1-300-364-277

Your confidentiality

Your test results will be entered into a computer program under a code number and will not be identifiable. Your test papers will be kept in a locked file cabinet in a locked office in the Griffith University Psychology building.
Your participation is voluntary

Your participation is strictly voluntary, and you are free to withdraw from the study at any time. Your decision will not have any impact on your membership in any organisation or your status as a patient or client of any clinic.

Questions / Further information

Contact Roberta Dobson-Patterson or her supervisor, Dr David Shum, (07) 3735-3370, email D.Shum@griffith.edu.au, if you have questions about the project.

Ethical conduct of the research

Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Research Involving Humans. If you have any concerns or complaints about the ethical conduct of the project, please contact the Manager, Research Ethics on (07) 3735-5585 or research-ethics@griffith.edu.au.

Feedback to you

Information about what the tests measured and what they may mean will be provided after your testing is completed. Any reporting of the research findings will be done as group averages and not as individual scores, and will be available to participants after the project is completed, if they wish.

Privacy Statement

The conduct of this research involves the collection, access, and/or use of your identified personal information. The information collected is confidential and will not be disclosed to third parties without your consent, except to meet government, legal or other regulatory authority requirements. A de-identified copy of this data may be used for other research purposes. However, your anonymity will at all times be safeguarded. For further information consult the University’s Privacy Plan at www.gu.edu.au/ua/aa/vc/pp, or phone (07) 3735-5585.
Appendix B

CONSENT FORM
Cognitive and Adaptive Functioning in Adults with AD/HD

Research Team

Associate Professor David Shum, Supervisor, Senior Investigator
School of Applied Psychology
Griffith University, Mt Gravatt Campus
NATHAN QLD 4111
Phone 3875-3333
Email D.Shum@griffith.edu.au

Roberta Dobson-Patterson, PhD Candidate, Student Researcher
School of Applied Psychology
Griffith University, Mt Gravatt Campus
NATHAN QLD 4111
Phone 3875-3341
Email R.Dobson-Patterson@griffith.edu.au

By signing below, I confirm that I have read and understood the Information Sheet and in particular have noted that:

- I understand that my involvement in this research will include completing a series of tests, undergoing an interview, and completing questionnaires;
- I have had any questions answered to my satisfaction;
- I understand the risks involved;
- I understand that there will be no direct benefit to me from my participation in this research;
- I understand that my participation in this research is voluntary, and does not impact upon my status in any organisation or clinic;
- I understand that if I have additional questions I can contact the research team;
- I understand that I can contact the research team if I have any questions about my test results within six months of testing;
- I understand that I am free to withdraw at any time, without comment or penalty;
- I understand that I can contact the Manager, Research Ethics, at Griffith University Human Research Ethics Committee on (07) 3875-5585 (or research-ethics@griffith.edu.au) if I have any concerns about the ethical conduct of the project; and
- I agree to participate in the project.

Name

________________________________________________________________________

Signature

________________________________________________________________________

Date  _____ / ____ / _____
Appendix C

ID __________

ABOUT YOU…

What is your date of birth? __________________________ Your age? ___

What is your postcode? __________________________

What ethnic group are you from? (Tick one)

- Aboriginal or Torres Strait Islander
- Australian Caucasian
- Other – please state __________________________

Are you… (Tick one)

- Right-handed
- Left-handed
- Both

Are you currently employed… (Tick one)

- No
- Yes, full-time (38 or more hours per week)
- Yes, part-time (less than 38 hours per week)

What is your current job, or your usual job (if unemployed)?

___________________________________________________

What is your current marital status? (Tick one)

- Single
- Married or Defacto (living with)
- Divorced
- Widowed

What is the highest level of education you have completed? (Tick one, or as many as apply)

- Some primary school
- Primary School
- Year 10
- Year 12
- Apprenticeship
- TAFE Certificate
- Graduate Diploma
- Bachelors Degree
- Postgraduate Degree
References


based on clinical presentation to a specialty clinic. *Comprehensive Psychiatry, 38*(3), 133-140.


Findings from a large group of adults with and without ADHD. *American Journal of Psychiatry, 158*, 611-617.


