Attention and Memory in Boys
with Predominantly Inattentive and Combined Subtypes of ADHD

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Except where due acknowledgement is given, I affirm that this thesis is the result of my own research carried out under the supervision of Dr. Bernd Heubeck of the Department of Psychology at the Australian National University.

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Abstract

Attention-Deficit/Hyperactivity Disorder (ADHD) is a common disorder in childhood which can have a significant impact upon many facets of a child’s life. The ADHD-Predominantly Inattentive (ADHD-PI) and ADHD-Combined (ADHD-C) subtypes share clinically significant problems of inattention, but differ from one another in the presence of clinically significant levels of hyperactivity-impulsivity for the latter subtype. Important differences between the ADHD-PI and ADHD-C subtypes have emerged in the ADHD literature pertaining to demographic and family characteristics, and psychosocial functioning. In addition, some theoretical conceptualisations of ADHD (e.g., Barkley, 1997; Sonuga-Barke, 2002) have distinguished between the subtypes, with Milich, Balentine, and Lynam’s (2001) having further asserted that the ADHD-PI and ADHD-C are distinct and unrelated disorders.

In the school context, children with either ADHD subtype have been found to display marked problems with their learning. Studies that have investigated the nature of the fundamental building blocks of learning – attention and memory – in ADHD have found mixed results pertaining to differences between the subtypes. At present, consensus has not been reached in the literature regarding the precise nature of attention and memory deficits for the ADHD-PI versus the ADHD-C subtypes.

The current study examined the nature of and differences in attention and memory between ADHD-PI, ADHD-C and Control groups. Differences in psychosocial functioning between groups were also explored as such functioning can have some impact upon a child’s learning at school. Twenty boys with ADHD-PI were matched on age, intelligence, and current medication status with 20 boys with ADHD-C and 20 control children. Different patterns in psychosocial functioning, as assessed by parent and child ratings on the Strengths and Difficulties Questionnaire, were found between groups.

Participants were administered the Test of Everyday Attention for Children, a battery of tests that assess different types of attention – selective attention, sustained attention and attentional control/switching. Different types of memory – working memory, explicit memory, and implicit memory – were assessed using the Digit Span Forward and Backward tasks, a Category Cued Recall task, and a Category Exemplar Generation
task. On attention tests, the ADHD-PI and ADHD-C subtypes performed comparably and were impaired relative to controls on sustained attention and attentional control/switching, with some additional selective attention impairments for the ADHD-C group. No differences on memory measures were found between groups, with the exception of the ADHD-PI subtype scoring higher on Digits Forward than the ADHD-C group. A discriminant analysis based on attention and memory test performance found attentional control/switching measures to best discriminate the ADHD groups from controls and a trend for selective attention measures to separate the ADHD subtypes. Sixty-seven percent of participants were correctly classified by the discriminant analysis which indicated that there was considerable heterogeneity in attention and memory profiles within groups.

The results of the present study suggest that the nature of attention and memory in the ADHD groups was more similar than dissimilar. The heterogeneous nature of these fundamental building blocks of learning within each ADHD subtype has clinical implications and points to the need for individualised assessment and treatment for children with ADHD.
Chapter 1: Introduction

Jamie is an 8-year-old boy in Grade 3. He is seated at his desk trying to complete some maths problems like the rest of his class. However, as Jamie works on the problems he swings on his chair and his eyes frequently dart around the room at any little noise he hears, whether it is coming from in or outside of the classroom. Jamie gets to problem three that he cannot solve and quickly gets up out of his chair and interrupts his teacher who is working with another student. The teacher reprimands Jamie and he is told to return to his seat, but on the way he flips through the book the class is reading before stopping to talk to a peer about recess. Jamie’s teacher reprimands him again for not doing what he is told and it becomes quite clear that Jamie does not seem to know what he should be doing or where he should be. Jamie’s teacher again prompts him to return to his desk and when he gets there he tips his pencil case on to his desk and begins to play with his new textas. The bell rings and the rest of the class who have finished 15 problems leave for lunch. Jamie has only completed two problems.

Kyle is also aged 8 and in Grade 3. His class is writing in their journals about what they did on the weekend. Kyle writes the date on his page and then stares out the window. He thinks about his birthday on Saturday and about the presents he received, and then about the Lego figurine that was his favourite. He only realises his teacher is standing beside him when she taps on his work to get his attention. Kyle looks at his workbook- he seems to have lost the pencil he was writing with and his teacher points out that he wrote the wrong date on his page. She then talks with Kyle about what he might write in his journal, and he starts to do so, but by the time he’s written ‘On the weekend I’ all his ideas are gone. The bell rings and the rest of the class close their journals- most of them have written a page. Kyle looks at his almost blank page and sighs thinking he will have to stay in at recess again to finish his work.

Both Jamie and Kyle have great difficulties which are seriously impacting upon their learning in the classroom. Their difficulties are common in children with Attention-Deficit/Hyperactivity Disorder (ADHD).

ADHD is a psychological disorder which has a profound impact upon a child’s life and affects between 3-7% of school-aged children (American Psychiatric Association [APA], 2000). Many of these children generally have the intellectual ability to succeed
(i.e., their intelligence is normally distributed), but they lack the capacity to use their ability effectively. Their deficit in attention and for some, their engagement in hyperactive and impulsive behaviours, significantly impacts their capacity to learn, engage in relationships and their broader functioning in the world.

Whilst there are many questions raised by the media (Armstrong, 1996; Spillane, 2010) pertaining to whether ADHD is a real disorder, there is broad consensus amongst researchers and clinicians that ADHD is a valid disorder (Barkley et al., 2002; Remschmidt & Global ADHD Working Group, 2005).

The Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition, Text Revision (DSM-IV-TR, APA, 2000) identifies three subtypes of ADHD: an ADHD-Combined subtype (ADHD-C); an ADHD-Inattentive subtype (ADHD-PI); and an ADHD-Hyperactive-Impulsive subtype (ADHD-PHI). These subtypes vary from one another in terms of the presence of clinically significant levels of inattention and/or hyperactivity and impulsivity.

In the cases of Jamie and Kyle, Jamie is likely to be diagnosed with ADHD-C, whereas Kyle would more likely be diagnosed with ADHD-PI. However, how similar the difficulties are that impact on Jamie and Kyle learning at school, is not conclusively answered by this subtyping.

For over 15 years, the conceptualisation of this difference in difficulties between ADHD subtypes has been a topic of controversy in the scientific community. Some researchers (Carlson, Shin, & Booth, 1999; Morgan, Hynd, Riccio & Hall, 1996; Nigg, Blaskey, Huang-Pollock & Rappley, 2002) have asserted that ADHD-PI is best conceptualised as a valid subtype within the overarching ADHD diagnosis. However, other theorists (e.g., Barkley, 1997; Milich, Balentine & Lynam, 2001) have posited, citing research of demographic and socio-emotional functioning differences between the subtypes, that ADHD-PI is a qualitatively distinct disorder from ADHD-C.

Perhaps the most pertinent issue for Jamie and Kyle is the nature of the difficulties which impact upon their learning. Attention and memory are conceptualised in cognitive and developmental psychology as the fundamental building blocks for learning (Lezak et al., 2004; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1996;
Webster, Hall, Brown, & Bolen, 1996). The aim of this thesis is to explore the possible similarities and differences between ADHD-PI and ADHD-C in the fundamental building blocks of attention and memory which underpin learning.
Chapter 2: Defining ADHD

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most common psychiatric disorders of childhood, and is characterised by developmentally inappropriate levels of inattention and/or hyperactivity and impulsivity (Kutcher et al., 2004; Remschmidt & the Global ADHD Working Group, 2005). The prevalence of ADHD is estimated to be between 3 and 7% of school-aged children (APA, 2000; Polanczyk, Silva de Lima, Horta, Biederman & Rohde, 2007). ADHD is a chronic condition which has been found to have an impact upon various aspects of a child’s development, including their social, emotional and cognitive functioning (Barkley et al., 2002; Remschmidt & the Global ADHD Working Group, 2005). ADHD has been linked to a number of negative sequelae, including poor academic achievement, school grade retention, school suspensions and expulsion, poor peer and family relations, anxiety, depression, aggression, conduct problems and delinquency, early substance experimentation and abuse, adverse driving consequences, as well as difficulties in adult social relationships, marriage and employment (Barkley, 2006b; Harpin, 2005; Young, 2000). The presence of these negative impacts and sequelae has highlighted the importance of attaining a comprehensive understanding of the nature of ADHD, which may allow for well-targeted interventions to be designed to prevent these substantial adverse consequences.

2.1 Conceptualisations of ADHD

A major question raised pertaining to ADHD is how best to conceptualise this disorder. Two views have been espoused. Firstly, a continuum view has been proposed which conceptualises ADHD at the extreme end of a continuum of behaviour dysfunction. Support for this view has been found in studies (e.g., Frazier, Youngstrom & Naugle, 2007; Haslam et al, 2006) using latent class and taxometric procedures. Alternatively, the categorical view conceptualises ADHD as a discrete condition, as reflected in the criteria for ADHD listed in the Diagnostic and Statistical Manual of Mental Disorders (DSM). At present, there has been no reconciliation of this question, with both views accepted by the scientific community.
2.2 The History of ADHD

Although ADHD was not formalised as a disorder until its introduction into the DSM-II (APA, 1968) it has been described in the research literature since the beginning of the twentieth century. In a series of lectures, George Still (1902) described 43 children who had presented to his clinic with marked problems in sustained attention and self-regulation, displayed as overactivity and often aggressive, defiant and emotionally excessive behaviour. Following the epidemic of encephalitis in 1917-1918 numerous child survivors of this brain infection presented to clinics with similar symptoms to those described by Still (1902). At this time, labels such as ‘postencephalitic behaviour disorder’ and later ‘minimal brain damage’ where no neurological damage was found to account for these symptoms, became popular (Barkley, 2006a). Barkley (2006a) noted that during the late 1960’s there was a marked shift in the conceptualisation of ADHD from a disorder defined by its aetiology to one described in terms of behavioural features. This was reflected in the description of *Hyperkinetic Reaction of Childhood* in DSM-II (1968) as a disorder characterised by symptoms of overactivity, restlessness, distractibility and a short attention span.

In DSM-III (APA, 1980) the term *Attention Deficit Disorder* (ADD) was coined, with increased emphasis placed upon the inattention and impulsivity symptoms. This change in emphasis was largely due to research findings reported by Douglas (1973) of problems with sustained attention and impulse control that accounted for most of the deficits displayed by children who were hyperactive. In addition in the DSM-III, ADHD was for the first time conceptualised as a multi-dimensional disorder with two subtypes delineated: *ADD with hyperactivity* (ADD+H) and *ADD without hyperactivity* (ADD-H). Milich et al. (2001) explained that the purpose for inclusion of the later subtype was to stimulate research that determined whether it was a valid diagnostic disorder.

However, in the subsequent revision of DSM-III (i.e., DSM-III-Revised; APA, 1987) the multi-dimensional conceptualisation of ADD was abandoned due to lack of empirical evidence for the ADD-H subtype at the time of publication (Barkley, 1990; Lahey, et al., 1988; Lahey & Carlson, 1991). Instead the disorder was renamed *Attention Deficit Hyperactivity Disorder* and a single list of inattention, hyperactivity, and impulsivity symptoms was presented for which children needed to meet at least 8 out of the 14 symptoms for a diagnosis of ADHD to be given.
A single list of symptoms was also presented in the criteria for *Hyperkinetic Disorder*, which was the corresponding disorder to ADHD in the International Classification of Mental and Behavioural Disorders-10 (World Health Organisation, 1993). However, unlike the DSM-III-R criteria for ADHD of any eight symptoms needed to be present, Hyperkinetic Disorder could only be diagnosed when at least three attention problems, 3 activity problems and one impulsivity problem was present.

A multi-dimensional conceptualisation of ADHD was reverted back to in the DSM-IV (APA, 1994) with separate lists for symptoms of inattention and hyperactivity-impulsivity, which were derived based upon factor analytic studies (Bauermeister, et al., 1992; McBurnett, Lahey & Pfiffner, 1993). In addition, three subtypes were specified: *ADHD- Predominantly Inattentive* (ADHD-PI), *ADHD-Combined* (ADHD-C), and *ADHD-Predominantly Hyperactive-Impulsive* (ADHD-PHI). No changes were made to the diagnostic criteria for ADHD in the DSM-IV-Text Revision (DSM-IV-TR; APA, 2000).

Over the past 15 years since the introduction of DSM-IV there has been increasing scientific support for the validity of the three subtypes of ADHD (Morgan et al., 1996; Woo & Rey, 2005). Furthermore, a number of research studies (Baumgaertel, Wolraich, & Dietrich, 1995; Morgan et al., 1996) have found strong evidence to support the correspondence between the ADD+H and ADHD-C subtypes, as well as the ADD-H and ADHD-PI subtypes. Hence, from this point forward these groups will be referred to only as ADHD-C and ADHD-PI, respectively.

### 2.3 The Current Diagnostic Criteria for ADHD

The current diagnostic criteria in DSM-IV-TR present a multi-dimensional conceptualisation of ADHD in which its symptoms are grouped into two dimensions: inattention and hyperactivity-impulsivity. In addition, age of onset, cross-situational presence of ADHD symptoms, impairment, and exclusion criteria for ADHD are specified in the DSM-IV-TR. The current DSM-IV-TR criteria for ADHD are displayed in Figure 1.

Further to these criteria, three distinct subtypes of ADHD are specified in DSM-IV-TR. Only six or more symptoms are required to be present from the inattention or from the hyperactivity-impulsivity symptom lists for a diagnosis of ADHD-PI or ADHD-PHI to
A. Either (1) or (2):
   (1) six (or more) of the following symptoms of inattention have persisted for at least 6 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 behaviour 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’
   (f) often talks excessively
   Impulsivity
   (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).

Figure 2.1: DSM-IV-Revised Criteria for Attention-Deficit/Hyperactivity Disorder (APA, 2000)
be given, respectively. For the diagnostic criteria of ADHD-C to be met at least six inattentive symptoms and six or more symptoms on the hyperactivity-impulsivity symptom lists must be present.

The ADHD-PHI subtype has been found to generally afflict preschool aged children who either outgrow their hyperactivity or, more commonly, develop inattentive symptoms, thus qualifying for the ADHD-C diagnosis (Hinshaw, et al., 1997; Lahey, Pelham, Loney, Lee & Willcutt, 2005). As a result, only the ADHD-PI and ADHD-C subtypes are focused upon in this literature review.

2.4 Evaluation of Current Diagnostic Criteria and Beyond

Since the introduction of the ADHD subtypes in DSM-IV/DSM-IV-TR there has been a proliferation of research studies examining subtype differences. Whilst some research studies (Faraone, Biederman, Weber, & Russell, 1998; McBurnett et al., 1999) have reported few differences between subtypes on cognitive and psychosocial measures, other studies (Carlson et al., 1999; Milich, et al., 2001) have found significant subtype differences on a multitude of dimensions.

However, whilst the DSM-IV/DSM-IV-TR criteria facilitated a better understanding of ADHD, Barkley (2003) has asserted that these criteria are not without flaws. Some of the problems that pertain to the DSM-IV/DSM-IV-TR criteria for ADHD have included: the underrepresentation of impulsivity symptoms, threshold artefacts (e.g., a child may display five inattention and five hyperactivity symptoms but not be eligible for an ADHD diagnosis), a premature age of symptom onset since some symptoms of ADHD (especially the inattention symptoms) manifest after the age of seven, and the applicability of these criteria to adult ADHD (APA, 2010; Barkley, 2003; Bell, 2011). However, the most pertinent criticism of the current ADHD criteria has pertained to the ADHD-PI subtype in two ways. Firstly, the question has been raised of whether the ADHD-PI subtype can be conceptualised as identical to the ADHD-C subtype, but without clinically significant levels of hyperactivity/impulsivity present. Secondly, the ADHD-PI subtype has become increasingly viewed as a heterogeneous category. This subtype is comprised of three groups of children: 1) those who are purely inattentive (i.e., clinically significant inattention with few, if any, hyperactivity-impulsivity symptoms), 2) those who are sub-threshold ADHD-C (i.e., clinically significant inattention with four to five hyperactivity-impulsivity symptoms), and 3) those who
previously met criteria for ADHD-C, but have since outgrown their clinically significant hyperactivity-impulsivity symptoms.

Looking forward there has been much speculation as to how the DSM-V, which is scheduled for publication in 2013, will conceptualise the ADHD-PI subtype. The ADHD and Disruptive Behaviour Disorders Taskforce have released draft guidelines proposing three options to address these criticisms of the ADHD-PI subtype. These options have included: 1) no change to the current criteria, but a separate code for ADHD-PI; 2) the introduction of an additional subtype, ADHD-Restrictive-PI, for individuals with ADHD-PI who have two or less hyperactivity-impulsivity symptoms; and 3) the creation of a new diagnostic category of Attention Deficit Disorder (APA, 2010). It is clear from the DSM-V proposed guidelines that the topic of how the diagnostic entity of ADHD-PI is best conceptualised is still under debate. Furthermore, it is evident that more research is needed to gain greater clarity on the precise nature of difficulties experienced by the different ADHD subtypes.

2.5 Summary
This chapter has outlined a categorical view by utilising the DSM criteria for ADHD. Whilst the diagnostic criteria have undergone numerous revisions in the preceding decades, the DSM-IV/DSM-IV-TR conceptualisation and specification of ADHD subtypes has remained unchanged for over 15 years. In anticipation of the publication of the DSM-V, problems have been identified pertaining to the current conceptualisation of the ADHD-PI subtype. The literature review explores the nature of difficulties and differences between the ADHD-PI and ADHD-C subtypes.
Chapter 3: Demographic Characteristics of the ADHD Subtypes

A helpful first step in delineating the precise nature of the difficulties and differences between ADHD subtypes is to examine the demographic characteristics of each subtype. This chapter reviews the research on subtype differences in prevalence, age of onset and referral, gender ratio, socio-economic status, and family characteristics.

3.1 Prevalence

The prevalence of ADHD is estimated to be between 3 – 7% of school-aged children (APA, 2000). However, in research studies the prevalence of ADHD has been found to vary widely from 2.4% (Gomez, Harvey, Quick, Scharer, & Harris, 1999) to 11.4% (Wolraich, Hannah, Pinnock, Baumgaertel, & Brown, 1996) depending upon a number of factors. These factors have included: the population being sampled (i.e., community or clinical sample), type of assessment employed (i.e., diagnosis by clinician versus parent/teacher rating on a questionnaire), criterion used (i.e., DSM or International Classification of Mental and Behavioural Disorders), and the number of informants on the child’s behaviour (i.e., parent and/or teacher). In Australia, Graetz, Sawyer, Hazell, Arney, and Baghurst (2001) found the prevalence of ADHD to be 7.5% in their community-based study of 3,597 children which used parent ratings on the Diagnostic Interview Schedule for Children.

In terms of ADHD subtype differences in prevalence rates, research studies have generally found ADHD-PI to be the most common subtype in community samples (Graetz et al., 2001), whereas ADHD-C tended to be more prevalent in clinical settings (Faraone et al., 1998). The latter trend may be explained by the more disruptive behaviour exhibited by children with ADHD-C which led to their prompt referral to clinical settings.

Prevalence rates have been found to vary in the community from 4.5% to 9% for ADHD-PI, and 1.9% to 4.8% for ADHD-C (Baumgaertel et al., 1995; Gaub & Carlson, 1997). Whilst teacher ratings on DSM-IV criteria were employed in both studies to determine the prevalence rates of ADHD subtypes, 1700 more students were assessed in the latter study than in the former, which may account for the different prevalence rates. Gomez et al.’s (1999) study, which employed more stringent criteria of parent-teacher
agreement, found that only 1.6% and 0.6% of children in their sample of Australian primary school students met criteria for ADHD-PI and ADHD-C, respectively.

The ADHD-C subtype tends to be more common in young people referred to specialist ADHD clinics for assessment and treatment with subtype distribution ranging from 30% to 48% for ADHD-PI, and 42% to 61% for ADHD-C (Faraone et al., 1998; Morgan et al., 1996). This difference in prevalence rates may be accounted for by the former study using structured clinical interviews to determine subtype diagnosis, whereas subtype identification was based upon clinical judgement using information from both parents and teachers in the latter study.

### 3.2 Age of Onset and Age of Referral

The developmental course of ADHD involves the emergence of problematic hyperactivity-impulsivity symptoms, if present, in the preschool years followed by the manifestation of inattention symptoms generally by Grade 2 (APA, 2000). The age of onset of ADHD symptoms for children with ADHD-C appears to be significantly earlier than their ADHD-PI counterparts (Bauermeister et al., 2005; Faraone et al., 1998; Hurtig et al., 2007). However, Paternite, Loney and Roberts’ (1996) study, which contained a relatively smaller clinical sample to Faraone et al. (1998), failed to find a marked difference in age of onset between subtypes.

Research studies (Faraone et al., 1998; Paternite et al., 1996) have also found significant differences between ADHD subtypes in the age of referral to paediatric services, wherein children with ADHD-PI were referred at approximately 9 years, whereas their ADHD-C counterparts were referred between the ages of 6 and 8.

### 3.3 Gender Differences

Across all subtypes, ADHD has been found to occur more frequently in males than females (APA, 2000; Gomez et al., 1999). Male-to-female ratios for ADHD-PI range from 1.5:1 to 3.3:1, whilst for ADHD-C ratios vary from 1.2:1 to 5.5:1 (Faraone et al., 1998; Morgan et al., 1996). There have been inconsistent findings regarding ADHD subtype differences in male-to-female ratios, with some studies finding the gender ratio of the ADHD-PI subtype to be significantly smaller compared to that of the ADHD-C subtype (Harrington, 2008; Weiss, Worling & Wasdell, 2003), whilst others failed to find such differences (Chhabildas, Pennington, & Willcutt, 2001; Eiraldi, Power, &
Maguth Nezu, 1997; Gaub & Carlson, 1997; Hurtig et al., 2007). This discrepancy can be accounted for by community and/or small samples being used in the studies finding no significant difference in gender ratios, whereas both Harrington’s (2008) and Weiss, et al’s (2003) studies used large (n > 230) clinical samples.

3.4 Socio-economic Status and Ethnicity

Overall, no clear link has been established between ADHD and socio-economic status (Edelbrock, Costello, & Kessler, 1984; Paternite, Loney, & Roberts, 1995; Willcutt, Pennington, Chhabildas, Friedman, & Alexander, 1999). Likewise, most studies (Barkley, Grodzinsky, & DuPaul, 1992; Barkley, DuPaul, & McMurray, 1990; Chhabildas et al., 2001; Paternite et al., 1996; Sheppard, 2009) investigating subtype differences in socio-economic status have not found such differences, although a few have noted a trend approaching significance wherein children with ADHD-C tend to be of lower socio-economic status than their ADHD-PI counterparts (Faraone et al., 1998; McBurnett et al., 1999). The results of Graetz et al.’s (2001) large-scale study of Australian children are consistent with the suggestion that children with ADHD-C may be of lower socio-economic status than their ADHD-PI counterparts. Specifically, Graetz et al.’s study found all ADHD subtypes to be socially disadvantaged relative to controls, but that parental education and employment of the ADHD-C group were the lowest, being significantly lower than that of parents of children with ADHD-PI.

In terms of ethnicity, the APA (2000) notes in the DSM-IV-TR that ADHD occurs across cultures, which implies that ADHD has not been linked to ethnicity. Furthermore, some research studies (Chhabildas et al., 2001; Eiraldi et al., 1997; Gaub & Carlson, 1997; Sheppard, 2009) have been unable to find differences in ethnicity between the ADHD subtypes.

3.5 Family Characteristics

In terms of family characteristics of ADHD and its subtypes, research has centred upon family size and type, and parental stress and psychopathology. Whilst few differences between subtypes have been found relating to family size and type (Eiraldi et al., 1997), there have been mixed findings regarding parental stress and psychopathology. Childhood ADHD was found to be linked, in Kessler et al.’s (2005) study, to childhood adversities which included child maltreatment, financial adversity and family instability. In terms of ADHD subtypes, Barkley et al.’s (1990) study comparing children with
ADHD-C, ADHD-PI, learning disorders and control children found no subtype differences in maternal stress and marital discord. In contrast, mothers in Bauermeister et al.’s (2005) study reported significantly more stress in rearing ADHD-C compared with ADHD-PI, and ADHD-PI compared with control children, although parenting practices did not vary between ADHD groups. A similar difference between subtypes was found by Graetz et al (2001). Whilst Cantwell and Baker (1992) found no subtype difference on most psychosocial stressors, they reported that marital discord was more common in families with an ADHD-C child relative to families of an ADHD-PI child.

Some interesting trends have emerged pertaining to immediate and extended family psychopathology. High rates of maternal and paternal psychopathology were reported for children with ADHD in Kessler et al.’s (2005) study. Cantwell and Baker (1992) found psychiatric illness in general to be more prevalent in mothers of children with ADHD-C. However Barkley et al. (1990) reported no subtype differences in paternal reports of depression, psychosis, mental retardation, and anti-social behaviour amongst relatives. Rather, in that study, children with ADHD-C were found to be significantly more likely to have paternal relatives with ADHD and maternal relatives with substance use problems and/or anxiety disorders, relative to the ADHD-PI, Learning Disorder and Control groups. Furthermore, children with ADHD-PI were significantly more likely to have siblings with learning disorders relative to children with ADHD-C and controls (Barkley et al., 1990).

**3.6 Summary & Conclusions**

Although no subtype differences were found in ethnicity, the ADHD subtypes have been found to differ on other important demographic characteristics. Firstly, the subtypes have been found to differ from each other in terms of prevalence and predominance across settings. Secondly, age of onset and referral are reported to be significantly younger for ADHD-C. Thirdly, differential patterns in parental psychopathology have been found for the ADHD subtypes. Finally, whilst not statistically significant, trends have emerged in the literature wherein the ADHD-PI subtype has been found to have a smaller gender ratio and the ADHD-C subtype has been linked to lower socio economic status. This review of the literature therefore suggests that the ADHD subtypes may differ from one another in several important respects.
Chapter 4: Psychosocial and Academic Differences Between the ADHD Subtypes

Whilst some differences were found in demographic and family characteristics between ADHD-PI and ADHD-C, the majority of studies in this area have focused on differences in psychosocial and academic functioning between the ADHD subtypes. This chapter reviews the current literature on subtype differences in general functioning, and more specifically differences in psychological correlates (e.g., comorbidity with internalising and/or externalising disorders). In addition, subtype differences in social, intellectual, and academic functioning, and differential treatment options are reviewed.

A multitude of studies have investigated ADHD subtype differences in the domains of functioning reviewed in this chapter. Yet there are many inconsistencies in the findings of such studies. These inconsistencies can be partly accounted for by variations across studies in sample type and selection criteria, assessment measures and informant type, and criteria used to define ADHD and impairment in functioning. Such study variations add to the confusion of interpreting contradictory results. However some consistency of findings has also emerged across studies.

4.1 General Functioning

Overall, a general trend found in the ADHD literature has been that there are significantly higher levels of psychopathology and general impairment in both subtypes of ADHD compared to controls (Bauermeister et al., 2005; Blackman, Ostrander, & Herman, 2005; Edmonds, 2007; Faraone et al., 1998). However, mixed results pertaining to ADHD subtype differences in ratings of general functioning have been found. The majority of studies report ratings of the ADHD-C group as significantly more impaired than their ADHD-PI counterparts (Bauermeister et al., 2005; Edmonds, 2007; Erk, 2000; Faraone et al., 1998; Gaub & Carlson, 1997; Hurtig et al., 2007; Jordan, 2003; Nolan, Gadow, & Sprafkin, 2001; Weiss et al., 2003). However several other studies found no significant subtype differences (Edelbrock, et al., 1984; Jordan, 2003) while Gadow et al.’s (2000) study found the ADHD-PI relative to the ADHD-C group was rated as significantly more impaired.
4.2 Co-morbidity
There is a general consensus in the ADHD field of “comorbidity being the norm” (Bird, Gould, & Staghezza-Jaramillo, 1994; Connor, Chartier, Preen, & Kaplan, 2010; Ghanizadeh, 2009; Gillberg et al., 2004; Kutcher et al., 2004; Willcutt et al., 1999). The few studies (Faraone et al., 1998; Wolraich et al., 1996) that have investigated comorbidity across subtypes have found a significantly greater number of comorbid disorders in ADHD-C groups relative to ADHD-PI. Volk, Neuman, and Todd (2005) noted that both internalising and externalising disorders are highly comorbid across subtypes.

4.3 Internalising Symptoms and Disorders
Internalising symptoms and disorders, such as anxiety and depression, have been identified to commonly co-occur with ADHD (Becker et al., 2006; Biederman, Newcorn, & Sprich, 1991; Bowen, Chavira, Bailey, Stein, & Stein, 2008; Breen & Barkley, 1983; Cuffe, Moore, & McKeown, 2009; Kutcher et al., 2004; Schatz & Rostain, 2006; Strine et al., 2006). Whilst this link has been firmly established, the comorbidity of such internalising symptoms and disorders across ADHD subtypes is not as clear. Mixed findings of subtype differences using parent ratings on behavioural checklists (e.g., Child Behaviour Checklist, Strengths and Difficulties Questionnaire) have been reported in the literature. Some studies report no differences between subtypes (Edmonds, 2007; Gadow et al., 2000; Paternite et al., 1996), whereas others report the ADHD-PI group to be more impaired (Erk, 2000; Gadow et al., 2000), and other investigations found more emotional symptoms in the ADHD-C group (Balantine, 2002; Gadow et al., 2004).

Studies investigating the comorbidity between ADHD subtypes and formally diagnosed anxiety disorders have yielded similarly inconclusive results. Some studies report no subtype differences in lifetime rates of anxiety disorders (Barkley et al., 1990; Bauermister et al., 2005; Eiraldi et al., 1997; Faraone et al., 1998). Other investigations (Cantwell & Baker, 1992; Weiss et al., 2003; Yang, Jong, Hsu, & Tsai, 2007) have found higher co-morbidity of anxiety disorders with the ADHD-PI subtype. Only Ostrander, Weinfurt, Yarnold, and August (1998) found higher comorbidity of anxiety disorders in the ADHD-C subtype. These discrepant results may be partly due to differences in the specific anxiety disorders assessed. In terms of specific anxiety disorders, significantly higher comorbidities with Generalised Anxiety Disorder (Nolan
et al., 2001), Separation Anxiety Disorder (Barkley et al., 1990) and Post-Traumatic Stress Disorder (Sprafkin, Gadow, Weiss, Schneider, & Nolan, 2007) have been found for children with ADHD-C. In contrast, ADHD-PI appears linked to higher comorbidities with Avoidant Disorder of Childhood (Ostrander et al., 1998) and Social Phobia (Nolan et al., 2001).

Mixed findings are also present for the comorbidity between ADHD subtypes and mood disorders. Some studies have reported no subtype differences (Bauermeister et al., 2005; Eiraldi et al., 1997; Faraone et al., 1998; Grizenko, Paci, & Joober, 2009; Ostrander et al., 1998; Willcutt et al., 1999; Yang et al., 2007). However, in studies which found significant differences, higher rates of mood disorders, in particular Major Depressive Disorder (Power, Costigan, Eiraldi, & Leff, 2004; Sprafkin et al., 2007) and Bipolar Disorder (Faraone et al., 1998; Sprafkin et al., 2007) were found for the ADHD-C group.

In summary, mixed findings have been reported pertaining to internalising symptoms and disorders in the ADHD-PI and ADHD-C subtypes. However, where studies found significant subtype differences, a trend has emerged whereby anxiety disorders and mood disorders are more highly comorbid with the ADHD-PI and ADHD-C subtypes, respectively.

4.4 Externalising Symptoms and Disorders
ADHD has been found to be significantly associated with elevated rates of externalising behaviours, which include: aggression, delinquency, oppositionality and conduct problems (Becker et al., 2006; Connor et al., 2010; Cuffe, Moore, & McKeown, 2005; Edmonds, 2007; Eiraldi et al., 1997; Gadow et al., 2004; Gaub & Carlson, 1997; Strine et al., 2006). Furthermore, numerous studies have found significantly higher ratings of externalising behaviour in the ADHD-C relative to the ADHD-PI subtype (Balantine, 2002; Barkley et al., 1992; Bauermeister et al., 2005; Cantwell & Baker, 1992; Connor et al., 2010; Edelbrock, et al., 1984; Edmonds, 2007; Erk, 2000; Faraone et al., 1998; Gadow et al, 2004; Gross-Tsur et al., 2006; Hurtig, et al., 2007; Jordan, 2003; King & Young, 1982; Nolan et al., 2001; Nolan, Volpe, Gadow & Sprafkin, 1999; Paternite, et al., 1996; Shepard, 2009; Weber, Jourdan-Moser, & Halsband, 2007).
A number of studies (Barkley et al., 1990; Gadow et al., 2000; Willcutt et al., 1999) have found children with ADHD to have significantly higher rates of comorbidity with formally diagnosed externalising disorders, such as Oppositional Defiant Disorder (ODD) and Conduct Disorder (CD). Willcutt, et al. (1999) reported that 53% and 40% of participants with ADHD in comparison to 10% and 2% of controls in their study were found to have ODD and CD, respectively. In studies investigating subtype differences, the ADHD-C subtype has been found to have significantly higher rates of comorbidity with ODD and CD (Barkley et al., 1990; Grizenko et al., 2009; Hynd et al., 1991; Kessler et al., 2005; Ostrander et al., 1998; Ter-Stepanian, 2007; Weiss et al., 2003; Wolraich et al., 2005).

In summary, whilst both ADHD subtypes appear to have elevated rates of externalising symptoms and disorders, the ADHD-C subtype has been found to rate higher on these indices than the ADHD-PI counterpart.

### 4.5 Social Functioning

Research has associated ADHD with marked social problems. This is reflected in significantly poorer social functioning and social skills (Breen & Barkley 1983; Edmonds, 2007; Faraone et al., 1998; Gaub & Carlson, 1997; Mikiami, Huang-Pollock, Pfiffner, McBurnett, & Hangai, 2007; Willcutt & Carlson, 2005; Wheeler, Maedgen, & Carlson, 2000) and fewer friendships (Paternite et al., 1996) for children with ADHD compared to controls. In addition, both subtypes are found to receive lower social preference scores, fewer positive nominations, and greater least-liked nominations (Hodgens, Cole, & Boldizar, 2000; King & Young, 1982; Mikiami et al., 2007). Some studies report no subtype differences in social functioning and sociometric status between the subtypes (Paternite et al., 1996). However the ADHD-C group has been found to receive lower ratings than children with ADHD-PI where studies have found significant differences (Gaub & Carlson, 1997; Mikiami et al., 2007; Semrud-Clikeman, 2010; Wheeler et al., 2000).

Differential social problems for the ADHD-C and ADHD-PI subtypes are described in the ADHD literature. Numerous studies have identified social problems for Children with ADHD-C to be largely due to their aggression and intense emotional behaviour (Carlson et al., 1999; Hodgens et al., 2000; Wheeler et al., 2000). Thus these children tend to be actively rejected by their peers. In contrast, children with ADHD-PI are often
described as passive, withdrawn, and shy in their social interactions (Carlson et al., 1999; Wheeler et al., 2000), such that they are neglected by their peers.

In summary, the research literature indicates that both the ADHD-PI and ADHD-C subtypes have impaired social functioning. However, such impairment appears to be different in nature between the two subtypes.

4.6 Intellectual and Academic Functioning

Intelligence quotients (IQs) of children with ADHD are found to be normally distributed (Kaplan, Crawford, Dewey, & Fisher, 2000). Whilst the majority of children with ADHD’s IQs fall in the average range, numerous studies have found the ADHD group (Faraone et al., 1993; Faraone et al., 1998; Lahey et al., 1998), ADHD-PI group (Bauermeister et al., 2005; Warner-Rogers, Taylor, Taylor, & Sandberg, 2000), and ADHD-C group (Carlson, Lahey, & Neeper, 1986; Nigg et al., 2002) to have significantly lower IQ scores than controls. The majority of studies have reported no ADHD subtype differences in IQ (Ackerman, Anhalt, Dykman, & Holcomb, 1986; Barkley et al., 1992; Bauermeister et al., 2005; Hynd et al., 1991; Lahey, Schaughey, Hynd, Carlson, & Nieves, 1987; Morgan et al., 1996; Nigg et al., 2002). Only Carlson et al. (1986) and Marshall, Hynd, Handwerk, and Hall (1997) found significant differences on IQ scores between ADHD subtypes, wherein the former study found the ADHD-C group to have significantly lower Full-scale IQ and Verbal IQ scores, whereas the latter study reported participants with ADHD-PI attained significantly lower Performance IQ scores than their ADHD-C counterparts.

ADHD is strongly associated with poor academic functioning, both in terms of poorer school grades and higher rates of grade retention (Barkley et al., 1990; Biederman et al., 1991; Edelbrock, et al., 1984). No subtype difference was found for grade retention (Weiss et al, 2003) or for performance on academic subjects in studies by Biederman et al. (1991) and Edelbrock, et al. (1984). However Gadow et al. (2000) reported lower grades for children with ADHD-PI relative to ADHD-C and controls.

Biederman et al (1991) observed that an overlap between ADHD and learning disorders is consistently reported in the literature. Overall, ADHD groups performed significantly more poorly on psychometric tests of reading, spelling, and mathematics compared to controls (Barkley et al., 1990; Bauermeister et al., 2005; Faraone et al., 1993; Faraone et
al., 1998; Semrud-Clikeman et al., 1992; Willcutt & Carlson, 2005). Only Warner-Rogers et al. (2000) and Carlson et al. (1986) reported no difference between the ADHD-C and control groups on reading and mathematics, respectively. No subtype differences have been found across different domains of learning problems (Barkley et al., 1990; Bauermeister et al., 2005; Carlson et al., 1986; Gadow et al., 2004; Morgan et al., 1996; Semrud-Clikeman et al., 1992; Weiss et al., 2003). Only Hynd et al. (1991) and Marshall et al. (1997) have reported contrary findings in the mathematics domain in finding that the ADHD-PI group performed significantly more poorly than the ADHD-C group on standardised mathematics tests.

Academic tutoring is common among children with ADHD, but with no subtype differences reported (Biederman et al., 1991; Faraone et al., 1998). Similarly, both subtypes are more likely to be placed in a Special Education class, but subtype differences have not been found (Biederman et al., 1991; Faraone et al., 1998; Lahey et al., 1998; Murphy, et al., 2002).

In summary, both ADHD subtypes have been associated with poor academic functioning across a range of indicators. Only a few differences have emerged between subtypes on these indicators, with the ADHD-PI subtype being found to have lower grades and scores on mathematics tests than their ADHD-C counterparts.

4.7 Referral, Receipt and Response to Treatment
Numerous differences between ADHD subtypes have emerged in the research literature pertaining to referral, receipt, and response to treatment. Jordan’s (2003) study found that children with ADHD-C were more likely to be referred for assessment by professionals (i.e., teachers and school counsellors), whereas parents often referred their children with ADHD-PI. Whilst Murphy, McKone and Slee (2002) reported no subtype differences of ever having received treatment in their clinical sample, the subtypes differed in their engagement in current treatment. ADHD-C groups are more likely to have used and be currently using stimulant medications compared to their ADHD-PI counterparts (Nolan et al., 2001; Weiss et al., 2003; Wolraich et al., 1996). In addition, the former group tend to be prescribed higher doses and benefit more from such medications, whereas the latter group respond better to lower doses (Stein et al., 2003; Weiss et al., 2003). Individuals with ADHD-PI are more likely to have tried but discontinued their use of stimulant medications (Jordan, 2003). In addition, both
Barkley et al. (1990) and Faraone et al. (1998) report higher rates of engagement in counselling/psychological treatments and/or multi-modal therapy in the ADHD-C compared to the ADHD-PI group. This difference is perhaps due to the presence of clinically significant hyperactivity and/or impulsivity symptoms in the former group which required immediate and diverse treatment strategies.

In summary, whilst similar rates of ever having tried treatment were reported for the ADHD subtypes, the ADHD-C subtype was found to be more likely engaged and benefiting from current treatment.

4.8 Summary and Conclusions
This chapter reviewed the differences in psychosocial and academic functioning between the ADHD-PI and ADHD-C subtypes. Both ADHD subtypes were found to be impaired across all the domains of functioning reviewed in this chapter however a few noteworthy differences between subtypes have emerged from the literature. Whilst the ADHD-C subtype has been found to have poorer general functioning, more externalising disorders, and differential treatment engagement and response compared to their ADHD-PI counterparts, lower grades and mathematics achievement have been reported for the latter subtype. In addition, differential patterns in the nature of social impairment and comorbidity with specific internalising disorders have been found for the ADHD-PI and ADHD-C subtypes. Such differences in psychosocial and academic functioning may lead to the conclusion that the ADHD-PI and ADHD-C subtypes differ on more aspects than merely the presence of clinically significant hyperactivity-impulsivity symptoms.
Chapter 5: Theoretical Conceptualisations of ADHD and its Subtypes

The review of the ADHD literature in Chapters 3 and 4 suggests that several differences exist between ADHD-PI and ADHD-C in demographic characteristics and the psychosocial and academic domains of functioning. Such empirical differences are suggestive of the subtypes differing in more than just the presence of clinically significant hyperactivity-impulsivity symptoms for the ADHD-C subtype. In addition to these empirical findings, existing theoretical conceptualisations of ADHD and its subtypes are suggestive of further differences in the precise difficulties that afflict the ADHD-PI and ADHD-C subtypes. These theoretical conceptualisations of ADHD and its subtypes are examined in the present chapter.

Three major theoretical models of ADHD are considered, with a focus placed on only the aspects of these models related to attention and memory. The models presented are: Barkley’s (1997) Hybrid Neuropsychological Model of Executive (Self-Regulatory) Functions; Sergeant’s (2000) Cognitive Energetic Model of ADHD; and Sonuga-Barke’s (2002) Dual Pathway Model of ADHD. In addition, Milich, et al.’s (2001) assertion of ADHD-PI and ADHD-C as distinct and unrelated disorders is presented. Whilst the former three models each postulate different pathways to account for ADHD and its associated symptoms, all models propose an executive function (EF) deficit in ADHD. Thus, it is worthwhile for the EF literature to be reviewed before each theoretical model of ADHD is examined.

5.1 Executive Functions

Executive functions, the mental control processes enabling purposive and self-serving behaviour (Lezak, 1995), include response inhibition, working memory, planning, cognitive flexibility, and fluency (Sergeant, Geurts, & Oosterlaan, 2002). Over the years, a link has been established between ADHD and executive function deficits (Biederman et al., 2004; Pennington & Ozonoff, 1996).

A number of theorists (e.g., Barkley, 1997; Sergeant, 2000) have postulated problems with response inhibition to be the core deficit in ADHD. Numerous tasks are used to assess response inhibition, including: the Change Task, Continuous Performance Task, Gordon’s Diagnostic System, Stop Task, Circle Drawing Task, Wisconsin Card Sorting Task, and Stroop Colour-Word Interference Test. Meta-analyses (Codd, Eckert,
Lewandowski, & Fiese, 2005; Lijffijit, Kenemans, Verbaten, & Engeland, 2005; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005) have found participants with ADHD to display significantly poorer performances on such tasks relative to controls. Similarly, Chhabildas et al. (2001) and Geurts, Verte, Oosterlaan, Roeyers, and Sergeant (2005) have reported findings of both ADHD subtype groups performing significantly worse on response inhibition measures, but with no significant differences between the two ADHD groups. Only Nigg et al.’s (2002) study found a subtype difference, wherein the ADHD-C group performed significantly worse on the Stop Task.

Furthermore, various tasks are used to measure the other executive functions, which include: working memory (e.g., Self-Ordered Pointing Task, Digit Span); planning (e.g., Tower of Hanoi, Rey Figure Test); cognitive flexibility (e.g., Change Task, Wisconsin Card Sorting Task, Trailmaking Task); and fluency (e.g., Controlled Word Association Task). With the exception of working memory, which will be examined in the chapter on Memory, few differences between ADHD and control groups are consistently found on these remaining executive function measures (Barkley et al., 1992; Geurts et al., 2005; Scheres et al., 2004; Willcutt et al., 2005). However, Houghton et al. (1999) and Martel, Nikolas, and Nigg (2007) report significant impairment of the ADHD group relative to controls on cognitive flexibility tasks. The research on subtype differences in executive functions is similar, whereby the majority of studies (Barkley et al., 1992; Geurts et al., 2005; Nigg et al., 2002; Willcutt et al., 2005) report no difference. Klorman et al.’s (1999) study provides an exception to these findings, wherein the ADHD-C group displayed planning and cognitive flexibility deficits compared to their ADHD-PI counterparts.

5.2 Theories of ADHD

Barkley’s (1997) Hybrid Neuropsychological Model of Executive Functions

Barkley’s (1997) Hybrid Neuropsychological Model of Executive Functions is considered to present the dominant theoretical view in the ADHD field (Sonuga-Barke, 2003). As displayed in Figure 5.1, Barkley’s (1997) model proposed two pathways whereby response inhibition, which is referred to as behavioural inhibition, influences the motor system in its production of goal-directed behaviour (i.e., motor control-fluency-syntax). This motor control-fluency-syntax component of the model affects the sensory-perceptual, linguistic, memory, emotional and other brain systems which also
contribute to the execution of goal-directed behaviour. Firstly, direct control is exerted by response/behavioural inhibition upon the motor system. In addition, response/behavioural inhibition sets the occasion in its provision of a sufficient delay period for the other executive functions to be proficiently performed (Barkley, 1998). In particular, Barkley (1998) identified these executive functions to be: (non-verbal) working memory; self-regulation of affect, motivation and arousal; internalisation of speech (verbal working memory); and reconstitution. The sub-functions that comprise each of these executive functions are detailed in Figure 5.1.

**Figure 5.1: Barkley’s (1997) Hybrid Neuropsychological Model of Executive Functions**

Barkley (1997) proposed a deficit in response/behavioural inhibition as the central deficit of ADHD. Empirical studies, as reviewed in the executive functions section, and behavioural symptoms of ADHD (e.g., high activity levels, talking a lot, and making numerous vocal noises) have been cited as evidence for his proposal. Likewise, due to
this response/behavioural inhibition deficit, subsequent deficits in the four executive functions identified ensue, which are reflected in the symptoms commonly associated with ADHD. For example, lower frustration tolerance and temper outbursts are noted in the DSM-IV-TR (APA, 2000) as behaviours associated with ADHD, and these behaviours reflect inefficient performance of the self-regulation of affect-motivation-arousal executive function. In addition, deficits in motor control-fluency-syntax, resulting from deficits in response/behavioural inhibition and the other EFs, are depicted in the motor problems commonly present in ADHD. Furthermore, deficits in this component of Barkley’s (1997) model have been asserted to also account for the appearance of inattention and distractibility symptoms characteristic of ADHD. Barkley (1997) ascribed such symptoms to result from an impairment in goal/task-directed persistence, and in inhibition of task-irrelevant responses and task re-engagement following disruption sub-functions of the motor control-fluency-syntax component, respectively.

Barkley’s (1997) model employed deficits in response/behavioural inhibition to account for the hyperactivity-impulsivity symptoms of ADHD. However, Barkley (1997) proposed that response/behavioural inhibition and other executive function deficits result in impairments in the execution of motor actions which are goal-directed. Barkley (1997) conceded that current research has not consistently identified a deficit in attention in children with ADHD, and he further questioned whether such deficits truly lie in the realm of attention. To overcome this problem, the goal-directed persistence sub-function of the motor control-fluency-syntax component was redefined as a type of sustained attention. Thus, the inattention symptoms of ADHD were conceptualised as secondary impairments that arise from the primary impairment in response/behavioural inhibition and its control over the motor system. Barkley’s (1997) model thus raised the question of whether inattention should be conceptualised as a core and/or defining characteristic of ADHD.

A second problem pertains to Barkley’s (1997) assertion that this model only applied to the types of ADHD with clinically significant hyperactivity and impulsivity symptoms (i.e., ADHD-C and ADHD-PHI). Barkley (1997) suggested, by citing a number of studies, that the same form of impairments in attention may not be shared between the ADHD-PI subtype and the two other subtypes of ADHD. However, no alternative
theoretical conceptualisation was offered for difficulties experienced by the ADHD-PI subtype.

Sergeant’s (2000) Cognitive Energetic Model of ADHD

The Cognitive Energetic Model of ADHD proposed by Sergeant (2000) was largely based on Sander’s (1983) cognitive-energetic framework of information processing. In Sergeant’s model three levels were identified, as displayed in Figure 5.2.

![Figure 5.2: Sergeant’s (2000; 2005) Cognitive Energetic Model of ADHD](image)

The bottom level consists of the computational mechanisms of attention, which Sonuga-Barke, Wiersema, van der Meere, and Roeyers (2010) described as processes mediating between stimulus and response. The four processes are encode, search, decision, and motor organisation (Sergeant, 2005).

Sergeant (2000; 2005) described the second level of his model as being comprised of three state factors/energetic states: effort, arousal, and activation. Effort functions to meet task demands by exciting and/or inhibiting the other energetic pools. The arousal pool consists of phasic responding temporally linked to stimulus processing, whereas the activation pool relates to physiological readiness to respond.

The top level of Sergeant’s (2000; 2005) model is the management mechanism which is associated with executive functioning. This mechanism is comprised of processes such
as planning, monitoring, detection of errors, error correction and other executive functions.

Sergeant (2005) asserted that ADHD is associated with deficits in all three levels of his model. However, the primary deficit in ADHD was thought to arise due to failures in the modulation of energetic states necessary to meet task demands (Sergeant, 2000; 2005). In particular, deficits in the activation, and to a lesser extent effort pools, lead to poor motor organisation. This relationship is supported by Sanders’ (1983) findings of underactivation in children with ADHD during slow event rate conditions which manifests as slow, inaccurate responding, whereas when event rates are fast, children with ADHD are overactivated and respond rapidly but incorrectly. In addition, deficits in the management mechanism, particularly in response inhibition, have been linked to ADHD as previously reviewed. Sergeant (2000; 2005) suggested that this deficit is primarily due to energetic pool dysfunction.

Whilst Sergeant (2005) alluded to differences between subtypes in the types of motor skill deficits they have, the application of his model to specific or all subtypes of ADHD was not specified. In addition, this model did not explicitly account for the inattention and/or hyperactivity-impulsivity symptoms characteristic of ADHD. Sergeant (2005) stated that the search process, which is a type of attention (i.e., selective attention) that will be examined in the Attention chapter, has been found to be intact in ADHD groups. Instead, the motor process has been identified to be deficit in ADHD. Sergeant (2005) identified traditional motor functions (i.e., gross motor and fine motor) to be subsumed within this motor organisation mechanism, but also cognitive functions such as task switching and temporal processing. Furthermore, in Sergeant’s (2000; 2005) model the primary deficit in ADHD was identified at the state factors level. This differed to Barkley’s (1997) model which proposed central deficiencies in response inhibition which is part of the management/executive level. Whilst Sergeant (2000; 2005) acknowledged the presence of response inhibition deficits, he stated that this deficit is not specific to ADHD by citing studies which had found response inhibition deficits in children with Oppositional Defiant Disorder and/or Conduct Disorder. A unique dysfunction pathway was identified for ADHD relative to other childhood disorders in Sergeant’s (2000; 2005) postulation of a specific deficit at the state factors level. A final criticism of Sergeant’s (2000; 2005) model pertains to his acknowledgement that direct
measures of such state factors are yet to be developed, and at the time deficits at this level were speculative.

**Sonuga-Barke’s (2002) Dual Pathway Model of ADHD**

Sonuga-Barke’s (2002) dual pathway model proposed two distinct pathophysiological pathways to account for the symptoms of ADHD. As displayed in Figure 5.3, this model is comprised of an executive dysfunction pathway and a delay aversion pathway. Whilst these pathways differ in terms of the neurobiological and psychological processes involved, both result in the same behavioural expression, namely, the inattention and hyperactivity-impulsivity symptoms characteristic of ADHD. Furthermore, due to such symptoms detraction from the task at hand, impaired task engagement ensues. For reasons unspecified, Sonuga-Barke (2002) stated that the dual pathways model applies only to ADHD-C.

![Figure 5.3: Sonuga-Barke’s (2002) Dual Pathway Model of ADHD](image)

The executive dysfunction pathway of ADHD proposes deficiencies in the executive circuit. Sonuga-Barke (2003) described this circuit to involve projections from the frontal and pre-frontal cortices to the caudate nucleus, which then connect to other cortical regions via the thalamus. Deficiencies in this executive circuit result in response
inhibition deficits, which are known to be associated with ADHD. These deficits in turn underpin a general executive dysfunction, as presented in Barkley’s (1997) model. Sonuga-Barke (2002) posited that deficits in these psychological processes to result in behavioural expression in the form of ADHD symptoms.

Sonuga-Barke’s (2002) delay aversion pathway assumed that underlying motivational style is reflected in ADHD behaviours. This pathway posited a dysfunction in the reward circuit of the brain, which is comprised of the ventral-striatal network associated with the meso-limbic branch of the dopamine system. This dysfunction was proposed to result in a shortened delay reward gradient. At the psychological level this gradient was described as the tendency to discount future rewards and prefer immediate rewards. This tendency manifests in delay aversion, whereby attempts are made to escape or avoid delay. Sonuga-Barke (2003) asserted that environmental factors, such as harsh parent/teacher responses, are likely to reinforce delay aversion. As a result, a child with ADHD’s delay aversion manifests as symptoms of ADHD, whereby in choice situations they prefer immediate reward, and in no-choice situations they act impulsively to reduce their perception of delay and/or attend to non-temporal environmental features manifested in inattention and hyperactivity symptoms.

A major drawback of the dual pathway model, with particular relevance for the current study, lies in Sonuga-Barke’s (2002) assertion that this model only applied to the ADHD-C subtype. No explanation was provided for such an assertion or how the ADHD-PI subtype may be alternatively conceptualised. In addition, there are two criticisms pertaining to the executive dysfunction pathway whereby, firstly, the presence of response inhibition deficits in other childhood disorders (e.g., ODD and CD) are not accounted for. Sonuga-Barke (2002) stated that inhibitory deficits distinguish ADHD from other disorders, but only cited studies comparing ADHD to schizophrenia and learning disorders. Secondly, Sonuga-Barke (2003) conceded that the nature of the link between executive dysfunction and ADHD symptomatology was yet to be established.
review of ADHD subtype differences that ADHD-PI and ADHD-C are distinct and unrelated disorders. Milich et al.’s (2001) conclusion was based on their differentiation of ADHD subtypes according to Cantwell’s (1995) six-stage approach for assessing the validity of childhood psychiatric disorders. Cantwell’s (1995) approach required evidence of differentiation between conditions in studies of: (1) essential and associated features of the disorder and exclusionary criteria; (2) physiology and neurology; (3) laboratory measures; (4) family psychopathology and family interaction; (5) follow-up; and (6) treatment responses. Milich et al. (2001) drew the explicit assumption in their review that ADHD-PI is a valid disorder and may not in fact even belong to the ADHD family. In addition, Milich et al. (2001) extrapolated from Cantwell’s (1995) approach that the more evidence to support subtype differences found across the six stages, the more likely that ADHD-PI and ADHD-C are valid, distinct disorders. Milich et al.’s (2001) review of each of Cantwell’s (1995) stages will be examined separately.

For the first stage, Milich et al. (2001) reviewed studies of subtype differences in attention problems, hyperactivity/impulsivity, age of onset, comorbidity, academic achievement, social functioning, prevalence, and gender, race and socio-economic status. From this review Milich et al. (2001) concluded that consistent subtype differences were found for age of onset, prevalence, gender and externalising disorders. Both subtypes were found to have deficits in academic and social functioning, although mixed findings with slightly different patterns emerged between subtypes. Milich et al.’s (2001) literature review pertaining to subtype differences for the first stage was similar to the findings of the review presented in Chapters 3 and 4. In addition, the subtypes were found to be distinguishable on parent/teacher ratings of attention problems and hyperactivity/impulsivity, but no such differences were found on laboratory measures of these constructs (Milich et al., 2001). Overall, Milich et al.’s (2001) review to some extent fulfils Cantwell’s (1995) stage one criteria for identifying the subtypes as distinct.

Milich et al. (2001) referenced the only study published at the time (Holcomb, Ackerman, & Dykman., 1985) pertaining to Cantwell’s (1995) stage two, in which no subtype differences were found in brain functioning. Since Milich et al.’s (2001) review, Clarke and colleagues (e.g., Barry, Clarke, McCarthy, & Selikowitz, 2002; Clarke, Barry, McCarthy, & Selikowitz, 2001a; 2001b) have published a number of studies that are suggestive of some subtypes differences on electroencephalogram
measures. In light of these findings Cantwell’s (1995) stage two appears to be partially met, although future research in this area is greatly needed. Inconsistent findings pertaining to Cantwell’s (1995) stage three, four, and six were present in Milich et al.’s (2001) review which found few subtype differences on intelligence and neurocognitive measures (stage three), although both subtypes displayed impaired performance. These findings are consistent with the review presented in Chapter 4 and the executive function section of the present chapter. Similarly, in regards to stage four, Milich et al. (2001) concluded their review by conceding the impossibility of deriving firm conclusions about differences between subtypes in family psychopathology on the basis of the inconsistent research to date. The current literature, as reviewed in Chapter 3, provides similarly mixed results. Finally, Milich et al. (2001) raised the question of whether differences between subtypes in stimulant dosage rates reflected biological differences or rather differences in symptom severity between ADHD-PI and ADHD-C. Overall, whilst some evidence of subtype differences emerged from Milich et al.’s (2001) review and subsequent research, criteria for Cantwell’s (1995) stages three, four and six have not been sufficiently fulfilled.

At the time of Milich et al.’s (2001) review, no studies were published pertaining to prognosis and follow-up (stage five) of ADHD subtypes. Hence, the criteria for stage five were not met.

In addition to their literature review, Milich et al. (2001) presented findings from factor and cluster analysis studies to support their distinction between the ADHD-PI and ADHD-C subtypes. Milich et al. (2001) found two factors - an inattention-disorganisation factor and a hyperactivity-impulsivity factor - to be present across the factor analysis studies reviewed thereby broadly supporting the DSM-IV ADHD subtype structure.

As previously noted, Milich et al. (2001) concluded from their literature review that ADHD-PI and ADHD-C are distinct and unrelated disorders. However, from the present review of Milich et al.’s (2001) paper and in light of current findings, it is clear that only two of Cantwell’s (1995) stages were partially fulfilled. Thus, the conclusion that ADHD-PI and ADHD-C are distinct disorders as drawn by Milich et al. (2001) is premature within the present context of the ADHD subtype literature. However, the
presence of notable differences between ADHD subtypes is not disputed and provides a strong rationale for continuing to investigate possible areas of difference.

5.3 Summary and Conclusions
Three models of ADHD and Milich et al.’s (2001) conclusion that ADHD-PI and ADHD-C are distinct and unrelated disorders have been reviewed. Whilst each model has flaws and gaps which future research is required to fill, each presented a slightly different conceptualisation of the difficulties experienced by those with ADHD. In addition, whilst Sergeant’s (2000) model appears to apply to all ADHD subtypes, Sonuga-Barke (2002) and Barkley (1997) have specified that their models apply to only the ADHD-C subtype. This distinction between the subtypes at a theoretical level, along with Milich et al.’s (2001) literature review, predicts the presence of further differences between subtypes. Perhaps the most pertinent difference that can be investigated between subtypes in a school context are whether the ADHD-PI and ADHD-C subtypes differ on the fundamental building blocks of attention and memory that underlie learning.
Chapter 6: Attention Deficits in the ADHD Subtypes

The current literature review has highlighted the many behavioural and social correlates and executive function deficits commonly associated with ADHD. On a number of levels (i.e., demographics, psychosocial functioning, and theoretical conceptualisations) differences between the ADHD-PI and ADHD-C subtypes have been noted. Furthermore, the strong link between ADHD and poor academic functioning, particularly poor school grades, and high rates of grade retention and comorbid learning disorders, is highly concerning. Hence, the fundamental building blocks of learning for each ADHD subtype need to be examined such that effective assistance for improving academic functioning can be provided if any differences emerge.

Attention is a fundamental building block for learning (Robertson et al., 1996). At present, a clear and universally accepted definition of attention has yet to appear in the literature (Coull, 1998; Lezak, 1995). However, Lezak et al. (2004) provided a broad definition, whereby attention refers to several processes or capacities which relate to stimulus perception and processing. Attention is associated with numerous constructs, including concentration, exertion of mental effort, staying alert, focusing, and ignoring distractions (Stefanatos & Baron, 2007). This chapter examines theoretical models of attention and provides a literature review of the ADHD subtype differences in attention.

6.1 Theoretical Models of Attention

The theoretical models presented are Posner and Peterson’s (1990) model of the Attention System of the Brain, which was later elaborated upon by Swanson et al. (1998) and Mirsky, Anthony, Duncan, Ahearn, and Kellam’s (1991) Restricted Taxonomy of Attentive Functions. Both models propose a fractionated view of attention, with distinct brain networks underlying the different types of attention. However the two models differ from one another in the division of attention functions.

Posner and Peterson’s (1990) Attention System of the Human Brain Model

Posner and Peterson (1990) identified three fundamental principles that underlie their attention systems of the human brain model. Firstly, attention systems were proposed to be an anatomically separate system in the brain, similar to the sensory or motor systems. Secondly, a network of anatomical areas was postulated to underlie attention. Thirdly, specific networks in the brain were said to carry out different functions. With these
principles in mind, Posner and Peterson (1990) divided attention into three subsystems based upon their review of both lesion and functional imaging studies. These subsystems are orienting, alerting, and executive control.

The orienting subsystem functions to prepare for stimulus processing by directing attention to a particular source of sensory signals (Penny, 2007). Posner and Peterson (1990) localised orienting to the posterior parietal network which Swanson et al. (1998) suggested includes connected brain regions centred in the posterior parietal lobes and also the superior colliculus and the thalamus. Both Posner and Peterson (1990) and Swanson et al. (1998) cited studies using visual-orienting tasks (e.g., cancellation tests and visual-spatial reaction time tasks) in brain injured or lesioned patients to support this localisation of orienting.

Swanson et al. (1998) described alerting as the preparation and maintenance, by suppressing background neural noise, of a readiness to react. The right frontal lobe and its surrounding brain connections, as well as the right parietal lobe and locus coeruleus, are posited to underlie this alerting function (Posner & Peterson, 1990). A number of studies are cited by Posner and Peterson (1990) and Swanson et al. (1998) in which participants perform tedious tasks, such as letter and word matching tests or continuous performance tests, to support this localisation of alerting.

Posner and Peterson (1990) proposed target detection to be the third subsystem of their attention system of the human brain model. This third subsystem was expanded in subsequent revisions of the model to encompass executive control. Swanson et al. (1998) suggested that executive control co-ordinate neural processes in directing behaviour toward a goal. Posner and Fan (2001) asserted that this subsystem is used in situations in which planning, error detection, novel responses or overriding habitual actions are required. Executive control is localised in the anterior attention system of the brain, which includes the anterior cingulate gyrus, and also the left lateral frontal lobe and basal ganglia (Swanson et al., 1998). Conflict resolution tasks (e.g., the Stop Signal Task) are suggested to best assess executive control (Swanson et al., 1998).

Mirsky et al.’s (1991) Restricted Taxonomy of Attentive Functions

Mirsky et al.’s (1991) model conceptualised attention as comprised of three components: focus, sustain, and shift. These components were derived, using principal
component analysis, from neuropsychological test scores of two samples, the first consisting of adult neuropsychiatric patients and normal controls, and the second of elementary-school children. Mirsky, Pascualvaca, Duncan, and French (1999) expanded this model to comprise four attention functions: focus-execute, sustain-stabilise, shift, and encode.

Mirsky et al. (1999) defined focus as the capacity to select target information, whilst ignoring distracting peripheral stimuli. Execute was added to this component due to the difficulty of separating focusing from the rapid execution of responses required by tasks. The inferior parietal cortex, superior temporal gyrus, and corpus striatum brain structures were identified to serve the functioning of this component (Mirsky et al., 1999). Focus-execute is measured by a number of tasks, including the Stroop test, Trailmaking test, and the Talland Letter Cancellation Test.

Sustain is the capacity to be able to remain on task in a vigilant manner for a considerable amount of time (Mirsky, et al., 1999). Mirsky et al. (1999) identified the rostral midbrain structures, including the mesopontine reticular formation and midline and reticular thalamic nuclei, as important for this component. The Continuous Performance Task is typically used to assess sustain. In addition, the variability in reaction time for target responses on the Continuous Performance Task is used to measure stabilise, which refers to the capacity to maintain a regular and predictable rhythm in responding to a task over time.

The shift component of Mirsky et al.’s (1999) model is the capacity to flexibly and efficiently shift attentional focus from one aspect of a task to another. Mirsky et al. (1999) identified the dorso-lateral prefrontal cortex and anterior cingulate gyrus to underlie shift. This component is commonly assessed using the Wisconsin Card Sorting Test.

Mirsky et al.’s (1999) fourth component, encode, referred to the mnemonic capacity of holding information briefly in mind while performing some cognitive operation on it. The Arithmetic and Digit Span subtests of the Wechsler Adult Intelligence Scale-III (WAIS-III) and/or the Wechsler Intelligence Scale for Children-Third Edition (WISC-III) are identified to assess encode. Mirsky et al. (1999) suggested that limbic system structures, including the hippocampus and amygdale, underlie the encode component.
Comparison and Evaluation of Attention Models

Whilst Posner and Peterson’s (1990) and Mirsky et al.’s (1991) models were developed independently using different methods (review of lesion and imaging studies versus principle component analysis of performance data), there are some similarities across the models. Directing attention to a particular aspect of a task appears to be the central function in both Posner and Peterson’s (1990) orienting subsystem and Mirsky et al.’s (1999) focus component. This function in both models is commonly referred to as selective attention. Likewise, both Posner and Peterson’s (1990) alerting subsystem and Mirsky et al.’s (1999) sustain component function to maintain attention on a task over time. This function is generally referred to as sustained attention in the literature.

In addition to orienting and alerting, Swanson et al. (1998) identified executive control to be the third attention subsystem. This subsystem plays a coordinating role in the production of goal-directed behaviour and Posner and Fan (2001) asserted that it involves a wide range of processes, including planning, error detection, creating novel responses, and overriding habitual actions. The overarching role, comprised of multiple processes, of this executive control system is similar to the role proposed for executive functions, as examined in Chapter 5. Similarly, Mirsky et al.’s (1999) model identified an encode component, which does not correspond to any of the subsystems proposed by Posner and Peterson (1990) or Swanson et al. (1998). Encode functions to hold and manipulate information in the mind, and reflects the well-established function of working memory, which will be further examined in the Memory chapter. Likewise the shift component identified in Mirsky et al.’s (1999) model has no equivalent subsystem in Posner and Peterson’s (1990) model. Mirsky et al. (1999) identified this shift component which functions to shift attentional focus.

An important point to note pertaining to the attention models reviewed is the overlap in tasks purported to assess the different subsystems or components of attention with those identified to measure executive functions. For example, the Continuous Performance Test is used as both a measure of attention (i.e., alerting and focus) and the response inhibition executive function. A similar overlap in attention and executive function measures is observed for the Stop Task, Stroop Task, Trailmaking Task, and Wisconsin Card Sorting Task. Whilst no definitive classification of such tasks as an attention or an executive function measure is provided in the literature, the presence of this overlap is important to keep in mind when interpreting subtype performance on these measures.
In summary, from the two models of attention reviewed, three types of attention have been identified: selective attention, sustained attention, and Mirsky et al.’s (1999) shift component. With this division of attention in mind, these different types of attention are examined in relation to the ADHD-PI and ADHD-C subtypes.

### 6.2 Attention Deficits in ADHD Subtypes

By definition, using the DSM-IV-TR (APA, 2000) criteria, both children with ADHD-PI and with ADHD-C display attention deficits to a degree that causes clinically significant impairment in their functioning. These attention difficulties are reflected in the common parent and teacher complaints of off-task behaviour displayed by children with ADHD, which includes poor concentration, low persistence on tedious tasks, forgetfulness, and poor listening skills (Stefanatos & Baron, 2007). In addition, Lahey, Schaughency, Frame, and Strauss (1985) found both ADHD subtypes to be rated significantly higher on the majority of items on the Attention Problem-Immaturity subscale of the Revised Behaviour Problem Checklist compared to controls.

In Milich et al.’s (2001) literature review, consistent differences on behavioural scale ratings for attention difficulties were reported between ADHD subtypes. In particular, Barkley (1997) suggested that the attention difficulties exhibited by the ADHD-C subtype pertain to problems with persistence and distractibility. Barkley’s (1997) suggestion is supported by findings of significantly greater amounts of off-task behaviour during task completion (Barkley et al., 1990), and significantly higher ratings on irresponsibility, distractibility, impulsivity, answering without thinking, and sloppiness items (Lahey, Schaughency, Frame, & Strauss, 1985) for the ADHD-C relative to the ADHD-PI subtype.

By contrast, the attention difficulties experienced by the ADHD-PI subtype are often asserted to reflect sluggish cognitive tempo (SCT) (Milich et al., 2001). SCT is described to be comprised of behaviours such as drowsiness, lethargy, hypoactivity, confusion, and a tendency to daydream or be lost in thought (Barkley et al., 1990; Carlson & Mann, 2002). A number of studies (Barkley et al., 1990; Lahey et al, 1985; Lahey et al., 1987) have found the ADHD-PI subtype to receive significantly higher ratings on such SCT items than their ADHD-C counterparts. However, these three studies only used teacher ratings. In recent studies (Garner, Marceauz, Mrug, Patterson, & Hodgens, 2010; Hartman, Willcutt, Rhee, & Pennington, 2004) in which both parents
and teachers rated children with ADHD-PI and with ADHD-C, differential results depending on rater type have emerged. Specifically, both studies found that whilst teacher ratings of SCT were significantly higher for the ADHD-PI relative to ADHD-C subtype, no differences between groups were reported for parent ratings. From these results it appears that only teacher ratings of SCT clearly distinguished between the ADHD subtypes.

Whilst consistent differences between subtypes in teacher ratings of attention at a behavioural level have emerged, the research is not as clear for such differences using cognitive laboratory tasks of attention. Stefanatos and Baron (2007) suggested that part of this problem is due to cognitive/laboratory tasks of attention being quite different from the attention used every day to function in the real world. The Test of Everyday Attention (Robertson et al., 1996) was developed to overcome these differences, in which cognitive measures of attention were assessed using tasks with high ecological validity (e.g., searching a map and counting levels in an elevator). Three types of attention are assessed in Robertson et al.’s (1996) battery of attention tests, namely, selective attention, sustained attention, and attentional control/switching. Manly, Robertson, Anderson, and Nimmo-Smith (1999) developed a children’s version of the Test of Everyday Attention: the Test of Everyday Attention for Children (TEA-Ch). The TEA-Ch is comprised of subtests assessing the three types of attention (selective attention, sustained attention, and attentional control/switching) proposed by Posner and Peterson (1990) and Mirsky et al. (1991). The research on differences between ADHD-PI and ADHD-C subtypes is examined for each of these types of attention below.

**Selective Attention**

Selective attention is defined as the ability to facilitate the processing of target information while attenuating the processing of other distracter information (Huang-Pollock, Nigg, & Carr, 2005). Three DSM-IV-TR (APA, 2000) inattention symptoms, that is, “fails to give close attention to details”, “easily distracted by extraneous stimuli”, and “does not seem to listen”, pertain to difficulties with selective attention. As reviewed previously, a number of tasks measure selective attention, including the Stroop task, both subtests of the Trailmaking task, and the Flanker task. Van Mourisk, Oosterlaan, and Sergeant’s (2005) meta-analysis of Stroop test performance, as well as some studies (Brodeur & Pond, 2001; Barkley et al., 1992) found significant impairments in ADHD groups relative to controls on such selective attention tasks.
These findings contrast with Sergeant’s (2000) Cognitive-Energetic model of ADHD, wherein the search process (which was identified to be analogous to selective attention) was purported to be intact in ADHD groups. However, only a few studies have investigated ADHD subtype differences on selective attention measures. Barkley et al.’s (1992) and Zago, Rosoman, Shum, O’Callaghan, and Lesley’s (2008) studies found no subtype differences. However, Lockwood, Marcotte, and Stern (2001) reported slower performance on the Trailmaking test for the ADHD-PI relative to ADHD-C subtype, which approached significance.

In addition, Barkley (1997) asserted that the ADHD-PI subtype has a specific deficit in selective attention. Barkley (1997) cited a number of reviews (e.g., Barkley et al., 1992; Hinshaw, 1994; Lahey & Carlson, 1992) in support of this assertion. However, on close inspection of the reviewed studies some of the support for selective attention deficits in the ADHD-PI subtype was questionable. For example, Hinshaw’s (1994) and Lahey et al.’s (1988) findings of selective attention deficits in ADHD-PI are based on teacher ratings, and Sergeant and Scholten’s (1985a, 1985b) studies do not use the DSM criteria to define groups. In addition, Barkley (1997) does not mention that Barkley et al (1992) found no subtype difference on the Stroop Test. However, a number of prominent researchers (e.g., Barkley, 1997; Milich et al., 2001) continue to purport this view, despite the lack of findings of a selective attention deficit specific to the ADHD-PI subtype. One possibility that must be considered is that the lack of subtype difference findings is due to the poor ecological validity of the laboratory-based selective attention tasks used.

The TEA-Ch claims to assess attention with ecological validity. It contains two subtests - Sky Search and Map Mission - which assess selective attention in a more ecologically valid manner. The findings of studies comparing ADHD to controls, and the ADHD subtypes to one another, on these TEA-Ch selective attention subtests are mixed. Lajoie et al.’s (2005) found their ADHD group to perform significantly more poorly than controls on the Sky Search subtest. However, other studies (Gardner, Sheppard, & Efron, 2008; Heaton et al., 2001; Manly et al., 1999) found no difference between groups. Only three studies (Heaton et al., 2001; Preston, Heaton, McCann, Watson, & Selke, 2009; West, Houghton, Douglas, & Whiting, 2002) have compared subtypes on these measures, all of which reported no significant differences. However, these studies
contained small samples (i.e., n < 22) of the ADHD-PI group. Further, as noted by West et al (2002), the analysis would be strengthened by using matched samples.

Sustained Attention

Sustained attention, or vigilance, is defined as the ability to maintain attention on a task over a lengthy period of time (Betts, Mckay, Maruff, & Anderson, 2006). Three of the DSM-IV-TR (APA, 2000) inattention symptoms, that is, “difficulty sustaining attention on tasks”, “avoids, dislikes or is reluctant to engage in tasks that require sustained mental effort”, and “does not follow through”, involve sustained attention processes. Sustained attention is required for common classroom activities such as writing a story or essay or listening to the teacher for an extended period of time. Various versions of the Continuous Performance Test are primarily used to assess sustained attention, however, some researchers have used alternate measures (e.g., cancellation tests, category fluency tasks, and controlled oral word fluency tests). Losier, McGrath, and Klein’s (1996) meta-analysis of 26 studies found children with ADHD made significantly more omission and commission errors on the Continuous Performance Test. Subsequent studies (Shallice et al., 2002; Tsal, Shalev, & Mevorach, 2005) have yielded similar results. Subtype differences on sustained attention measures have been mixed. Some studies (Barkley et al., 1992; Mayes, Calhoun, Chase, Mink, & Stagg, 2009; Paternite et al., 1996) have found no subtype difference, whilst other studies (Collings, 2003; Ter-Stepanian, 2007) report significant sustained attention deficits for the ADHD-C relative to the ADHD-PI group. These latter findings are consistent with Barkley’s (1997) theory of ADHD, wherein a sustained attention deficit was proposed for only the ADHD-C subtype. In addition, higher omission error rates were found for participants with ADHD-C relative to learning disordered and controls, but no difference emerged between the ADHD-PI and the other groups (Barkley et al., 1990).

Four TEA-Ch subtests (Score!, Score DT, Walk Don’t Walk, Code Transmission) assess sustained attention. Findings of impaired performance on sustained attention tasks are reported for ADHD groups relative to controls (Gardner et al., 2008; Heaton et al., 2001; Hood, Baird, Rakin, & Isaacs, 2005; Manly et al., 1999; Sutcliffe, Bishop, & Houghton, 2006; Wu, Anderson, & Castiello, 2002). However, currently only two studies have examined subtype differences on the TEA-Ch subtests. No subtype differences were reported on the Score! subtest (West et al., 2002), and with each of the
TEA-Ch sustained attention subtests (Preston et al., 2009). Both of these studies were based on small samples of participants with ADHD-PI (n < 18).

**Attentional Control/Switching**

Manly et al. (1999) defined attentional control/switching as the ability to smoothly switch attentional focus from one task to another. In the classroom, attentional control/switching is required during transitions. Only three studies (Cepeda, Cepeda, & Kramer, 2000; Koschack, Kunert, Derichs, Weniger, & Irle, 2003; Oades & Christiansen, 2008) have investigated differences in attentional control/switching between children with ADHD and controls. All of these studies found the ADHD group to have significantly higher error rates and longer response latencies on the attentional control/switching tasks. None of these studies investigated attentional control/switching differences between the ADHD subtypes. Furthermore Oades and Christiansen (2008) specified that their ADHD sample was comprised of only Children with ADHD-C so it remains largely unknown whether this deficit is also found in children with ADHD-PI.

The Creature Counting and Opposite Worlds Task subtests assess attentional control/switching on the TEA-Ch. ADHD groups are found to be more impaired, compared to controls, on these tasks (Heaton et al., 2001; Manly et al., 1999; Sutcliffe et al., 2006; West et al., 2002). In the four studies conducted investigating subtype differences, no differences were reported by Heaton et al. (2001), Preston et al. (2009) and West et al. (2002) while Lemiere, et al.’s (2010) study found participants with ADHD-C to be significantly less accurate than their ADHD-PI counterparts on the Creature Counting subtest.

**6.3 Summary and Conclusions**

This chapter presented Posner and Peterson’s (1990) and Mirsky et al.’s (1991) models of attention, from which three types of attention were identified: selective attention, sustained attention, and attentional control/switching. In addition, research comparing the ADHD subtypes on behavioural and cognitive measures of attention were reviewed. Whilst difficulties with persistence, distractibility, and teacher ratings of SCT appear to differentiate the ADHD subtypes, the research is not as clear using cognitive measures of attention. Although ADHD groups are generally found to display some attention deficits on cognitive measures compared to controls, few studies have investigated subtype differences and these have yielded mixed results. Stefanatos and Baron (2007)
suggested that these mixed results may be partly due to the lack of relevance laboratory measures of attention have to real world functioning. The TEA-Ch presents an ecologically valid measure of selective attention, sustained attention, and attentional control/switching. However, at present few studies using the TEA-Ch to investigate differences between ADHD groups and controls, and more importantly for the current review between the ADHD subtypes, have been conducted. The few studies that have been undertaken have yielded mixed results, which may indicate that further research is required to determine whether the ADHD-PI and ADHD-C subtypes have different attention deficits.
Chapter 7: Memory Deficits in the ADHD Subtypes

In the review of the literature presented thus far, ADHD has been associated with a number of negative sequelae, one of the most concerning being poor academic functioning. Furthermore, some differences between the ADHD-PI and ADHD-C subtypes have emerged from the literature. As examined in the previous chapter, some subtype differences in attention, a fundamental building block of learning, have been found. However, further research is needed to clarify the precise nature of these attention difficulties and how they may vary between the ADHD-PI and ADHD-C subtypes. This chapter focuses upon memory, the other fundamental building block of learning.

7.1 Theoretical Models of Memory

Memory is defined as the mental process which underlies the storage, retention, and retrieval of information (Galotti, 1999). Lezak et al. (2004) suggested that memory plays a central role in all cognitive functions, and is strongly associated with learning efficiency (Webster et al., 1996). Whilst general consensus exists in the memory field that there is more than one type of memory, there is some debate regarding its fractionation. Atkinson and Shiffrin (1968) proposed in the Modal Model a division of memory into three structural components: a sensory register, a short-term store, and a long-term store. However, since the introduction of this model the sensory register has been re-conceptualised as part of the perceptual system rather than a memory component, and the short-term store replaced with the concept of working memory (Baddeley, 1984; Baddeley, 2004). Over the past 30 years working memory has been firmly established as a type of memory (Baddeley, 1996). However, debate has continued regarding the division of long-term memory. Most recently, Baddeley (2004) suggested that the clearest distinction in long-term memory lies between explicit and implicit memory.

Working Memory

The concept of working memory was introduced to overcome the problems associated with Atkinson and Shiffrin’s (1968) simple unitary short-term store (Baddeley, 1984; 2004). Working memory is defined as the capacity to hold information in the mind, whilst simultaneously manipulating that information (Baddeley, 1996). Whilst the capacity of working memory is limited and information only retained for a few seconds
unless rehearsed, Engle, Kan, and Tuholski’s (1999) literature review found strong links for working memory with following directions, vocabulary learning, reading and language comprehension, note-taking, writing, reasoning, and complex learning. As noted previously, some researchers (e.g., Mirsky & Duncan, 2001; Nyden, Gillberg, Hjelmquist, & Heiman, 1999) have suggested that Mirsky et al.’s (1999) encode component tapped working memory.

Gathercole and Packiam Alloway (2006) suggested that although several models of working memory have been proposed, Baddeley and Hitch’s (1974) model of working memory has been the most influential. This model, which has been subsequently elaborated upon in the writings of Baddeley and colleagues (e.g., Baddeley 1984; 2002; 2003; Baddeley, Gathercole, & Papagno, 1998), is comprised of three components: a central executive and two subsidiary storage systems. The central executive functions to regulate and control the two subsystems, as well as act upon information retrieved from long-term memory (Baddeley, 1984; 1996). Baddeley (2003) asserted that this central executive relies heavily upon the frontal lobes.

The two storage systems proposed in Baddeley’s (1996) model of working memory are: the phonological loop and the visuospatial sketchpad. The phonological loop is responsible for storage of acoustic or linguistic information which is maintained by sub-vocal rehearsal and is involved in the performance of verbal working memory tasks. Both Galotti (1999) and Baddeley et al. (1998) suggested that this system plays an important role in language acquisition. In contrast, the visuospatial sketchpad stores visual, spatial, and possibly kinaesthetic, information through the creation and use of mental images (Galotti, 1999; Baddeley, 2003). Baddeley et al. (1998) suggested that information of different sensory modalities is maintained in separate, but strongly interacting, subcomponents within this system. The visuospatial sketchpad is involved in the performance of non-verbal working memory tasks.

Baddeley (1996) introduced the concept of an episodic buffer, which in Baddeley (2000) was established as the fourth component of working memory. The episodic buffer is a limited capacity system which binds and temporarily stores information from different modalities in the form of a multimodal code.
A range of tasks are used to assess working memory. These tasks can be separated into measures of verbal working memory (e.g., the Digit Span and Arithmetic subtests of the WISC-III, reading span, listening span and counting span) and non-verbal working memory (e.g., spatial span, pattern span, and the Self Ordered Pointing Task). Questions have been raised about whether tasks that involve only the storage, but not the manipulation of information, component of working memory (such as the Digits Forward part of the Digit Span subtest) capture the true nature of working memory.

**Long-term Memory**

Whilst a number of different divisions of long-term memory have been proposed, the most widely accepted distinction occurs between explicit (declarative) memory and implicit (non-declarative) memory (Baddeley, 2004; Naito & Komatsu, 1993). An equivalent study phase is generally involved in explicit and implicit memory, but they differ in terms of how memory is assessed in the test phase. Explicit memory involves the conscious recollection of information presented previously and can be further divided into two separate systems – episodic and semantic memory (Baddeley, 2004). Free recall, cued recall, and old-new recognition tasks are commonly used to assess explicit memory. In the classroom, explicit memory tests (e.g., dictation and tests that involve the direct recall of facts, or multiple choice tests which involve recognition) are generally used to assess learning.

In contrast, implicit memory is present in situations where past experiences, in the absence of conscious recollection, facilitate performance on tasks (Burden & Mitchell, 2005). Squire (1992) identified a number of different types of implicit memory, which included: skill and habit formation, priming, simple classical conditioning and non-associative learning. Schacter (1994) suggested that priming has been the most intensively studied type of implicit memory. Priming has been described to occur when there is an overlap of items presented in the study and test phases wherein the participant is influenced to respond with previously studied items (Burden & Mitchell, 2005). Tasks such as naming degraded pictures, word-stem completion or category exemplar generation, are commonly used to assess the priming type of implicit memory. Implicit memory is involved in classroom activities wherein previous learning aids performance in a new situation or when copying a word numerous times assists in spelling the word correctly in a sentence.
Two major theories are proposed to explain the distinction between explicit and implicit memory, these being the Memory Systems account and the Levels of Processing view. In the Memory Systems account, proposed by Graf and Schacter (1985) and Zola-Morgan and Squire (1993), explicit and implicit memory are conceptualised as distinct memory systems. Three lines of evidence are cited in support of this distinction. Firstly, Graf and Schacter (1985) reported findings of intact implicit memory present in amnesic patients, who are known to have severe explicit memory impairments, to a level comparable to control participants. This is consistent with findings in the well-documented case of amnesic patient H.M. Secondly, Zola-Morgan and Squire’s (1993) review of the available literature at the time suggested that different brain systems support explicit and implicit memory. Specifically, the medial temporal lobe, diencephalon, and basal forebrain are identified to underlie explicit memory, whereas implicit memory is associated with the neocortex and neostriatum. The third line of support comes from differential developmental trajectories for these memory systems. Implicit memory was found to be present within the few months of life and was relatively fully functioning, whereas explicit memory emerged later (i.e., after 8 months of life) and developed markedly from infancy to adulthood (Nelson, 1995; Parkin & Streete, 1988). Thus, the Memory Systems account distinguishes explicit memory from implicit memory in terms of clinical presentation, neuroanatomy, and developmental trajectories.

A major criticism of the Memory Systems account exists pertaining to the confounding nature of tasks used to assess explicit and implicit memory. Blaxton (1989) noted that conceptual (semantic or meaning-based) tasks were generally used to test explicit memory, whereas implicit memory was generally assessed with perceptual (appearance or form-based) tests. As a result, Blaxton (1989) formulated the Levels of Processing view, based on a series of experiments, to explain the distinction between explicit and implicit memory. Five tasks were used to test the explicit-implicit memory distinction: a perceptually-based (i.e., graphemic cued recall) and two conceptually-based (i.e., free recall and semantic cued recall) explicit memory tasks, and a perceptually-based (i.e., word-fragment completion) and conceptually-based (i.e., general knowledge) implicit memory tasks. Results from these experiments found conceptually-based manipulations during the study phase, wherein participants were instructed to generate or form mental images of target items, enhanced performance on explicit more than implicit memory tasks in the test phase. An opposite trend was reported when participants were
encouraged to use perceptually-based strategies, such as analysing the physical features of items in the study phase for implicit memory tests. Blaxton (1989) explained these results using Morris, Bransford, and Franks’ (1977) transfer appropriate processing framework, which suggested that performance on memory tasks were benefitted when the same type of processing is used in the study and test phases. Blaxton (1989) concluded that conceptually-based and perceptually-based processing during the study phase benefited performance on explicit and implicit memory tests, respectively. Thus, Blaxton’s (1989) experiments showed that explicit and implicit memory differed in level of processing suggest that these are not two distinct memory systems.

Viable accounts for the distinction between explicit and implicit memory were presented by both the Memory Systems and Level of Processing views, but neither was able to account for all the evidence of this distinction. Blaxton’s (1989) experiments showed that performance on all explicit memory tasks was not uniform, but varied according to the level of processing used during the study phase. A similar result was found for implicit memory tasks. These findings were inconsistent with the Memory Systems account (Graf & Schacter, 1985), which suggested that performance on any explicit memory test should be similar regardless of the level items are processed. By contrast, the intact performance of amnesic patients found on implicit memory tests that were processed conceptually (Roediger, 1990) provided evidence contrary to Blaxton’s (1989) Levels of Processing view, which purported conceptually-based processing would only benefit performance on explicit, but not implicit memory tests. The inability of both theories to account for all of the evidence, however, does not render them futile in the study of explicit and implicit memory. Rather, Tulving and Schacter (1990) suggested that the combination of these two theories provides the most promising route for further expansion of knowledge of explicit and implicit memory.

7.2 Memory and ADHD Subtypes

Compared to attention, much less research has been conducted investigating memory in ADHD and its subtypes. However, as stated earlier in this chapter, memory plays an essential role in learning (Lezak et al., 2004; Webster et al., 1996). This section reviews the ADHD literature pertaining to working memory, explicit memory, and implicit memory, with the aim of highlighting any differences between the ADHD-PI and ADHD-C subtypes.
Working Memory

In the ADHD literature working memory is the type of memory most extensively studied. A summary of studies that have investigated working memory in ADHD and its subtypes is displayed in Table 7.1. Meta-analyses conducted by Hervey, Epstein, and Curry (2004), Martinussen, Hayden, Hogg-Johnson, and Tannock. (2005) and Willcutt et al. (2005) have found ADHD groups to be significantly impaired on various working memory tasks compared to controls. However, Gathercole and Packiam Alloway’s (2006) and Pennington and Ozonoff’s (1996) literature reviews reported no difference in working memory between ADHD and controls.

The majority of studies (Engelhardt, Nigg, Carr, & Ferrerira, 2008; Mealer, Morgan, & Luscomb, 1996; Rapport et al., 2008; Siklos & Kerns, 2004) that have investigated verbal working memory in ADHD have found the ADHD group to display a deficit on such measures relative to controls. Only West et al.’s (2002) study reported no difference between groups. Mixed results on verbal working memory tasks were found in both McInnes, Humphries, Hogg-Johnson, and Tannock’s (2003) and Schmitz et al.’s (2002) studies. McInnes et al. (2003) reported differences between participants with ADHD and controls, whereby the former group was more impaired on tasks which assessed the manipulation component of verbal working memory, but not on tasks assessing only the storage component. Schmitz et al. (2002) found differences on a Digit Span task, but not a Word Span task, between ADHD and control groups.

The ADHD groups were found to display impaired performance on non-verbal working memory tasks relative to controls in most studies (McInnes et al., 2003; Mealer et al., 1996; Rapport et al., 2008; West et al., 2002), with only Geurts et al. (2005) reporting no difference between groups. These results indicate that ADHD groups in most studies evidence impaired performance on tasks of verbal and non-verbal working memory.

On a theoretical level, Barkley’s (1997) model of ADHD proposed that the ADHD-C subtype is impaired in both verbal (for which he specified impairment in the phonological loop; Barkley, 1998) and non-verbal working memory. However, because this model only applies to the ADHD-C subtype, it is unclear whether working memory deficits are also expected for the ADHD-PI subtype. Alternatively, Diamond (2005) has argued that the primary deficit for the ADHD-PI subtype is in working memory.
<table>
<thead>
<tr>
<th>Study</th>
<th>Study Groups</th>
<th>Age range</th>
<th>Sex %</th>
<th>Type of WM</th>
<th>Tasks Used</th>
<th>Main Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engelhardt et al. (2008)</td>
<td>115 ADHD</td>
<td>13 – 37 Years</td>
<td>57% male</td>
<td>Verbal WM storage and manipulation</td>
<td>Stroop WM task</td>
<td>ADHD group significantly less accurate than controls</td>
</tr>
<tr>
<td></td>
<td>173 Controls</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Geurts et al. (2005)</td>
<td>16 ADHD-PI</td>
<td>6 – 13 years</td>
<td>Male</td>
<td>Visual WM Self Ordered Pointing Test</td>
<td>No group differences</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16 ADHD-C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16 Controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaplan, Dewey, Crawford &amp; Fisher (1998)</td>
<td>53 ADHD</td>
<td>11.8 years average</td>
<td>75% male</td>
<td>Verbal WM, and Visual WM</td>
<td>Number/Letter Memory and Finger Window subtests of the (WRAML)</td>
<td>ADHD group significantly poorer than controls on both the verbal WM and visual WM subtests</td>
</tr>
<tr>
<td></td>
<td>112 Controls</td>
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</tr>
<tr>
<td>Mariani &amp; Barkley (1997)</td>
<td>34 ADHD</td>
<td>4 - 5 years</td>
<td>Male</td>
<td>WM – Persistence Factor</td>
<td>K-ABC Hand Movements, Number Recall, and Spatial Memory tests</td>
<td>ADHD group scored significantly higher on WM – Persistence factor than controls</td>
</tr>
<tr>
<td></td>
<td>30 Controls</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>McInnes et al. (2003)</td>
<td>21 ADHD</td>
<td>9 – 12 years</td>
<td>Male</td>
<td>Verbal WM storage and manipulation, and Spatial WM storage and manipulation</td>
<td>Numbers subtest of the Child Memory Scale, and the Finger Window subtest of the WRAML</td>
<td>ADHD group significantly poorer than controls on verbal WM manipulation, but not storage. ADHD groups significantly poorer on both spatial WM storage and manipulation.</td>
</tr>
<tr>
<td></td>
<td>19 Controls</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Study</td>
<td>Participants</td>
<td>Age</td>
<td>Gender</td>
<td>Tasks</td>
<td>Results</td>
<td></td>
</tr>
<tr>
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</tr>
<tr>
<td>Mealer et al. (1996)</td>
<td>20 ADHD, 20 Controls</td>
<td>6–13 years</td>
<td>Male</td>
<td>Verbal WM, Spatial WM, Digit Span subtest of WISC-IV, and Finger Window subtest of the WRAML</td>
<td>ADHD group significantly poorer on verbal WM and spatial WM</td>
<td></td>
</tr>
<tr>
<td>Rapport et al. (2008)</td>
<td>12 ADHD, 11 Controls</td>
<td>8–12 years</td>
<td>Male</td>
<td>WM manipulation, verbal storage, and visuospatial storage, Variation of Letter Number Sequencing subtest of the WISC-IV, and Visuospatial WM task</td>
<td>ADHD group significantly poorer than controls on WM manipulation, and verbal and visuospatial storage</td>
<td></td>
</tr>
<tr>
<td>Schmitz et al. (2002)</td>
<td>10 ADHD-PI, 10 ADHD-C, 60 Controls</td>
<td>12–16 years</td>
<td>55% male</td>
<td>Verbal WM, Digit Span, and Word Span</td>
<td>ADHD groups significantly poorer than controls on Digit Span, No group differences on Word Span</td>
<td></td>
</tr>
<tr>
<td>Siklos &amp; Kerns (2004)</td>
<td>19 ADHD-C, 19 Controls</td>
<td>7–13 years</td>
<td>89% male</td>
<td>Verbal WM storage and manipulation processes, Children’s Paced Auditory Serial Addition Task, and Digit Span Backward</td>
<td>ADHD-C group significantly poorer than controls on both tasks</td>
<td></td>
</tr>
<tr>
<td>West et al. (2002)</td>
<td>14 ADHD-PI, 36 ADHD-C, 50 Controls</td>
<td>6–12 years</td>
<td>Male</td>
<td>Verbal WM, Spatial WM, Child Memory Scale Numbers and Sequences subtests</td>
<td>No group differences on Numbers subtest, ADHD groups significantly poorer on Sequences subtest than controls</td>
<td></td>
</tr>
</tbody>
</table>
Only a few empirical studies have investigated ADHD subtype differences on working memory tasks. These studies (Geurts et al., 2005; Schmitz et al., 2002; West et al., 2002) report no significant differences between ADHD-PI and ADHD-C subtypes. Geurts et al.’s (2005) study assessed non-verbal working memory using the Self-Ordered Pointing Task. Verbal working memory in the ADHD subtypes was examined in both Schmitz et al.’s (2002) and West et al.’s (2002) studies using the combined score of the Digits Forward and Digits Backward parts of the WISC-III Digit Span subtest. As mentioned previously, questions have been raised about whether Digits Forwards, a measure of verbal working memory storage, can capture the true nature of working memory which has been purported to involve an additional manipulation component. The combination of Digits Forward and Backward scores in Schmitz et al.’s (2002) and West et al.’s (2002) studies may have concealed possible subtype differences that could have emerged if only Digits Backward was used, which contains both storage and manipulation components of verbal working memory. It would be helpful if Digits Forward and Backward were examined separately.

Explicit Memory
Mixed results are reported as to whether children with ADHD have deficits in explicit memory. A summary of these studies are presented in Table 7.2. A number of studies (Ballesteros, Reales, & Garcia, 2007; Burden & Mitchell, 2005; Kaplan et al., 1998) have found ADHD groups to perform comparably to controls on explicit memory tasks. In contrast, two studies have found differences in explicit memory between ADHD and control groups. Aloisi, McKone, and Heubeck (2004) reported significantly poorer performance for children with ADHD compared to controls on a perceptually-based (non-verbal) explicit test of long-term memory. Similarly, in West et al.’s (2002) study the ADHD group obtained significantly lower recall scores after a delay, relative to controls, on two conceptually-based (verbal) memory subtests (i.e., Stories and Word Pairs) of the Children’s Memory Scale. Significantly poorer recognition after a delay on only the Stories subtest was also found for the ADHD group. However, on the perceptually-based subtests of the Children’s Memory Scale no difference between groups for recall was reported. The mixed findings of comparisons between ADHD and controls raise the question of whether differences in explicit memory between subtypes may account for these inconsistencies.
Table 7.2
Studies that Investigated Explicit Memory in ADHD and its Subtypes

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Groups</th>
<th>Age range</th>
<th>Sex %</th>
<th>Type of EM</th>
<th>Task Used</th>
<th>Main Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aloisi et al. (2004)</td>
<td>20 ADHD 20 Controls</td>
<td>7 – 15 years</td>
<td>85%</td>
<td>Perceptually-based</td>
<td>Own task (old-new recognition)</td>
<td>ADHD group was more impaired on EM task relative to controls</td>
</tr>
<tr>
<td>Ballesteros et al. (2007)</td>
<td>21 ADHD 21 Controls</td>
<td>Grade 2 &amp; 5</td>
<td>Not stated</td>
<td>Perceptually-based</td>
<td>Own task (recognition)</td>
<td>No difference between ADHD and control groups on EM task</td>
</tr>
<tr>
<td>Barkley, DuPaul &amp; McMurray (1991)</td>
<td>17 ADHD-PI 23 ADHD-C</td>
<td>6 – 11 years</td>
<td>89%</td>
<td>Conceptually-based</td>
<td>Wisconsin Selective Reminding Test (recall)</td>
<td>The ADHD-PI group was more impaired than their ADHD-C counterparts on EM task</td>
</tr>
<tr>
<td>Burden &amp; Mitchell (2005)</td>
<td>30 ADHD 48 Controls</td>
<td>7 – 14 years</td>
<td>76%</td>
<td>Conceptually- and perceptually-based</td>
<td>Own task (category cued recall and recognition)</td>
<td>No difference between groups on category cued recall for pictures or words, or on recall for words</td>
</tr>
<tr>
<td>Kaplan et al. (1998)</td>
<td>53 ADHD 112 Controls</td>
<td>11.8 years (average)</td>
<td>80% Male</td>
<td>Conceptually- and perceptually-based</td>
<td>WRAML subtests (story memory, verbal learning, visual learning, sound symbol)</td>
<td>No difference between groups on any of these WRAML subtests</td>
</tr>
<tr>
<td>Solanto et al. (2007)</td>
<td>26 ADHD-PI 34 ADHD-C 20 Controls</td>
<td>7 – 12 years</td>
<td>52%</td>
<td>Conceptually-based</td>
<td>Bushke Selective Reminding Test</td>
<td>ADHD-C group was more impaired than their ADHD-PI counterparts on EM task</td>
</tr>
<tr>
<td>West et al. (2002)</td>
<td>14 ADHD-PI</td>
<td>6 – 12 years males</td>
<td>Conceptually- and perceptually-based</td>
<td>Children’s Memory Scale subtests (dot locations, faces, stories, word pairs)</td>
<td>ADHD group impaired relative to controls on both conceptually-based recall EM tests. No difference between groups on perceptually-based recall EM tests</td>
<td>36 ADHD-C</td>
</tr>
</tbody>
</table>
From a theoretical level, Barkley has asserted in a number of publications (Barkley, 1998; 2000; 2003; Barkley et al., 1990) that only the ADHD-PI subtype displays problems with recall of information stored in long-term memory. These assertions are largely based upon Barkley, DuPaul, and McMurray’s (1991) findings wherein the ADHD-PI group displayed significantly worse recall than the ADHD-C and control groups on a verbal memory task whereas no difference was reported on this measure between the two latter groups. However, Solanto et al. (2007) reported contrary findings to Barkley et al. (1991), wherein the ADHD-C group was found to have significantly worse Delayed Recall than both the ADHD-PI and control groups on the Bushke Selective Reminding Test. A further study by West et al. (2002) failed to find any subtype differences on verbal or non-verbal explicit memory tests.

Implicit Memory
Only three studies have investigated implicit memory in ADHD, a summary of which is presented in Table 7.3. In Ballesteros et al.’s (2007) study, children with ADHD were found to perform significantly more poorly than controls on a degraded pictures (perceptually-based) implicit memory task. Contrary to these findings, Aloisi et al. (2004) reported no deficit for the ADHD group on a similar perceptually-based implicit memory task. Burden and Mitchell (2005) found differences in the performance of participants with ADHD according to type of implicit memory task used. Whilst on the perceptually-based implicit memory task the ADHD group’s performance was comparable to controls, a priming deficit was present for participants with ADHD on the conceptual implicit memory task. At present, no research studies have been conducted to investigate ADHD subtype differences in implicit memory.
Table 7.3
Studies that Investigated Implicit Memory in ADHD and its Subtypes

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Groups</th>
<th>Age range</th>
<th>Sex %</th>
<th>Type of IM</th>
<th>Task Used</th>
<th>Main Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aloisi et al.</td>
<td>20 ADHD</td>
<td>7 – 15 years</td>
<td>85% male</td>
<td>Perceptually-based</td>
<td>Own task (degraded pictures)</td>
<td>No difference between ADHD and control groups on IM task</td>
</tr>
<tr>
<td>(2004)</td>
<td>20 Controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Ballesteros et</td>
<td>21 ADHD</td>
<td>Grade 2 &amp; 5</td>
<td>Not stated</td>
<td>Perceptually-based</td>
<td>Own task (degraded pictures)</td>
<td>ADHD group was more impaired on IM task relative to controls</td>
</tr>
<tr>
<td>al. (2007)</td>
<td>21 Controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burden &amp;</td>
<td>30 ADHD</td>
<td>7 – 14 years</td>
<td>76% male</td>
<td>Conceptually- and perceptually-based</td>
<td>Own task (category exemplar generation, word-stem completion and picture fragment identification)</td>
<td>ADHD group was more impaired on category exemplar generation than controls. No difference between groups on word-stem completion and picture fragment identification tasks</td>
</tr>
<tr>
<td>Mitchell</td>
<td>48 Controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(2005)</td>
<td></td>
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</tbody>
</table>
## 7.3 Summary and Conclusions

The nature of and theories pertaining to three types of memory - working memory, explicit memory, and implicit memory - were explored in this chapter. In addition, the relevance of each of these types of memory for classroom learning activities was noted. The review of the current literature pertaining to these three types of memory in ADHD populations presented predominately mixed findings. Furthermore, very few studies have investigated ADHD subtype differences in working memory and explicit memory, and no studies to date have examined such differences in implicit memory. From this literature review it can be concluded that some differences in memory may be found between ADHD and control groups, and more importantly between ADHD subtypes, however further research is needed to more clearly delineate the nature of such differences.
Chapter 8: Research Questions and Hypotheses of the Present Study

The review of the literature presented in Chapters 2 to 7 highlighted the complex nature of ADHD. In particular, the problems encountered by individuals with ADHD are found to extend beyond attention deficits into the domains of psychological, social, and academic functioning. In addition, it is evident from the literature review that the differences between the ADHD-PI and ADHD-C subtypes are more than merely the presence or absence of clinically significant levels of hyperactive-impulsive behaviour. Some differences between the ADHD-PI and ADHD-C subtypes have emerged in the literature at theoretical, psychosocial, and demographic levels. However, differences between the ADHD subtypes at a cognitive level have not been convincingly demonstrated by the existing literature.

Both children and adolescents with ADHD-PI and with ADHD-C are found to have concerning problems with learning, as evidenced by their poor school grades, high rates of grade retention, and comorbidity with Learning Disorders. Attention and memory are the fundamental building blocks of learning, hence the nature of these need to be examined such that the underpinnings of learning problems experienced by children with ADHD can be more fully understood.

The present study raises the question of whether differences exist in attention and memory between the ADHD-PI and ADHD-C subtypes. On one hand, the differences found between the ADHD subtypes at various levels suggest that subtype differences will also be found for attention and memory. On the other hand, the lack of substantial differences at a cognitive level, and similar problems in learning experienced by both ADHD subtypes, predict that the nature of attention and memory in the ADHD-PI and ADHD-C subtypes will be similar. The present study aims to examine the nature of and differences in attention and memory between the ADHD-PI and ADHD-C subtypes. Four main research questions are posed in the present study.

8.1 Research Question 1

The first research question pertains to the psychosocial functioning of the ADHD-PI and ADHD-C groups. The question is raised of whether these ADHD groups have problems in their psychosocial functioning compared to Control participants and, if so, do these problems differ between ADHD subtypes. Psychosocial functioning can have...
some impact upon a child’s learning at school. Whilst numerous studies have investigated psychosocial functioning in ADHD and its subtypes, only a few studies (e.g., Graetz, et al., 2001; Levy, Hay, Bennett, & McStephen, 2005) have examined such functioning in an Australian sample. The present study intends to use the Strengths and Difficulties Questionnaire (SDQ: Goodman, 1997) to assess psychosocial functioning in the ADHD-PI, ADHD-C, and Control groups. The SDQ will be used to assess several aspects of psychosocial functioning including: Internalising Disorders with the SDQ Emotional Symptoms subscale; Externalising Disorders with the SDQ Conduct Problems subscale; Social Functioning with the SDQ Peer Problems and SDQ Prosocial Behaviour subscales; and General Functioning with the SDQ Total Problems subscale. Both parents and children will be asked to provide ratings on the SDQ in the present study.

From the review of the literature pertaining to the psychosocial functioning of ADHD-PI, ADHD-C, and non-clinical children and adolescents several hypotheses are derived.

**Internalising Symptoms**
The Emotional Symptoms subscale of the SDQ is comprised of items pertaining to anxiety, depression, and somatic complaints. Based on the literature review, wherein high comorbidity was found between ADHD and internalising disorders, it is predicted that both ADHD groups will have higher ratings on the Emotional Symptoms subscale compared to Controls. However, because findings of subtype differences in internalising symptoms on behavioural rating scales have been mixed, it is expected that the ADHD groups will be rated similarly on this subscale.

The ADHD subtypes have been found to differ in rates of comorbidity with anxiety and mood disorders. For this reason the ADHD-PI group is expected to receive higher ratings on the three anxiety items of the SDQ Emotional Symptoms subscale than their ADHD-C counterparts, with an opposite result predicted for the groups on the depression item.

**Externalising Symptoms**
Items related to aggression, oppositionality, and problems with conduct comprise the Conduct Problems subscale of the SDQ. The literature review found that whilst both ADHD subtypes are highly comorbid with externalising disorders, the ADHD-C
subtype had substantially higher ratings than their ADHD-PI counterparts on externalising scales. Therefore, it is hypothesised that both ADHD groups will have elevated ratings on the Conduct Problems subscale relative to controls. It is also predicted that the ADHD-C group will have higher ratings on this subscale than the ADHD-PI group.

**ADHD Symptoms**
The Hyperactivity subscale of the SDQ contains items related to both attention problems and hyperactive-impulsive behaviour. According to the DSM-IV-TR (APA, 2000) criteria, both the ADHD-PI and ADHD-C subtypes are defined by the presence of clinically significant levels of attention problems, and the presence of significant hyperactivity-impulsivity symptoms in the latter group. Therefore, it is predicted that the ADHD-C group, who have problems with both attention and hyperactivity-impulsivity, will have higher ratings on the Hyperactivity subscale than both the ADHD-PI and Control groups. Given the presence of attention problems, the ADHD-PI group is also expected to be rated higher on this subscale than Control participants.

**Social Functioning**
Two subscales, the Peer Problems subscale and the Prosocial subscale, assess social functioning on the SDQ. Whilst, the Peer Problems subscale contains items pertaining to being friends and liked by peers, preference for solitary activities, and being bullied, items related to sharing and helping others comprise the Prosocial subscale. From the literature review both ADHD subtypes were found to have marked impairments in social functioning compared to non-clinical children. Hence, it is predicted that both ADHD groups will receive higher ratings on the Peer Problems subscale compared to Controls.

The research found different types of social problems, wherein the problems for the ADHD-C subtype pertained to their aggressive and overly emotional behaviour, whereas problems arose for ADHD-PI subtype due to their passive and withdrawn behaviour. Hence, it is expected that the ADHD-PI group will have higher ratings than their ADHD-C counterparts on the preference for solitary activities item of the SDQ Peer Problems subscale. In addition, the nature of the social problems experienced by the ADHD subtypes led to the prediction that both groups will receive lower ratings on
the Prosocial subscale in comparison to the Control group. No differences are expected between the two ADHD groups on either subscale.

**General Functioning**

The Total Difficulties subscale of the SDQ is comprised of the four SDQ problem subscales (i.e., emotional, conduct, hyperactivity, and peer problems). Given the preceding hypotheses, it is predicted that both ADHD groups will have higher scores on the Total Difficulties subscale than Controls. In terms of subtype differences the literature has suggested that ADHD-C groups were more impaired and had higher comorbidity with other psychological disorders than their ADHD-PI counterparts. Thus, it is predicted that this difference will be reflected in higher Total Difficulties scores for the ADHD-C group.

**8.2 Research Question 2**

The second research question of the present study relates to different types of attention problems (i.e., in selective attention, sustained attention, and attentional control/switching) in the ADHD-PI, ADHD-C and Control groups. The question raised is whether specific deficits in different attention types exist for ADHD groups relative to Controls and, if so, whether the patterns of deficits differ between the ADHD-PI and ADHD-C groups.

From the literature review it is evident that children with ADHD, in general, have difficulties on tasks assessing selective attention, sustained attention, and attentional control/switching. However, the research on these attention measures in ADHD subtypes has tended to report mixed results. Despite the lack of clear findings on cognitive measures of attention, the attention problems of ADHD-PI and ADHD-C subtypes are described in the literature as fundamentally different from one another. Some theorists (e.g., Barkley, 1997; Milich et al., 2001) have strongly asserted that the ADHD-PI subtype has a core deficit in selective attention, whereas only sustained attention is impaired in the ADHD-C subtype. The present study intends to employ the Test of Everyday Attention for Children (TEA-Ch) battery of attention tests, which contains two tests that assess selective attention, three that assess sustained attention and two that assess attentional control/switching.
Based on the review of the theoretical and empirical literature, hypotheses were derived for selective attention, sustained attention, and attentional control/switching.

**Selective Attention**
The TEA-CH contains two subtests - Sky Search and Map Mission - which will be used to assess selective attention. Consistent with theoretical assertions, it is hypothesised that the ADHD-PI group will be more impaired on these selective attention tasks compared to the ADHD-C and Control groups. Furthermore, no differences on these subtests are expected between the two latter groups.

**Sustained Attention**
Four subtests of the TEA-CH - Score!, Score DT, Walk Don’t Walk, and Code Transmission – will be used to assess sustained attention. Consistent with theoretical assertions and some empirical findings it is predicted that the performance of the ADHD-C group will be more impaired on all sustained attention subtests of the TEA-Ch compared to the ADHD-PI and Control groups. No differences are expected between the two latter groups on these subtests.

**Attentional Control/Switching**
The TEA-Ch contains two subtests - Creature Counting and Opposite Worlds Task (Same World condition, Opposite World condition) - which will be used to assess attentional control/switching. Consistent with empirical findings it is expected that the ADHD-PI and ADHD-C groups will display impaired performance on these attentional control/switching subtests compared to the Control group. Due to no theoretical assertions pertaining to attentional control/switching in the ADHD subtypes, it is expected that the ADHD-PI and ADHD-C groups will perform similarly on attentional control/switching subtests, although the underlying mechanisms may be different.

**8.3 Research Question 3**
The third research question of the present study relates to memory in ADHD and its subtypes. Three types of memory are considered: working memory, explicit memory and implicit memory. The question raised is whether specific deficits in different memory types exist for ADHD groups relative to Controls and, if so, whether the patterns of deficits between the ADHD-PI and ADHD-C groups are different.
In the present study verbal working memory and conceptually-based explicit and implicit memory will be assessed in the three study groups. Hypotheses were derived from the literature review pertaining to the nature of memory in ADHD and its subtypes for each type of memory.

**Working Memory**

In the present study the Digits Forward and Digits Backward parts of the WISC-III Digit Span subtest will be used to assess verbal working memory because this subtest has been used in a number of previous studies (Mealer et al., 1996; Schmitz et al., 2002; Siklos & Kerns, 2004) with ADHD samples. The majority of studies that have investigated working memory in ADHD groups have found these groups to be impaired on verbal working memory tasks. For this reason, both ADHD groups are expected to perform more poorly on Digits Forward and Digits Backward.

From a theoretical perspective Barkley (1997) proposed a deficit in working memory for the ADHD-C subtype, whereas Diamond (2005) asserted a central deficit in working memory for the ADHD-PI subtype. The few empirical studies conducted that have investigated working memory in ADHD subtypes have found no differences between groups. However, it is questionable whether the combined scores on both parts of the Digit Span subtest, as used in these studies, is a valid measure of working memory. To overcome this problem, Digits Forwards and Digits Backwards will be used separately to assess verbal working memory. Because working memory deficits are proposed for both ADHD subtypes it is predicted that the ADHD-PI and ADHD-C subtypes will perform comparably on Digits Forward and Digits Backward.

**Explicit Memory**

Three studies have investigated ADHD subtype differences in explicit memory with different results yielded by each study. The present study intends to use the conceptually-based Category Cued Recall task as a measure of explicit memory. Mixed findings have been reported in the literature related to differences in performance on conceptually-based explicit memory tasks between ADHD and controls. However, it is predicted, based upon West et al.’s (2002) significant findings, that both ADHD groups will display poorer performance on the Category Cued Recall task relative to control participants. Due to contradictory results reported by Barkley et al. (1991) and Solanto et al. (2007) of subtype differences on conceptually-based explicit memory tasks, no
difference in performance on the explicit memory task in the current study is predicted between the ADHD subtypes.

**Implicit Memory**
To date, the present study is the first to examine implicit memory in the ADHD subtypes. The Category Exemplar Generation task will be used to assess conceptually-based implicit memory in the present study. Based upon Burden and Mitchell’s (2005) findings, it is predicted that the ADHD groups will display impairment on the Category Exemplar Generation task relative to controls. Because this appears to be the first study to investigate subtype difference on an implicit memory tasks a null hypothesis was adopted for comparisons between the ADHD-PI and ADHD-C groups.

**8.4 Research Question 4:**
Research questions 2 and 3 attempt to pinpoint individual processes that may contribute to the attention and memory problems experienced by children with ADHD. The fourth research question asks whether a combination of these attention and/or memory tests can assist in the discrimination between the ADHD-PI, ADHD-C and Control groups. A discriminant analysis will be conducted to ascertain which combination of attention and memory measures that will be used in the present study, best distinguish between groups.
Chapter 9: Method

9.1 Design
This study employed a matched triples design in which participants meeting criteria for ADHD-PI were matched on age and IQ with participants meeting criteria for ADHD-C and control participants. In addition, participants in the two ADHD groups were matched on their current medication status. This matching design decreases the error variance associated with age, IQ and medication status, and reduces the possible confounding effects of these variables (Kirk, 1995).

9.2 Recruitment and Selection
Approval to conduct the study was attained from the ANU Human Research Ethics Committee, the ACT Department of Education and Training, and the Canberra and Goulburn Catholic Education Office (see Appendix A for evidence of ethical approval and Appendix B for copies of the Parental Information Statement and Consent Form).

ADHD Groups
Participants in the two ADHD groups (ADHD-PI and ADHD-C) were recruited in three phases. In Phase One 95 public, Catholic, and independent primary schools in Canberra and the Canberra and Queanbeyan ADHD Support Group were approached. Principals were sent a letter and received follow-up phone calls to determine whether their school would participate in the study. If principals could not be contacted after two attempts, the school was regarded as not replying. Ninety-five schools were approached in Canberra, of which six indicated that they would participate in the study, 41 replied that they were unable to participate, and 48 did not reply. For the schools agreeing to participate, the researcher met with the principal and/or other interested school staff (i.e., classroom teacher, special education teacher, or school counsellor). The principal and/or school staff were asked to identify students who were diagnosed with ADHD and to send information about the study and the consent form home to their parents. In addition, to contacting school principals, the Canberra and Queanbeyan ADHD Support Group distributed information about the study to their members, as well as placing an advertisement in their monthly newsletter. Fifteen participants with ADHD-PI and 16 with ADHD-C were recruited in Phase One.
In Phase Two presentations were made at two meetings of school counsellors working in ACT public schools. The school counsellors were given specific criteria for participant entry into the study and were asked to send home to parents of children meeting these criteria information about the study and the consent form. In addition, the researcher met with five Paediatricians, Psychiatrists and Psychologists who were known to specialise in the treatment of ADHD in Canberra. These Paediatricians, Psychiatrists, and Psychologists were asked to send information about the study and the consent form home to the parents of patients who met the specific entry criteria for the study. Only one ADHD-PI participant was recruited in Phase Two.

In Phase Three the inclusion criteria for the study were expanded to include students who may not have received a formal diagnosis, but met all diagnostic criteria for ADHD. Participants were recruited in this phase of the study from the school where the researcher was undertaking a clinical research placement using two methods: 1) through referrals made to the school counsellor directly by concerned parents regarding difficulties with attention and/or school work experienced by their child, and 2) through classroom teachers who had genuine concerns that a student had symptoms suggestive of ADHD. In both recruitment methods information about the study and the possibility of a provisional diagnosis of ADHD being made was discussed with parents. An information sheet and consent form was then sent home to interested parents.

Prior to completing the standard set of measures of the study, a multi-method assessment approach was adopted to determine whether a child met criteria for ADHD and if so identify which subtype of ADHD was present. Firstly, parents completed a diagnostic questionnaire (see Measures section for discussion of the specific items included in this questionnaire) which covered all DSM-IV-TR (APA, 2000) criteria for ADHD, and included further questions that pertained to the nature and context of a child’s difficulties. A parent interview was conducted to clarify responses to the questions, where it was ambiguous from the diagnostic questionnaire whether the child met full criteria for ADHD. Secondly, the researcher conducted observations of the child participating in classroom activities on two occasions to assess the presence or absence of symptoms of ADHD in a school context. Thirdly, the classroom teacher of the child was interviewed to discuss their concerns and the presence of symptoms of ADHD displayed by the child in their classroom learning. Lastly, a review of past school report cards was conducted to determine the history of symptoms of ADHD.
displayed by the child. Only children who met full criteria for ADHD using this multi-
method assessment approach were included in the study as participants.

Nine participants with ADHD-PI and 11 with ADHD-C were recruited in Phase Three.

Feedback reports that detailed the performance of each participant on assessment
measures were provided to parents for all participants (including control participants) of
the current study. In addition, the contact details of the researcher were provided such
that parents could access further assistance where required. Further assistance offered to
parents included: referrals to appropriate professionals for further assessment and/or
provision of psychoeducation on ADHD, consultations with classroom teachers to
discuss ways to better support the learning of a student with ADHD, or formalised
individualised treatment plans were implemented.

Control Group
Control participants were recruited after the ADHD groups, such that age and IQ could
be matched. Principals and/or other school staff were asked to identify a child who did
not have ADHD of a similar age and IQ range as the clinical participants. An
information letter and consent form stating that the child was a control participant was
sent home to the parents inviting them to participate in the study.

9.3 Participant Characteristics and Matching
Participant Characteristics
In total, 84 boys were recruited as participants in the study, of which 25 met criteria for
ADHD-PI, 27 for ADHD-C and 32 were non-clinical controls. However, six
participants (three participants from each ADHD group) were excluded from the study
because they had a comorbid diagnosis of Autism Spectrum Disorder or Asperger’s
Syndrome. This exclusion criterion has been adopted in numerous large-scale studies
involving participants with ADHD (Hay, McStephen, Levy, & Pearsall-Jones, 2002;
Hinshaw et al., 1997). In addition, two participants from the ADHD-PI, four from the
ADHD-C and 12 from the Control groups were excluded because a matched triple
(based on age, IQ, and medication status) could not be formed with other participants.

The final sample consisted of 20 boys in each group (ADHD-PI, ADHD-C, Control),
forming 20 matched triples. Similar sample sizes have been used in a number of studies
(e.g., Collings, 2003; Lahey, Schaugency, Strauss & Frame, 1984; Lockwood, Marcotte, & Stern, 2001; Zago et al., 2008) also investigating ADHD subtype differences in attention and memory. The participants in the current study ranged in age from 7 to 16 years old (M = 11.80, SD = 2.24), with a mean age of 11.9 years (SD = 2.43) for ADHD-PI, 11.8 years (SD = 2.29) for ADHD-C, and 11.6 years (SD = 2.10) for the Control group. Intellectual quotient was estimated using the Standard Progressive Matrices (SPM; Raven, Raven & Court, 1998), which reflects Spearman’s g factor of intelligence. In the current sample IQ ranged from 75 to 125 (M = 101.80, SD = 13.05), with a mean IQ of 100.5 points (SD = 13.76) for ADHD-PI, 101.0 points (SD = 13.29) for ADHD-C, and 103.9 points (SD = 12.49) for the Control group. Twenty-six boys (13 boys in each of the ADHD-PI and ADHD-C groups) had received a formal diagnosis of ADHD in the final sample, whereas 14 boys (7 in each ADHD group) had a provisional diagnosis of ADHD.

The majority (95%) of participants lived in Canberra or Queanbeyan, with 5% of participants living in surrounding rural areas. Fifty-eight percent of participants lived in households in which their parents were married, 13% in which their parents were in a defacto relationship, and 29% in a single-parent household. Approximately half (56%) of the participants’ parents worked full-time, 26% part-time, and 18% were homemakers or not looking for work. The percentages of current marital and employment status for each group are presented in Table 9.1. While these percentages across groups do not appear to differ greatly, the lowest expected frequency per cell assumption for a chi-squared analysis was violated due to the low number of participants in each group so that these differences could not be tested statistically (Tabachnick & Fidell, 2007). In addition, socio-economic status was assessed using the Daniel’s (1983) Prestige Scale. Participants were assigned scores according to their parents’ occupation/s, where lower scores indicated higher social status or prestige. Using a Paired-Samples T-test no significant differences in prestige scores were found between groups.
Table 9.1: Socio-economic Characteristics of the ADHD-PI, ADHD-C and Control Groups

<table>
<thead>
<tr>
<th>Marital Status (%)</th>
<th>ADHD-PI</th>
<th>ADHD-C</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married</td>
<td>65</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Defacto</td>
<td>10</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Single</td>
<td>25</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current Employment Status (%)</th>
<th>ADHD-PI</th>
<th>ADHD-C</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time</td>
<td>53</td>
<td>60</td>
<td>53</td>
</tr>
<tr>
<td>Part-time</td>
<td>27</td>
<td>25</td>
<td>27</td>
</tr>
<tr>
<td>Not Working</td>
<td>20</td>
<td>15</td>
<td>20</td>
</tr>
</tbody>
</table>

Daniel’s (1983) Prestige Scale (1-7)

<table>
<thead>
<tr>
<th>Mean (SD)</th>
<th>ADHD-PI</th>
<th>ADHD-C</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.9 (.64)</td>
<td>3.8 (1.17)</td>
<td>3.5 (.83)</td>
<td></td>
</tr>
</tbody>
</table>

For the ADHD groups, 95% of parents of participants in the ADHD-PI group and 85% in the ADHD-C group indicated that their children had a degree of ADHD at the two highest ratings (somewhat and very much so) on a four point scale. Parents of participants who were rated as having ADHD to a little extent were contacted to clarify their child’s ADHD status, as well as conducting classroom observations of these children. Only children for whom multiple sources of information indicated that they had ADHD were included in the study. Eighty-five percent of participants in the control group were rated as having ADHD not at all on the same four point scale. For participants that received a higher rating, their parents and teachers were consulted and a school observation conducted to rule out ADHD.

Where provided, professional diagnoses which specified ADHD subtype were used to assign participants to groups. For participants whose parents did not specify an ADHD subtype, the ADHD Rating Scale-IV-Home Version (DuPaul, Power, Anastopolous & Reid, 1998) was used to classify participants into the ADHD-PI or ADHD-C groups. Parents rated on this four-point rating scale of 0 (rarely/never) to 3 (very often) the frequency at which participants displayed each ADHD symptom, based on the DSM-IV criteria, over the past 6 months. Inattention and Hyperactivity/Impulsivity scores were computed and converted into percentiles using DuPaul et al.’s (1998) normative data. Table 9.2 displays the mean Inattention and Hyperactivity/Impulsivity percentiles for each group.
Table 9.2: Inattention and Hyperactivity/Impulsivity Percentiles for the ADHD-PI, ADHD-C and Control Groups (means with standard deviations in parentheses)

<table>
<thead>
<tr>
<th></th>
<th>ADHD-PI</th>
<th>ADHD-C</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inattention</td>
<td>88.5 (14.82)</td>
<td>94.5 (5.41)</td>
<td>49.5 (24.36)</td>
</tr>
<tr>
<td>Hyperactivity/Impulsivity</td>
<td>61.9 (24.88)</td>
<td>90.4 (9.92)</td>
<td>41.7 (20.44)</td>
</tr>
</tbody>
</table>

Participants were classified as having ADHD if their parent ratings were at or above the 80th percentile on the Inattention subscale. Furthermore, ADHD subtypes were differentiated by participants’ parent ratings on the Hyperactivity/Impulsivity subscale, whereby scores at or above the 90th percentile indicated membership to the ADHD-C subtype. DuPaul et al. (1998) and Power et al. (1998) found these criteria to be the best for discriminating children with ADHD-C from ADHD-PI. For the two participants with ADHD whose scores on the ADHD Rating Scale-IV did not allow straightforward allocation to a particular subtype group, clinical judgement and additional information (i.e., school report cards, parent and teacher interviews, and classroom observations) was used to classify their subtype membership. This method of assessment is consistent with that suggested by Stefanatos and Baron (2007) who recommend using other sources of information in addition to behavioural rating scales when diagnosing ADHD.

Significant differences, using a Bonferroni adjustment ($\alpha = 0.017$), were found for both the ADHD-PI ($t = 6.85, p < .001$) and ADHD-C ($t = 8.00, p < .001$) groups when compared to the control group on Inattention. In addition, significant differences in Hyperactivity/Impulsivity were also present between the ADHD-PI and ADHD-C groups ($t = -5.48, p < .001$), and the ADHD-C and Control groups ($t = 9.29, p < .001$). The ADHD-PI and Control groups were not significantly different, using a Bonferroni adjustment, on Hyperactivity/Impulsivity ($t = -5.48, p = .027$).

Both ADHD groups had received diagnoses of ADHD from one to six different types of professionals, with an average of 3.05 (SD = 1) for the ADHD-PI group and 3.55 (SD = 1.36) for the ADHD-C group. Seventy-eight percent received a diagnosis from a Psychologist (including the 15 cases diagnosed by the researcher), 48% from a GP, and 53% from a Paediatrician. Other diagnoses were provided by psychiatrists (n = 1), neuropsychologist (n = 1), school counsellors (n = 26), teachers (n = 26), and others (n = 6).
Sixty percent of ADHD-PI group (n = 12) and 55% of ADHD-C group (n = 11) had taken medication for their ADHD prior to their involvement in this study. At the time of task administration nine participants from the ADHD-PI group and also from the ADHD-C group were currently taking medication. In the ADHD-PI group 44% were taking Ritalin (n = 4) with an average dosage of 35mg/day (SD = 7.64), 22% were taking Dexamphetamine (n = 2) with an average dosage of 25mg/day (SD = 5), and 33% were taking Concerta (n = 3) with an average dosage of 27.3mg/day (SD = 8.67). Fifty-six percent of participants in the ADHD-C group were taking Ritalin (n = 5) with an average dosage of 44mg/day (SD = 9.80), 33% were taking Dexamphetamine (n = 3) with an average dosage of 13.3mg/day (SD = 1.67), and one participant was taking Concerta with a dosage of 36mg/day.

Thirty-five percent and 10% of participants in the ADHD-PI and ADHD-C groups, respectively, had been diagnosed with a Learning Disorder. None of the control participants had received such a diagnosis. In addition, 55% of ADHD-PI, 50% of ADHD-C, and 25% of control participants had been referred for special tutoring at some time during their schooling.

**Participant Matching**
Participants were matched across groups in a four-step procedure. Firstly, clinical participants were assigned to the ADHD-PI or ADHD-C groups based on a professional diagnosis which specified their ADHD subtype. In the absence of such ADHD subtype specification participant scores on the ADHD-RS-IV completed by their parents were used. Within these groups, participants were further divided according to their current medication status (i.e., currently taking medication at the time of testing or not taking any medication). This grouping was necessary, as participants were not required to discontinue taking medication in order to participate in this study. Participants in the ADHD-PI group were then matched to their counterparts in the ADHD-C group based on current medication status, age and IQ. Lastly, a control participant was matched on age and IQ with each pair of participants with ADHD.

The matched triples had a maximum age difference of two years with an average difference of 0.6 years (SD = 0.45), and a difference of maximum 20 IQ points, as estimated using the Standard Progressive Matrices, with an average difference of 5.5
(SD = 5.56). Both age and SPM were normally distributed. All t-values between groups on age and IQ were less than 2.2 with a lowest p-value of .043, and no significant differences in either characteristic were found between groups, using a Bonferroni adjustment (α = .017).

9.4 Measures:

The Diagnostic Questionnaire (contained in Appendix C) was completed by parents of children who had not yet received a formal diagnosis of ADHD. This questionnaire was developed for the present study covered all criteria, as specified in the DSM-IV-TR, necessary for an ADHD diagnosis to be made (i.e., age of onset, persistence of behaviour across time and settings, and impairment). In addition, questions were included relating to the child’s medical and developmental history, consultations with health professionals, medication prescriptions, communications from the school expressing concern about the child’s learning, and difficulties experienced completing homework. The Child Behaviour Checklist (Achenbach, 2001) was also included as part of the diagnostic questionnaire to aid diagnosis by obtaining a thorough clinical picture of the child’s socio-emotional profile.

To ensure the exclusion of participants with autism spectrum disorders from the current study, items related to key diagnostic symptoms of such disorders (i.e., social impairment, restricted and stereotyped behaviours, interests and activities) were analysed. Parents were contacted to clarify their responses, where symptoms of autism spectrum disorders were indicated, and participants were excluded if enough evidence was present to suggest they met criteria for such disorders.

Participant Matching Measures

The ADHD Rating Scale – IV (ADHD-RS-IV; DuPaul, Power, Anastpolous & Reid, 1998). The ADHD-RS-IV (contained in the Parent Questionnaire presented in Appendix D) is an 18-item questionnaire in which parents rated the frequency at which participants displayed ADHD symptoms over the past 6 months. The ADHD-RS-IV has been used to assess ADHD symptomatology in a multitude of studies (Greenhill et al., 2006; Power, Costigan, Leff, Eiraldi & Landau, 2001; Simonsen & Bullis, 2007). In addition, Collett, Ohan and Myers (2003) report that the ADHD-RS-IV has solid psychometric properties, which makes it highly useful with clinical samples.
The Standard Progressive Matrices (SPM; Raven, Raven & Court, 1998). The SPM is a test of educative ability, which is the ability to forge new insights, to discern meaning in confusion, and to perceive and to identify relationships. Furthermore, the SPM is one of the best single measures of g or general intelligence (Carpenter, Just & Shell, 1990; Pind, Gunnarsdottir & Johannesson, 2003). The SPM has been used in over 2,500 published studies and is widely applied in educational, clinical, and occupational settings (Raven et al., 1998). In addition, the SPM offers Australian norms for children and adolescents.

The SPM consists of 60 items that require participants to choose out of six to eight options a piece that correctly completes the pattern. These items are divided into five sets of 12 items each, which become progressively harder within each set. No time limit was given to participants. The total number of items correct was computed to derive a Total SPM Score, which was converted to a scaled score when compared to the norms for the participant’s age group.

Psychosocial Functioning Measures

The Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). The SDQ (contained in the Parent Questionnaire presented in Appendix D) is a 25 item questionnaire covering five domains: emotional symptoms, conduct problems, hyperactivity, peer problems, and prosocial behaviour. Participants and their parent(s), separately, rated on a 3-point scale how true each of the items were about the participant. Participants’ scores on the five domains were computed and compared to the norms established by Mellor (2005) for Australian children of the same age group.

The SDQ was chosen as a measure of psychosocial functioning in the current study for a number of reasons. Firstly, the SDQ contains subscales that assess key domains of psychosocial functioning, which includes: internalising symptoms (SDQ Emotional Symptoms subscale), externalising symptoms (SDQ Conduct Problems subscale), and social functioning (SDQ Peer Problems and SDQ Prosocial subscales). Secondly, the SDQ uses 25 items to assess these key domains of psychosocial functioning, which is considerably briefer than other psychosocial rating scales (e.g., Child Behaviour Checklist, Behavioural Assessment System for Children) that contain 120 – 160 items. In addition to the SDQ, parents are required to complete the Parent Questionnaire which
contains questions that relate to demographic and clinical information as well as the ADHD Rating Scale – IV. The brevity of the SDQ is a key reason for its selection as a study measure, so as to lower the time demands on parents agreeing for their child to participate in this study. Thirdly, Hawes and Dadds (2004) found the SDQ (Australian Version) to have sound psychometric properties, including moderate to strong internal reliability across all SDQ subscales and sound external validity in comparison to similar scales. And furthermore, these psychometric properties were comparable to those of the other more lengthy psychosocial rating scales (e.g., Child Behaviour Checklist). Lastly, the SDQ has been used in large-scale population studies based in Australia, including the National Survey of Mental Health and Well-Being – Child and Adolescent component (Sawyer, et al., 2001) and the Western Australian Aboriginal Child Health Survey (Blair, Zubrick & Cox, 2005).

Attention Tests

*Test of Everyday Attention for Children* (TEA-Ch; Manly, Robertson, Anderson & Nimmo-Smith, 1999). The TEA-Ch is a standardised and normed clinical battery assessing different forms of children’s attention. The TEA-Ch is based on Posner and Peterson’s (1990) theory which posited that there was good evidence for at least three attentional systems in the brain: selective attention, sustained attention, and attentional control/switching. Thus, each of its nine subtests provides separate measures of these forms of attention.

The TEA-Ch was chosen to assess the different forms of attention in the current study for a number of reasons. Firstly, the TEA-Ch is presented in a game-like format and was designed to minimise the demands on other brain systems, for example memory, verbal ability and motor speed (Manly et al., 2001). Secondly, unlike other laboratory measures of attention which have very little relevance to the types of attention used in everyday life, the TEA-Ch uses tasks of real-world activities children are likely to complete to assess each type of attention. Two examples of such TEA-Ch tasks include searching a map for places to eat and counting scoring sounds in a computer game. A more detailed description of each TEA-Ch task is presented below. Thirdly, good test-retest reliability (Manly et al., 1999) and convergent validity between the TEA-Ch subtests and other measures of attention has been reported (Manly et al., 2001; Verstraeten, Vasey, Claes & Bijttebier, 2010). Furthermore, the TEA-Ch has been used in a number of research studies (e.g., Geurts, et al., 2005; Heaton et al., 2002; Hood,
Baird, Rankin, & Isaacs, 2005; Sutcliffe, et al., 2006) to assess attention in children and adolescents aged 6–16 years, with and without ADHD, and offers Australian norms.

The present study used eight of the nine TEA-Ch subtests, which was comprised of two selective attention tasks, four sustained attention tasks, and two attentional control/switching tasks. Each subtest used is briefly described below. The Sky Search DT subtest was not used in the current study because it was the only subtest with a divided attention component, which was not a type of attention included in Posner and Peterson’s (1990) conceptualisation of attention.

Selective Attention Tasks

Sky Search. Participants were presented with an A3 sheet filled with rows of paired spacecraft, and instructed to find all the target pairs whilst ignoring all the distracter pairs. Both accuracy and completion time were emphasised and a time per target score was calculated. In the Motor Control component of this subtest, participants were given a similar A3 sheet, but with no distracters present. A motor control time per target score was calculated and an attention score was computed by subtracting the motor control score from the first time by target score.

Map Mission. Participants were instructed to find as many target symbols distributed across a map containing distracter symbols as they could in 1 minute. The outcome measure of this subtest was number of target symbols found.

Sustained Attention Tasks

Score! Participants were required to count the number of scoring sounds (without using their fingers) presented on a tape. Participants played 10 games in which 9 to 15 sounds were presented, with interstimulus intervals of varied duration. The number of games correct was the outcome measure.

Score DT. This subtest was presented to participants in a similar manner to the Score! subtest. However, in addition to counting the number of scoring sounds, participants were instructed to simultaneously listen for an animal’s name in a news broadcast. Participants played 10 games in this subtest and scored a point each for identifying the correct animal and the correct number of sounds presented.
Walk Don’t Walk. Participants were instructed to take a step along a path, by making a mark for each step, after they hear a certain tone (go tone) sounded on the tape. When another, slightly different, tone (no-go tone) is sounded participants were required to withhold their response. Participants complete 20 games in this subtest and the number of correct games (i.e., participants withheld their response on the no-go tone) constituted the final score.

Code Transmission. In this subtest participants were required to listen to a stream of monotonous digits presented on tape for a code (e.g., 5-5) and on hearing this code they must identify the number that came just before it. This code was presented 40 times during this 12-minute task, and the final score is the total of correctly identified numbers.

Attentional Control/Switching Tasks

Creature Counting. This subtest required participants to count the creatures in the burrows, running from the top to bottom of the page. Interspersed with these creatures in their burrows were arrows indicating when participants needed to switch between counting upwards and counting downwards. Time and accuracy were scored in the seven games. If three or more items were correct a Timing Score was calculated by dividing the time taken to complete all correct games by the number of switches within those games.

Opposite Worlds. This subtest is composed of two parts: the Same World and the Opposite World. In the Same World participants are required to read aloud the digits “1” and “2” scattered along a path as quickly as possible. In the Opposite World part of this subtest participants again followed the path, but this time whenever they saw a “1” they were to say “two” and vice versa. Participants completed two games each of the Same World and Opposite World, and the time taken to complete each game was recorded. The Same World score was computed by summing the times recorded for the two Same World games; likewise, the Opposite World score was obtained using the times of the two Opposite World games.

Memory Tests

Three memory tests were administered to participants as part of the study. These tests included a Digit Span subtest, a Category Exemplar Generation task, and a Category
Cued Response task, which assessed working memory, implicit memory, and explicit memory, respectively.

Working Memory

*Digit Span.* The Digit Span subtest of the Wechsler Intelligence Scale for Children- III (WISC-III; Wechsler, 1991) was used to assess working memory. This subtest is composed of two parts: Digits Forward and Digits Backward. Digits Forward required participants to repeat in the same order a series of digits read aloud by the researcher, whereas participants were required to repeat the digits in the reverse order in Digits Backward. The number of digits varied from two digits being presented in the two trials of Item 1 to nine digits presented in the trials of Item 8 for Digits Forward and eight digits in Item 7 for Digits Backward. In order to ensure adequate time had elapsed between the encoding and test phases of the other memory tasks, all participants attempted both trials of the seven digit sequence in Digits Forward and the five digit sequence in Digits Backward. Tasks were discontinued when participants got both trials of any item incorrect thereafter. Participants were awarded 1 mark for each correct trial and the Digits Forward score and Digits Backward score was calculated by summing all marks on the task. The Digit Span score was calculated by adding the Digits Forward and Digits Backward scores. A scaled Digit Span score was obtained by comparing this Digit Span score to the normative data for children of a similar age.

The Digit Span subtest is a reliable and valid measure of working memory in children (Perugini, Harvey, Lovejoy, Sandstrom & Webb, 2000). In addition, this subtest has been widely used to assess working memory in non-clinical and ADHD samples (Schmitz et al., 2002; Seidman et al., 1997; Wu, et al., 2002)

Implicit and Explicit Memory

The *Category Exemplar Generation* task (CEG) and the *Category Cued Recall* Task (CCR). The CEG and CCR were used in the current study as tests of implicit and explicit memory, respectively. These tasks were chosen for use for a number of reasons. Firstly, both the encoding and test phases of the implicit and explicit memory tasks involved the conceptual processing of stimuli. This was important because conceptual processing of information is more likely to be involved in classroom learning. Secondly, the encoding phase for both tasks was identical and the tasks were matched in all respects, with the exception of retrieval instructions given for the test phase. This close
matching ensured that the same type of processing was involved in both tasks. This assurance would not have been achieved if more standardised measures of children’s memory (e.g., Children’s Memory Scale; Wide Range Assessment of Memory and Learning) had been used, because these measures only contained explicit subtests with no equivalent test of implicit memory. Thirdly, the CEG and CCR tasks were chosen because they were used previously in research conducted by Murphy et al. (2003) and Clapham (2006), with both studies indicating that these tasks were appropriate for use with children and adolescents with ADHD and Controls.

*Stimuli selection for CEG and CCR.* Fifty-two target items, comprising of two atypical exemplars from 26 common semantic categories were chosen. These categories, along with their corresponding exemplars, were divided into two sets, such that each set contained 13 categories and 26 exemplars. These sets served as the target stimuli for the CEG and CCR, and were counterbalanced whereby for half of the participants Set One was the stimuli for the CEG and Set Two for the CCR, and vice versa for the other half of participants.

Within each set, two lists (i.e., List A and List B) were created, each containing one exemplar from each category. For the CEG, one of these lists served as the primed (studied) items which were presented in the encoding phase of the task, whereas the other list was the unstudied items that were identified in participant’s responses, if present, during the CEG test phase. Similarly, these lists were counterbalanced.

The counterbalancing of Set One with Set Two, and List A with List B yielded 8 different stimuli sets, as displayed in Table 9.3.
Table 9.3: Counterbalancing of Stimuli Sets for the Explicit and Implicit Memory Tasks

<table>
<thead>
<tr>
<th>Stimuli Set</th>
<th>CEG Task</th>
<th>CCR Task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Set</td>
<td>List</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
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<td>A</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>B</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>B</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>B</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>B</td>
</tr>
</tbody>
</table>

The current study employed the same categories and exemplars as was used by Murphy et al. (2003) and Clapham (2006). These studies obtained the stimuli from two sources. Firstly, 20 categories and the corresponding 40 exemplars were generated from Posnansky’s (1978) and Battig and Montague’s (1969) category norms. These norms allowed category generation strength to be estimated, which Murphy et al. (2003) defined as the percentage of participants who produce a given exemplar in response to a given category name. Secondly, six categories and their 12 exemplars were generated from Van Overschelde, Rawson, and Dunlosky’s (2004) category norms. The degree of atypicality between lists was matched as closely as possible.

Twenty-six filler items which were not exemplars of any target category were used. Thirteen of these filler items were assigned to Set One, and the remaining items to Set Two. Hence, in the CEG and CCR participants were presented with a study list containing 13 target items and 13 filler items.

*Category Exemplar Generation task (CEG).* The CEG consisted of two phases: the encoding phase and test phase. During the encoding phase participants were read the study list containing target and filler items, and asked to repeat each word. Following each word, participants were asked a question relating to the word’s category membership, which they answered “yes” or “no”. The correct response to target items was always a positive category membership. In the test phase, participants were asked to generate the first five words that came to mind belonging to a particular category.
The researcher presented a list of categories containing 13 target categories, as presented in the encoding phase, and 13 filler categories.

Three scores were computed for the CEG task: studied items score; unstudied items score; and absolute priming score. The number of studied target items present in the participant’s responses during the test phase was computed to obtain a studied items score. The unstudied items score was calculated by identifying in the participant’s responses the number of target items that had not been presented in the encoding phase. The absolute priming score was computed by subtracting the unstudied item score from the studied item score.

*Category Cued Response task (CCR).* The CCR also consisted of two phases, with the encoding phase being identical to that presented in the CEG. In the test phase, participants were presented with only the 13 target categories and asked to recall the target item that belonged to that category. The cued recall score was the number of studied exemplars present in the participant’s responses.

### 9.5 Procedure

Written parental consent for the study was obtained before tasks were administered to the participants, and relevant questionnaires distributed to parents. All participants were individually administered the tasks by the researcher. Task administration took place in a small, quiet room in which all distractions were minimised either at the participant’s school or at the Department of Psychology of the Australian National University.

Participants were administered tasks over two sessions, with each session lasting between one to one and a half hours. The two sessions were separated by approximately one week break to ensure adequate time elapsed between the administration of the CEG and CCR. Tasks were also administered over two sessions to minimise the effects of fatigue and to ensure participants were motivated to complete tasks to the best of their ability. In addition, participants were allowed to take a break and/or to play games approximately half-way through each session. Verbal praise and stickers were given to participants for “trying really hard” in between tasks.
Session One

Session One commenced with the researcher introducing herself to the participants and addressing any questions or concerns the participant had. A get-to-know-you exercise was then played to establish rapport.

The *Encoding Phase of the CEG task* was administered by instructing participants: “I am going to read some words. After I say the word I want you to say it back to me. Then I’m going to ask you a question about the word and I’d like you to answer it”. The researcher then proceeded to read an item from the list (e.g., “lips”), waited for the participant to repeat, and then asked the participant a question about the item (e.g., “Is that a body part?”) which they were required to answer “Yes” or “No”.

The *Digit Span Forward task* was then administered to participants to measure working memory, but also as a distracter task between the CEG encoding and test phases. Participants were given the instructions verbatim, as specified in the WISC-III Administration and Scoring Manual (Wechsler, 1991). Both trials of each Item starting with Item 1 were then administered.

Participants were then administered the *Test Phase of the CEG task*. The following instructions were given to participants: “I’m going to name some categories, or groups, and I’d like you to name the first five things you can think of that belong to that group or category. It doesn’t matter what answers you give as long as they are the first five you can think of” Participants were given one practice (e.g., “If I said ‘types of lollies’ you would say...”), then the 26 categories were read. All responses were recorded verbatim.

Seven of the nine subtests of the *TEA-Ch* were administered to participants. The verbatim instructions as specified in the TEA-Ch Administration and Scoring Manual (Manly et al., 1999) were given to participants.

Session One concluded with the researcher playing a short game with participants and thanking them for their hard work on the tasks. In addition, the time for the next session was arranged, which was scheduled for the week following Session One.
Session Two

Session Two commenced with the researcher chatting with participants on how their past week was and answering any questions. The researcher then provided participants with instructions from the Standard Progressive Matrices Manual. Participants completed Problems A1 and A2, and feedback was given on their responses. Participants were then allowed to work through the booklet of problems. To ensure that participants attention was maintained during the lengthy SPM task, the researcher redirected participants back to the test if they were observed to be distracted.

During the Encoding Phase of the CCR task identical instructions were given to participants as provided during the Encoding Phase of the CEG task. For the Digit Backward task participants were told the researcher would “say some numbers, but this time when I stop, I want you to say them backward”. Participants were provided with two examples and feedback was given. The test trials were then administered until the discontinue criterion was met.

In the Test Phase of the CCR task participants were instructed to “think back to the words that you repeated and answered questions about. I am going to say the name of a group or category and I’d like you to try and think of a word from that list that belongs to it”. Any questions participants had were answered and then the target categories were administered.

For the Code Transmission subtest of the TEA-Ch participants were provided with the instructions for the task, as specified in the TEA-Ch Administration and Scoring Manual (Manly et al., 1999). Session Two concluded with the research playing a short game with participants and thanking them for their hard work on the tasks.
Chapter 10: Results

10.1 Statistical Analyses

The results of the study are presented according to the research questions outlined in Chapter 8. The data were screened and distributions checked. No data were deemed to be in need of transformation. All analyses were conducted using SPSS 18 for Windows. A Bonferroni-type adjustment was made, such that $\alpha = 0.017$ was set as the significance level to test each hypothesis (Tabachnick & Fidell, 2007) because within each research question three planned comparisons were made between each pair of groups.

Firstly, to check the representativeness of the groups in the study and further explore their psychosocial functioning, comparisons were made between groups using a series of Paired Samples t-tests.

Secondly, hypotheses pertaining to differences in attention between groups were tested. Planned comparisons were made between groups on the different type of attention, as measured by participant performance on the TEA-Ch subtests, using Paired Samples T-tests. Correlations were run to examine the relationship between TEA-Ch subtests purported by Manly et al. (1999) to assess the same type of attention. In addition, the differences on TEA-Ch subtest performance between children on- versus off-medication within each ADHD subtype were assessed using ANCOVAs.

Thirdly, group differences between groups in their performance on the memory tasks were tested. The same procedure for analyses of attention measures was used for memory measures.

Whilst participants were matched between groups as closely as possible on age and IQ some matches still had larger differences than are considered ideal. Hence, ANCOVAs with age and IQ as covariates were computed. Overall there results obtained using the Paired Samples t-tests compared to the ANCOVAs for attention and memory measures were very similar with minor discrepancies between results. The results of these analyses are presented in Appendix E for interested readers.
Following these comparisons, a discriminant analysis was conducted for all 60 participants to identify the pattern of attention and memory measures that best separated the ADHD groups from controls, and the ADHD-PI from ADHD-C groups.

10.2 Research Question 1

*Do the ADHD-PI and ADHD-C groups have significantly higher problems in their psychosocial functioning compared to Control participants and, if so, do these problems differ between ADHD subtypes?*

Both parents and participants completed the Strengths and Difficulties Questionnaire, which measures psychosocial functioning. Comparisons between groups on each SDQ subscale for parents and child ratings are considered separately. The results of these comparisons are presented in Table 10.1. In addition, as a further analysis of the representativeness of the sample, ratings for each group were compared to normative data for the SDQ in Australia (Mellor, 2005). These data provided three levels of scores for each subscale: normal, borderline (top 20%), and abnormal (top 10%).

**Emotional Symptoms**

The results of comparisons between groups on the Emotional Symptoms subscale were similar across raters. Both parent \((t = 3.64, p = .002)\) and child \((t = 4.10, p = .001)\) ratings for the ADHD-PI group were significantly higher when compared to controls. No other group comparisons for Emotional Symptoms were significant.

When compared to Mellor’s (2005) normative data, participants in the ADHD-PI were rated, on average, at the borderline level for Emotional Symptoms, regardless of rater type. Only parent ratings for the ADHD-C group were, on average, at the borderline level. Both parent and child ratings for the Control group were in the normal range.

Both parent \((t = 3.09, p = .006)\) and child \((t = 4.14, p = .001)\) ratings of the ADHD-PI group were significantly higher compared to controls on the combination of the three anxiety items on the SDQ Emotional Symptoms subscale. In addition, children with ADHD-PI rated themselves as significantly higher compared to their ADHD-C counterparts on the combined anxiety items \((t = 2.62, p = .017)\). For the depression item, the ADHD-PI group compared to controls received higher parent \((t = 2.65, p = .016)\) and child \((t = 2.67, p = .015)\) ratings.
Table 10.1:
Mean, SD and Group Comparisons on the SDQ Subscales for the ADHD-PI, ADHD-C, and Control Groups.

<table>
<thead>
<tr>
<th></th>
<th>ADHD-PI</th>
<th>ADHD-C</th>
<th>Controls</th>
<th>Comparisons</th>
<th>t</th>
<th>Sig</th>
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<td>n.s</td>
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<td>(1.88)</td>
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<td>3.64</td>
<td>.002</td>
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<td>n.s</td>
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<td>(1.81)</td>
<td>ADHD-PI v Controls</td>
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<td>.001</td>
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<td>1.60</td>
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<td>.002</td>
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<td></td>
<td>(2.02)</td>
<td>(2.12)</td>
<td>(1.54)</td>
<td>ADHD-PI v Controls</td>
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<td>n.s</td>
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<td></td>
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<td></td>
<td></td>
<td>ADHD-C v Controls</td>
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<td>.000</td>
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<td>3.60</td>
<td>1.85</td>
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<td></td>
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<td>(2.09)</td>
<td>(1.39)</td>
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<td>.017</td>
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<td>(1.50)</td>
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<td>(1.42)</td>
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<td></td>
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<td>1.75</td>
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<td>ADHD-PI v Controls</td>
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<td>ADHD-C v Controls</td>
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<td>.000</td>
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<td>ADHD-PI v Controls</td>
<td>ADHD-C v Controls</td>
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<td>1.67</td>
<td>1.89 n.s</td>
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</tr>
<tr>
<td>1.51</td>
<td>(1.14)</td>
<td>(1.67)</td>
<td>n.s</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Prosocial:**

<table>
<thead>
<tr>
<th>Parent ratings</th>
<th>ADHD-PI v ADHD-C</th>
<th>ADHD-PI v Controls</th>
<th>ADHD-C v Controls</th>
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<tr>
<td>7.80</td>
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<td>1.97 n.s</td>
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<td>1.69 n.s</td>
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<tr>
<td>8.65</td>
<td>(1.14)</td>
<td>(1.14)</td>
<td>3.51 .002</td>
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**Total Difficulties:**

<table>
<thead>
<tr>
<th>Parent ratings</th>
<th>ADHD-PI v ADHD-C</th>
<th>ADHD-PI v Controls</th>
<th>ADHD-C v Controls</th>
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<tbody>
<tr>
<td>15.70</td>
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<td>2.14 n.s</td>
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<tr>
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<td>5.18</td>
<td>3.57</td>
<td>4.52 .000</td>
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<tr>
<td>8.65</td>
<td>(3.57)</td>
<td>(3.57)</td>
<td>8.75 .000</td>
</tr>
</tbody>
</table>

Conduct Problems

The ADHD-C group had a significantly higher Conduct Problems score when compared to controls based on both parent ($t = 5.15, p < .001$) and self ($t = 2.83, p = .011$) ratings. In addition, parents rated children in the ADHD-C group significantly higher than their ADHD-PI counterparts on the Conduct Problems scale. There were no other significant group comparisons.

Only parent ratings of Conduct Problems for the ADHD-C group were at the abnormal level. All other parent and child ratings across groups were in the normal range.

Hyperactivity

Both ADHD-PI ($t = 4.69, p < .001$) and ADHD-C ($t = 10.02, p < .001$) groups were significantly elevated on parent ratings for Hyperactivity relative to controls. Similar results were found for child ratings on the Hyperactivity subscale between ADHD-PI
and control participants \( (t = 4.12, p = .001) \), and ADHD-C and Controls groups \( (t = 5.26, p < .001) \). The ADHD groups differed significantly only on parent ratings, whereby participants with ADHD-C were rated as displaying significantly more Hyperactivity than their ADHD-PI counterparts.

The parent ratings for Hyperactivity were, on average, at the borderline level for the ADHD-PI group and at the abnormal level for the ADHD-C group. All child ratings and scores for the Control group were, on average, in the normal range.

**Peer Problems**
Only participants with ADHD-C received significantly higher parent ratings on the Peer Problems subscale relative to controls \( (t = 4.22, p < .001) \). No other group comparisons were significant for either parent or child ratings.

Likewise, only parents of the ADHD-C group rated their children as having, on average, Peer Problems at the borderline level. All other ratings were in the normal range.

On the preference for solitary activities item, the ADHD-C group received higher parent rating than control participants \( (t = 2.13, p = .045) \), whereas the ADHD-PI group rated themselves as higher than controls \( (t = 2.33, p = .031) \). Both these difference between groups approached significance.

**Prosocial**
Similarly to peer problems, parents rated only the ADHD-C group as having significantly lower levels of Prosocial behaviour compared to controls \( (t = 3.51, p = .002) \). No child ratings or other group comparisons were significant.

Only the ADHD-C group received, on average, parent ratings on the Prosocial subscale at the abnormal level. All other ratings were at the normal level.

**Total Difficulties**
Compared to controls, both the ADHD-PI \( (t = 4.52, p < .001) \) and ADHD-C \( (t = 8.75, p < .001) \) groups were rated by parents as having significantly higher Total Difficulties. Similarly, both ADHD-PI \( (t = 4.92, p < .001) \) and ADHD-C \( (t = 4.88, p < .001) \) participants rated themselves significantly higher on the Total Difficulties subscale.
compared to controls. No significant ADHD subtype differences were found for parent or child ratings.

The ADHD-PI group was rated, on average, at the borderline level for both parent and child ratings. By comparison, parents rated the ADHD-C, on average, at the abnormal level on the Total Difficulties subscale. Control group comparisons to Mellor’s (2005) normative data were, on average, in the normal range.

**10.3 Research Question 2**

Do specific deficits in selective attention, sustained attention, and/or attentional control/switching exist for ADHD groups relative to Controls and, if so, are the patterns of deficits between the ADHD-PI and ADHD-C groups different?

Participants were administered 8 of the 9 subtests of the Test of Everyday Attention for Children (TEA-Ch). The results of group differences on the TEA-Ch subtests are presented according to the different types of attention they assessed. Table 10.2 displays the mean and SD for the performance of each group on the subtests and the differences between groups on these measures.

**Selective Attention:**

Two TEA-CH subtests, Sky Search and Map Mission, were employed to assess selective attention. A general trend is evident, wherein controls displayed the highest performance on these subtests, followed by participants with ADHD-PI and then the ADHD-C group. No significant differences were found on either subtests between the ADHD-PI group and the other two groups. However, the ADHD-C group displayed significantly poorer performances than their Control counterparts on Sky Search ($t = 3.21, p = .005$), and approached the specified significance level for this study on Map Mission ($t = 2.17, p = .043$).

A significant correlation was found between the Sky Search and Map Mission subtests for only the ADHD-C group ($r = .458, p = .042$) and was of a medium effect size.

**Sustained Attention:**

Sustained attention was assessed using the Score!, Score DT, Walk Don’t Walk, and Code Transmission subtests of the TEA-Ch. Overall the ADHD groups performed more
Table 10.2:
Mean, SD and Group Comparisons on the TEA-Ch Subtests for the ADHD-PI, ADHD-C and Control Groups

<table>
<thead>
<tr>
<th></th>
<th>ADHD-PI</th>
<th>ADHD-C</th>
<th>Control</th>
<th>Comparisons</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Selective Attention:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sky</td>
<td>9.60</td>
<td>8.00</td>
<td>10.75</td>
<td>ADHD-PI v ADHD-C</td>
<td>1.63</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>(2.74)</td>
<td>(3.29)</td>
<td>(1.92)</td>
<td>ADHD-PI v Controls</td>
<td>1.48</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ADHD-C v Controls</td>
<td>3.21</td>
<td>.005**</td>
</tr>
<tr>
<td>Search</td>
<td>9.35</td>
<td>9.05</td>
<td>10.65</td>
<td>ADHD-PI v ADHD-C</td>
<td>.34</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>(2.60)</td>
<td>(2.96)</td>
<td>(2.76)</td>
<td>ADHD-PI v Controls</td>
<td>1.78</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ADHD-C v Controls</td>
<td>2.17</td>
<td>.043*</td>
</tr>
<tr>
<td><strong>Sustained Attention:</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Score!</td>
<td>7.60</td>
<td>8.65</td>
<td>10.20</td>
<td>ADHD-PI v ADHD-C</td>
<td>1.00</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>(3.28)</td>
<td>(3.72)</td>
<td>(2.12)</td>
<td>ADHD-PI v Controls</td>
<td>2.65</td>
<td>.016**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ADHD-C v Controls</td>
<td>1.47</td>
<td>n.s</td>
</tr>
<tr>
<td>Score</td>
<td>8.55</td>
<td>8.50</td>
<td>10.95</td>
<td>ADHD-PI v ADHD-C</td>
<td>.05</td>
<td>n.s</td>
</tr>
<tr>
<td>DT</td>
<td>(3.03)</td>
<td>(2.69)</td>
<td>(2.24)</td>
<td>ADHD-PI v Controls</td>
<td>2.73</td>
<td>.013**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ADHD-C v Controls</td>
<td>3.77</td>
<td>.001**</td>
</tr>
<tr>
<td>Walk,</td>
<td>8.15</td>
<td>7.10</td>
<td>9.75</td>
<td>ADHD-PI v ADHD-C</td>
<td>.89</td>
<td>n.s</td>
</tr>
<tr>
<td>Don’t</td>
<td>(4.59)</td>
<td>(3.11)</td>
<td>(3.51)</td>
<td>ADHD-PI v Controls</td>
<td>1.39</td>
<td>n.s</td>
</tr>
<tr>
<td>Walk</td>
<td></td>
<td></td>
<td></td>
<td>ADHD-C v Controls</td>
<td>2.29</td>
<td>.034*</td>
</tr>
<tr>
<td>Code T</td>
<td>8.00</td>
<td>7.95</td>
<td>10.55</td>
<td>ADHD-PI v ADHD-C</td>
<td>.62</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>(2.71)</td>
<td>(2.28)</td>
<td>(3.17)</td>
<td>ADHD-PI v Controls</td>
<td>3.07</td>
<td>.006**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ADHD-C v Controls</td>
<td>3.28</td>
<td>.004**</td>
</tr>
<tr>
<td><strong>Attentional Control/Switching</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creature</td>
<td>8.15</td>
<td>8.45</td>
<td>11.20</td>
<td>ADHD-PI v ADHD-C</td>
<td>.32</td>
<td>n.s</td>
</tr>
<tr>
<td>Counting</td>
<td>(3.15)</td>
<td>(3.52)</td>
<td>(1.80)</td>
<td>ADHD-PI v Controls</td>
<td>4.07</td>
<td>.001**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ADHD-C v Controls</td>
<td>3.07</td>
<td>.006**</td>
</tr>
</tbody>
</table>
poorly on sustained attention subtests relative to controls, however no general trend was evident for subtype group performance. No significant differences were found between the ADHD subtypes on any sustained attention subtest. However, the ADHD-C group displayed significantly poorer performances than their Control counterparts on the Score DT ($t = 3.77, p = .001$) and Code Transmission ($t = 3.28, p = .004$) subtests. In addition, this group comparison on the Walk Don’t Walk subtest approached significance ($t = 2.29, p = .034$). Participants in the ADHD-PI group, on average, performed significantly more poorly on the Score! ($t = 2.65, p = .016$), Score DT ($t = 2.73, p = .013$), and Code Transmission ($t = 3.07, p = .006$) subtests compared to Control participants.

Each group displayed different patterns of correlations between sustained attention measures. Significant correlations in the ADHD-PI group were found between scores on the Score and Score DT ($r = .546, p = .013$), Score and Walk Don’t Walk ($r = .469, p = .037$), Score and Code Transmission ($r = .815, p < .001$), Score DT and Walk Don’t Walk ($r = .594, p = .006$), and Score DT and Code Transmission subtests ($r = .530, p = .016$). These correlations were of a large effect size, with the exception of the correlation between the Score and Walk Don’t Walk subtests which was of a medium effect size. For the ADHD-C group, only the correlation between Score and Score DT subtests ($r = .604, p = .005$) was significant and of a large effect size. Significant correlations were found between Score DT and Walk Don’t Walk ($r = .542, p = .014$), Score DT and Code Transmission ($r = .517, p = .02$), and Walk Don’t Walk and Code Transmission subtests ($r = .586, p = .007$) for the Control group, and were again of a large effect size.
Attentional Control/Switching:
The Creature Counting and the two conditions of the Opposite World subtest assessed attentional control/switching on the TEA-Ch. In general, controls displayed better performance on these subtests relative to the ADHD groups, with the ADHD-C group scoring higher than their ADHD-PI counterparts on two of the attentional control/switching measures. However, the two ADHD groups did not differ significantly from each other on any of the attentional control/switching measures. The ADHD-PI group displayed a significantly poorer performance compared to their Control counterparts on the Creature Counting subtest \((t = 4.07, p = .001)\), Opposite World-Same World condition \((t = 4.02, p = .001)\), Opposite World-Opposite World condition \((t = 3.68, p = .002)\). Similar results of significantly poorer performances of the ADHD-C group compared to the Control group were found on the Creature Counting subtest \((t = 3.07, p = .006)\), Opposite World-Same World condition \((t = 4.97, p < .001)\) and Opposite World-Opposite World condition \((t = 4.25, p < .001)\).

Significant correlations were found between the majority of attentional control measures for all groups. For the ADHD-PI group the Creature Counting and Opposite World-Opposite World condition \((r = .476, p = .034)\), and Opposite World-Same World condition and Opposite World-Opposite World condition \((r = .848, p < .001)\) were significantly correlated, with the former comparison having a medium effect size and the latter having a large effect size. The correlations between Creature Counting and Opposite World-Same World condition \((r = .532, p = .016)\), Creature Counting and Opposite World-Opposite World condition \((r = .621, p = .003)\), and Opposite World-Same World conditions and Opposite World-Opposite World condition \((r = .854, p < .001)\) were all significant in the ADHD-C group and of large effect sizes. Significant and large correlations were found between Creature Counting and Opposite World-Same World condition \((r = .634, p = .003)\), Creature Counting and Opposite World-Opposite World condition \((r = .453, p = .045)\), and Opposite World-Same World condition and Opposite World-Opposite World condition \((r = .780, p < .001)\) for the Control group.

Medication Status and TEA-Ch Subtest Performance:
A further analysis, using Independent Sample t-tests, was conducted to examine whether current medication status was associated with participants’ performance on the attention tests. There were no significant differences in the performance of participants
in the ADHD-PI group currently taking medication compared to those not taking
treatment on any of the TEA-CH subtests. A similar pattern of results was observed
for the ADHD-C group, with the exception of the Sky Search subtest wherein the
participants with ADHD-C currently on medication performed significantly worse than
their non-medicated counterparts ($F = 12.966, p = .002$).

**10.4 Research Question 3**

Do specific deficits in working memory, explicit memory, and/or implicit memory exist
for ADHD groups relative to Controls and, if so, are the patterns of deficits different
between the ADHD-PI and ADHD-C groups?

Tests of three different types of memory were administered in the present study, the
means of which and differences between groups are displayed in Table 10.3. Two
general trends appear to show up, wherein the ADHD-C group performed more poorly
on all memory measures compared to the other two groups, and the ADHD groups
displayed poorer performance than controls on both long-term memory tests.

**Working Memory**

The two parts of the Digit Span subtest, Forward and Backward, of the WISC-III were
employed as Working Memory measures. No significant differences were found
between groups on either measure, with the exception of the ADHD-C group displaying
a significantly shorter Digit Span Forward mean score than the ADHD-PI group ($t =
2.82, p = .011$).

Significant correlations were found between the Working Memory measures only for
the ADHD-C group ($r = .692, p = .001$), which was of a large effect size.

**Explicit Memory**

The Recall score on the Category Cued Recall task was used to measure Explicit
Memory. No significant differences between groups were found on this measure.

**Implicit Memory**

Implicit Memory was assessed using the Absolute Priming score of the Category
Exemplar Generation task. No significant difference was found between groups on this
measure.
Table 10.3:
Mean, SD and Group Comparisons on the Memory Tasks for the ADHD-PI, ADHD-C and Control Groups

<table>
<thead>
<tr>
<th></th>
<th>ADHD-PI</th>
<th>ADHD-C</th>
<th>Control</th>
<th>Comparisons</th>
<th>$t$</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Working Memory:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>8.15</td>
<td>6.60</td>
<td>7.45</td>
<td>ADHD-PI v ADHD-C</td>
<td>2.82</td>
<td>.011</td>
</tr>
<tr>
<td></td>
<td>(2.25)</td>
<td>(1.43)</td>
<td>(1.99)</td>
<td>ADHD-PI v Controls</td>
<td>1.01</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ADHD-C v Controls</td>
<td>1.78</td>
<td>n.s</td>
</tr>
<tr>
<td>Digit Span Backward</td>
<td>4.30</td>
<td>3.95</td>
<td>4.30</td>
<td>ADHD-PI v ADHD-C</td>
<td>.59</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>(1.53)</td>
<td>(1.47)</td>
<td>(1.42)</td>
<td>ADHD-PI v Controls</td>
<td>0</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ADHD-C v Controls</td>
<td>.91</td>
<td>n.s</td>
</tr>
<tr>
<td><strong>Explicit Memory:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCR Recall Forward</td>
<td>9.65</td>
<td>9.45</td>
<td>10.35</td>
<td>ADHD-PI v ADHD-C</td>
<td>.32</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>(1.76)</td>
<td>(2.61)</td>
<td>(1.76)</td>
<td>ADHD-PI v Controls</td>
<td>1.44</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ADHD-C v Controls</td>
<td>1.89</td>
<td>n.s</td>
</tr>
<tr>
<td><strong>Implicit Memory:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEG Absolute Forward</td>
<td>1.65</td>
<td>1.55</td>
<td>2.25</td>
<td>ADHD-PI v ADHD-C</td>
<td>.24</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>(1.39)</td>
<td>(1.36)</td>
<td>(.91)</td>
<td>ADHD-PI v Controls</td>
<td>1.37</td>
<td>n.s</td>
</tr>
<tr>
<td>Priming Forward</td>
<td></td>
<td></td>
<td></td>
<td>ADHD-C v Controls</td>
<td>1.93</td>
<td>n.s</td>
</tr>
</tbody>
</table>

Correlations between Memory Measures
Significant and large correlations were found between the Digit Forward and Explicit Memory tasks for the ADHD-PI group ($r = .546, p = .013$), and between the Digit Backward and Explicit Memory tasks ($r = .548, p = .012$) and the Digit Backward and Implicit Memory tasks ($r = .469, p = .037$) for the Control group.

Medication Status on Memory Test Performance:
The association between medication status and memory test performance was examined using Independent Sample t-tests with each ADHD group. There were no significant differences on any memory task performance measures between participants currently on and off medication in the ADHD-PI group. However, in the ADHD-C group, participants on medication had significantly poorer performances than their off
medication counterparts on the Digit Span Forward \((F = 10.419, p = .005)\) and Backward tasks \((F = 7.199, p = .016)\).

10.5 Research Question 4

*Which combination of attention and memory tests best discriminates between the ADHD groups and controls, and between the ADHD-PI and ADHD-C group?*

A Discriminant Analysis was conducted to further describe differences between the ADHD-PI, ADHD-C and Control groups. This type of analysis was chosen because it predicts group membership on the basis of a set of characteristics (Tabachnick & Fidell, 2007). In the present study, the characteristics of particular interest were tests of attention, memory, and intelligence.

A direct discriminant analysis was performed with all nine attention measures, the four memory scores, and IQ (as estimated by the SPM score). Two discriminant functions were calculated, for the groups, with a combined \(X^2_{(28)} = 41.96, p < .05\). After removal of the first function, the association between groups and tests was no longer significant, \(X^2_{(13)} = 11.59, p > .05\). The two discriminant functions accounted for 76% and 24%, respectively, of the between-group variability. As shown in Figure 10.1 the first discriminant function maximally separates Control children from the two ADHD groups. The second discriminant function discriminates ADHD-PI from ADHD-C, with Controls falling between these two groups.

In this study a test was considered to be a good discriminator if its discriminant function coefficient was greater than +/- .50 (Tabachnick & Fidell, 2007). The loading matrix of correlations between tests and discriminant functions is presented in Table 10.4. The results suggest that the best predictors for distinguishing between Controls and the ADHD groups are the Opposite World-Same World Condition, Opposite World-Opposite World condition, and Creature Counting subtests of the TEA-Ch. As presented earlier in the Attention part of this chapter, the Controls had higher scores compared to the ADHD-PI and ADHD-C groups on these subtests of the TEA-Ch.
Two tests - Digits Forward and the Sky Search subtest - had loadings in excess of .50 on the second discriminant function, which separates ADHD-PI from the ADHD-C group. As presented previously, the ADHD-PI group had higher scores on both the Digits Forward and the Sky Search tests compared to the ADHD-C group.

On the basis of these two discriminant functions, 67% of the cases were correctly classified into one of the three groups. This was considerably greater than chance, which would correctly classify only 33% of cases. Not surprisingly controls were more likely to be correctly classified than either of the ADHD groups, as presented in Table 10.5. Interestingly, whilst 60% of participants with ADHD-PI were correctly classified, six (30%) and two (10%) of these participants were re-classified, based on the two discriminant functions, as belonging to the ADHD-C and Control groups, respectively. Similarly, 65% of the ADHD-C group were correctly classified, with the remaining three (15%) and four (20%) participants with ADHD-C were reclassified into the ADHD-PI and Control groups, respectively.
Table 10.4: Coefficients of each of the Attention and Memory Tasks on the Two Discriminant Functions

<table>
<thead>
<tr>
<th>Tests</th>
<th>Function 1</th>
<th>Function 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opposite World_SW</td>
<td>.650^</td>
<td>.117</td>
</tr>
<tr>
<td>Opposite World_OW</td>
<td>.633^</td>
<td>.219</td>
</tr>
<tr>
<td>Creature Counting</td>
<td>.529^</td>
<td>.097</td>
</tr>
<tr>
<td>Code T</td>
<td>.489</td>
<td>.184</td>
</tr>
<tr>
<td>Score DT</td>
<td>.473</td>
<td>.179</td>
</tr>
<tr>
<td>Score!</td>
<td>.378</td>
<td>-.153</td>
</tr>
<tr>
<td>CEG Absolute Priming</td>
<td>.268</td>
<td>.160</td>
</tr>
<tr>
<td>Map Mission</td>
<td>.263</td>
<td>.182</td>
</tr>
<tr>
<td>CCR Recall</td>
<td>.193</td>
<td>.148</td>
</tr>
<tr>
<td>SPM Intelligence Estimate</td>
<td>.128</td>
<td>.012</td>
</tr>
<tr>
<td>Digit Span Forwards</td>
<td>-.050</td>
<td>.660^</td>
</tr>
<tr>
<td>Sky Search</td>
<td>.325</td>
<td>.608^</td>
</tr>
<tr>
<td>Walk, Don’t Walk</td>
<td>.269</td>
<td>.326</td>
</tr>
<tr>
<td>Digit Span Backwards</td>
<td>.041</td>
<td>.214</td>
</tr>
</tbody>
</table>

^ Discriminant function coefficients greater than +/- .5

Table 10.5: Discriminant Function Classifications for the ADHD-PI, ADHD-C and Control Groups

<table>
<thead>
<tr>
<th>Original Groups</th>
<th>Number of Cases</th>
<th>Predicted Group Membership (%)</th>
<th>ADHD-PI</th>
<th>ADHD-C</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADHD-PI</td>
<td>20</td>
<td>60</td>
<td>30</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>ADHD-C</td>
<td>20</td>
<td>15</td>
<td>65</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>20</td>
<td>10</td>
<td>15</td>
<td>75</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 11: Discussion

ADHD is a complex disorder. The DSM-IV-TR (APA, 2000) distinguishes between the two most prevalent ADHD subtypes - ADHD-PI and ADHD-C - on the basis of the presence of clinically significant levels of hyperactivity-impulsivity in the latter subtype. Some differences between the ADHD subtypes have emerged from the literature pertaining to demographic and family characteristics, and psychosocial and academic functioning. In addition, the ADHD-PI and ADHD-C subtypes have been differentiated from one another in theoretical conceptualisations of ADHD, with Milich et al. (2001) asserting that ADHD subtypes are distinct and unrelated disorders. How best to conceptualise the ADHD-PI and ADHD-C subtypes continues to be a topic of debate amongst ADHD researchers.

In the classroom both the ADHD-PI and ADHD-C subtypes have been found to display problems with their learning. A few differences have emerged between the subtypes, with ADHD-PI groups reported to have poorer grades and math achievement compared to their ADHD-C counterparts. The present study examined the nature of and differences in the fundamental building blocks of learning - attention and memory - in the ADHD-PI and ADHD-C subtypes.

Four research questions were raised in the present study. The first pertained to the psychosocial functioning of the current sample, whilst the second and third questions called for the examination of attention and memory, respectively, in the ADHD-PI, ADHD-C, and Control groups. The fourth question asked which combination of attention and memory tests best discriminated between the ADHD-PI, ADHD-C, and Control groups.

11.1 Psychosocial Functioning

The first question asked whether the ADHD groups exhibited problems in their psychosocial functioning compared to controls and, if so, whether these problems differed between the ADHD subtypes. The purpose of this was firstly to investigate the psychosocial characteristics of the current sample, as psychosocial functioning can have some impact upon a child’s learning at school. And secondly to shed further light upon ADHD subtype differences in psychosocial functioning using an Australian sample of children. The present study employed the use of parent and child ratings on the six SDQ
subscales to assess psychosocial functioning. Overall, the results on these subscales were generally consistent with hypotheses.

**Internalising Symptoms and Disorders**

The present study found significantly higher mean ratings from both the parent and child raters on the Emotional Symptoms subscale of the SDQ for the ADHD-PI group relative to controls, with a similar result in parent ratings for the ADHD-C group approaching significance. When compared to Mellor’s (2005) normative data, a similar pattern was found whereby both raters for the ADHD-PI group and parent ratings for the ADHD-C groups on the Emotional Symptoms subscale were at the borderline level. These results are consistent with past research (e.g., Becker et al., 2006; Kutcher et al., 2004; Strine et al., 2006) which reported higher internalising symptoms and disorders in ADHD groups compared to controls.

Consistent with past research (Edmonds, 2007; Gadow et al., 2000; Paternite et al., 1996) no difference was found between the ADHD-PI and ADHD-C groups on the Emotional Symptoms subscale. This subscale contains three items related to anxiety, plus an item each pertaining to depression, and somatic symptoms. In the literature, the ADHD subtypes have been found to have differential comorbidity rates with anxiety and mood disorders. For this reason the groups were compared separately on the anxiety items and on the depression item of the SDQ Emotional subscale. The ADHD-PI group was found to be rated significantly higher than controls by both raters on the anxiety items and the depression item. Furthermore, consistent with past research (Cantwell & Baker, 1992; Weiss et al., 2003; Yang et al., 2007) child ratings were significantly higher for the ADHD-PI compared to the ADHD-C groups on the anxiety items. No subtype difference was found for the depression item. This was consistent with past research (Bauermeister et al., 2005; Eiraldi et al., 1997; Grizenko et al., 2009; Ostrander et al., 1998; Willcutt et al., 1999; Yang et al., 2007), but contrary to Power et al.’s (2004) and Sprafkin et al.’s (2007) findings of the ADHD-C subtype to have higher comorbidity with mood disorders than the ADHD-PI subtype. The present results, however, were based on only one item related to depression, which leaves open the possibility that subtype differences could emerge if more depression items were used.
Externalising Symptoms and Disorders

In the present study, parents rated children with ADHD-C as having significantly more conduct problems than ADHD-PI and control children. This result was also reflected in parent ratings for the ADHD-C group on the Conduct Problems subscale being at the abnormal level using Mellor’s (2005) normative data.

These results are consistent with predictions and past research findings of children and adolescents with ADHD-C having the highest rates of externalising symptoms and disorders compared to the ADHD-PI and Control groups (Barkley et al., 1992; Gadow et al., 2000; Kessler et al., 2005; Weber et al., 2007). However, it is surprising that parents did not rate the ADHD-PI group significantly higher on the Conduct Problems subscale than controls. Examination of the Conduct Problems subscale reveals one oppositional item and four items related to anti-social behaviour (e.g., aggression, fighting, cheating and stealing). Thus, the preponderance of anti-social over oppositional items may have contributed to this lack of significant finding in the parent ratings since research suggests that whilst children with ADHD-PI are likely to display oppositional behaviour, the level of such anti-social behaviour for these children lies somewhat between the level displayed by ADHD-C and Control children (Barkley et al., 1992; Bauermeister et al., 2005; Edelbrock et al., 1984; Faraone et al., 1998; Gross-Tsur et al., 2006; Paternite et al., 1996).

ADHD Symptoms

Both parents and children rated the ADHD-PI and ADHD-C groups significantly higher on the Hyperactivity subscale than controls. This trend was reflected in parent ratings at the borderline and abnormal level, using Mellor’s (2005) norms, on the Hyperactivity subscale for the ADHD-PI and ADHD-C groups, respectively. These results were consistent with predictions due to the Hyperactivity subscale containing both attention and hyperactivity-impulsivity problem items, the former of which pertains to both ADHD subtypes. In addition, the ADHD-C group was rated significantly higher, by their parents, on the Hyperactivity subscale than their ADHD-PI counterparts. Again, this was as expected due to the presence of clinically significant levels of hyperactivity-impulsivity symptoms in only the ADHD-C group.

An interesting result was found in the present study, whereby both ADHD groups were comparable in their self-ratings on the Hyperactivity subscale. It was expected that the
ADHD-C subtype which displayed both clinically significant inattention and hyperactivity-impulsivity symptoms would be higher on this subscale than their ADHD-PI counterparts who displayed only the former symptoms. The lack of subtype differences in self-ratings on the Hyperactivity subscale could possibly be accounted for by the greater tendency for children with ADHD-C, relative to ADHD-PI, to underreport the severity of ADHD symptoms, whilst still acknowledging the presence of such symptoms.

**Social Functioning**

It was hypothesised that both ADHD groups would receive higher ratings on the Peer Problems subscale compared to controls. This hypothesis was partially supported by the results of the present study, whereby the ADHD-C group had higher parent ratings on the Peer Problems subscale compared to controls, and were the only group rated at the borderline level on this subscale by their parents. These results are interesting because both ADHD subtypes have been found to have poor social functioning and are liked less by their peers (e.g., Mikiami et al., 2007; Paternite et al., 1996; Willcutt & Carlson, 2005). However, the results of the present study may be accounted for by the differences in nature of social problems found for the ADHD subtypes. Children with the ADHD-C subtype have been found to display more overt peer problems, as manifested in their aggressive and overly emotional behaviour often leading to their active rejection by peers (Carlson et al., 1999; Hodgens et al., 2000; Wheeler et al., 2000). By contrast, the ADHD-PI subtype has often been described as passive, withdrawn, and shy in social situations in the research literature (Carlson et al., 1999; Wheeler et al., 2000), leading to them being neglected by their peers. One possible explanation for the lack of difference between the ADHD-PI and Control groups on the Peer Problems subscale in the present study is that the parents of the former group may not perceive their children’s behaviour as problematic because it is less overt and less likely to be associated with negative consequences such as being bullied.

Groups were compared on the preference for solitary play item of the Peer Problems subscale because it was predicted that this item would differentiate between the ADHD groups. Contrary to predictions both the ADHD-PI and ADHD-C groups were rated similarly on this item regardless of rater type. However, interesting trends emerged which approached significance in the comparison of the ADHD groups with controls. For parent ratings on this item the ADHD-C group was rated higher than control
participants, whereas children with ADHD-PI rated themselves as higher on this item compared to controls. Further research is needed, using a scale containing a larger number of items pertaining to preference for solitary play and other behaviour characteristic of the ADHD-PI subtype, to examine whether the ADHD subtypes can be differentiated on scales assessing the nature of their social problems.

A similar result was found for prosocial behaviour, whereby only the ADHD-C group received significantly lower parent ratings on the Prosocial subscale compared to controls. The parent ratings for the ADHD-C group on this subscale were of such low frequency that these ratings were at the abnormal level using Mellor’s (2005) normative data. These results, as with the Peer Problems subscale, are only partly consistent with the predictions that both ADHD groups would be rated as impaired on the Prosocial subscale. It is understandable how parents may perceive their children with ADHD-C whose interactions with their peers are predominantly negative (e.g., arguing and fighting), as engaging in low amounts of prosocial behaviour. Yet contrary to predictions was the finding that the ADHD-PI subtype was rated to display similar amounts of prosocial behaviour as control children. This finding is unexpected given the shy, withdrawn nature of children with ADHD-PI in their social interactions with their peers. However, one possible explanation for this finding is that in more structured interactions with peers (e.g., helping peers) children with ADHD-PI may interact similarly to controls, whereas their social deficits may become more obvious in less structure settings (e.g., playing games).

Child ratings on both the Peer Problems and Prosocial subscales were at the normal level, using Mellor’s (2005) normative data, across all groups. Children in the ADHD-C group rated themselves as displaying notably fewer peer problems than indicated by their parents’ ratings, thus accounting for the lack of difference in child ratings between the ADHD-C and Control groups. One possible explanation to account for this difference between raters lies in children with ADHD’s failure to perceive the full extent of their peer problems, which is reflected in their lower self-ratings of peer problems. A similar trend was observed for child ratings on the Prosocial subscale of the SDQ.
**General Functioning**

Consistent with predictions, both the ADHD-PI and ADHD-C groups were rated by their parents and themselves as significantly higher on the Total Difficulties subscale compared to controls. Using Mellor’s (2005) normative data, the ADHD-PI group was rated at the borderline level by both raters, and the ADHD-C group at the abnormal level by their parents on the Total Difficulties subscale. These results are similar to past findings of greater general impairment in children with ADHD relative to controls (Bauermeister et al., 2005; Blackman et al., 2005; Edmonds, 2007; Faraone et al., 1998). As expected, there was no significant subtype differences on the Total Difficulties subscale, which is consistent with Edelbrock et al.’s (1984) and Jordan’s (2003) findings of similar levels of impairment in general functioning in the ADHD-PI and ADHD-C subtypes.

**Psychosocial Functioning Summary**

The purpose of the first question was to examine the psychosocial characteristics of the three groups in the current study, and to shed further light upon differences in such functioning between the ADHD-PI and ADHD-C subtypes. The ADHD subtypes displayed different patterns of impairment in psychosocial functioning relative to controls. However, only a few significant differences emerged between the ADHD subtypes (e.g., child ratings on anxiety items, and parent ratings on the Conduct Problems and Hyperactivity subscales). These results suggest that the ADHD subtypes differ on other aspects of psychosocial functioning beyond the presence of clinically significant levels of hyperactivity-impulsivity in the ADHD-C subtype.

**11.2 Attention**

The second question of the present study pertained to attention, which asked whether specific deficits in different attention types existed for the ADHD groups relative to Controls and, if so, whether the patterns of deficits between the ADHD-PI and ADHD-C groups were different. Three types of attention were examined in the present study: selective attention, sustained attention, and attentional control/switching. Conflicting results were present in the theoretical and empirical literature on these types of attention in ADHD and its subtypes. The present study aimed to provide some clarity on this topic by using TEA-Ch subtests that have been proposed as more ecologically valid than laboratory measures. The TEA-Ch subtests were used to assess each of these types...
Selective Attention
It was hypothesised in the present study, based upon Barkley’s (1997) assertion in his model of ADHD, that the ADHD-PI subtype would display a deficit on selective attention subtests, whilst the ADHD-C group would perform comparably to controls. Two subtests of the TEA-Ch - Sky Search and Map Mission - were used as selective attention measures. The results of the present study were inconsistent with hypotheses in that the ADHD-PI group performed similarly to the ADHD-C and Control groups on both selective attention subtests. This result indicates that a selective attention deficit was not found specifically for the ADHD-PI subtype. These findings contrast to Barkley’s (1997) assertion that the ADHD-PI subtype has a deficit in selective attention which discriminates them from the ADHD-C subgroup. However, on closer scrutiny, Barkley’s (1997) assertion was based upon teacher ratings rather than direct measures of performance on tasks of selective attention. The results of the present study, however, are consistent with past research findings using the TEA-Ch subtests (Heaton et al., 2002; West et al., 2002) and other measures of selective attention (Zago et al., 2008) in which no selective attention deficit was found for the ADHD-PI group. Three possible explanations account for the discrepancy between the predictions and results of the current study. Firstly, the results of the current study, along with past research findings and knowledge that Barkley’s (1997) theoretical assertion was based upon indirect measures of selective attention, suggest that there is no selective attention deficit for the ADHD-PI subtype has been found. An alternate explanation is that the two TEA-Ch subtests used in the present study assessed selective attention only in the visual modality. This leaves open the possibility of the presence of a selective attention deficit in other modalities. Future studies are needed to explore this possibility. Thirdly, methodological limitations such as low power due to small sample size and participants being medicated during test administration may account for this discrepancy.

A second finding of the study, contrary to hypotheses, was the significantly poorer performance of the ADHD-C group relative to controls on the Sky Search subtest, and a difference between these groups on Map Mission that approached significance. In the literature only two studies have compared the ADHD-C subtype with controls on selective attention measures. These studies yielded contradictory results, with Barkley
et al. (1992) finding the ADHD-C group to be more impaired on a selective attention task than controls, whereas Zago et al (2008) reported no difference between groups. Both studies used the Stroop Test to assess selective attention. The Stroop Test is a well-established measure of selective attention (Brodeur & Pond, 2001; Barkley et al., 1992; Van Mourisk et al., 2005), with Manly et al. (1999) reporting significant correlations between the Stroop Test with the Sky Search ($r = .4, p < .001$) and Map Mission ($r = .31, p < .01$) subtests of the TEA-Ch. However, the Stroop Test has also been identified as a measure of interference control, a type of response inhibition (Archibald & Kerns, 1999; Barkley, 1997; Nigg et al., 2002). It is plausible that the selective attention subtests of the TEA-Ch, like the Stroop Test, also tap response inhibition abilities. Barkley’s (1997) model of ADHD, which proposed central deficits in response inhibition for the ADHD-C subtype, can account for the possible response inhibition deficits reflected in the poor performance of this group on the TEA-Ch selective attention tasks.

Sustained Attention
Four TEA-Ch subtests - Score!, Score DT, Walk Don’t Walk and Code Transmission - assessed sustained attention in the present study. The performance of the ADHD-PI, ADHD-C, and Control groups varied across subtests.

Consistent with hypotheses and past research (Loiser et al., 1996; Shallice et al., 2002; Tsal et al., 2005) the ADHD-C group performed significantly more poorly than controls on the Score DT and Code Transmission subtests, with the difference between these groups on the Walk Don’t Walk subtest approaching significance. This result is consistent with Barkley’s (1997) model of ADHD which posits a deficit in sustained attention for the ADHD-C subtype.

However, a number of interesting findings emerged in the present study that were contrary to predictions. Firstly, the performance by the ADHD-C group on the Score! subtest was not significantly different to that of the Control group. This result contrasts to the significant differences in performance between the ADHD-C and Control groups found on the other three sustained attention measures of the TEA-Ch. A possible reason for this lack of a group difference may be the considerably shorter duration of the Score! subtest compared to the other sustained attention subtests. Due to this short duration, considerably less demand was placed on participants with ADHD-C to
maintain attention on this subtest which may have enabled them to manifest a performance in the average range.

A second possible explanation is related to the categorisation of the TEA-Ch subtests. Whilst Manly et al. (1999) reported their three factor model of attention (selective attention, sustained attention and attentional control/switching) to be a good fit for TEA-Ch subtest performance, they also acknowledged that additional attention dimensions could be tapped into for each subtest beyond its primary attention function. For example, Manly et al. (1999) identified the Score!, Score DT, Walk Don’t Walk, and Code Transmission subtests to assess sustained attention but only the latter three subtests could also tap the attentional control/switching component of attention.

Secondly, contrary to predictions, the ADHD-PI and ADHD-C groups performed similarly on all of the sustained attention subtests. This result is inconsistent with Barkley’s (1997) model of ADHD in which only the ADHD-C subtype was suggested to have a deficit in the realm of sustained attention. Empirical findings of sustained attention in ADHD subtypes have been mixed. The results of the present study are consistent with some previous research findings of no differences between the subtypes on TEA-Ch subtests (Preston et al., 2009; West et al., 2002) and other measures (Barkley et al., 1992; Mayes et al., 2009; Paternite et al., 1996) of sustained attention. However, other studies (Collings, 2003; Ter-Stepanian, 2007) have found the ADHD-C relative to the ADHD-PI group to be more impaired on sustained attention tasks.

One reason for the lack of a subtype difference found in the present study, but also an interesting finding in itself, is the significantly impaired performance of the ADHD-PI subtype on three of the four sustained attention subtests of the TEA-Ch compared to the Control group. This finding contrasts with predictions and Barkley’s (1997) model of ADHD which differentiates between subtypes with only the ADHD-C posited to have a sustained attention deficit. However, this finding may account for why no ADHD subtype differences emerged in the present study as both the ADHD-PI and ADHD-C groups were impaired on sustained attention tasks relative to Controls. The unexpected sustained attention deficits of the ADHD-PI subtype may be explained with reference to the heterogeneous composition of this subtype. Three groups of children comprise the ADHD-PI subtype: 1) those who are purely inattentive (i.e., clinically significant inattention with few, if any, hyperactivity-impulsivity symptoms), 2) those with ADHD-C who have outgrown some of their hyperactive-impulsive symptoms, and 3) those who are sub-threshold ADHD-C (i.e., clinically significant inattention with 4 to 5
hyperactivity-impulsivity symptoms). In the current study the presence of children with
the second type of ADHD-PI could not be checked, however five of the 20 children in
the ADHD-PI group appeared to be sub-threshold ADHD-C. Heterogeneity of the
ADHD-PI group in the current study is suggested and may be one possible explanation
for the sustained attention deficit found for this group.

**Attentional Control/Switching**

Two subtests of the TEA-Ch - Creature Counting and Opposite Worlds Task (Same
World condition and Opposite World condition) - were used to assess attentional
control/switching. Consistent with the hypotheses, both ADHD groups performed
significantly more poorly than controls on all attentional control/switching subtests,
with no difference in performance between the ADHD-PI and ADHD-C groups. These
results are consistent with past research findings of impaired attentional
control/switching performance in ADHD groups (Cepeda et al., 2000; Koschack et al.,
2003; Oades & Christiansen, 2008). An alternate explanation for these significant
findings is that the Creature Counting and Opposite Worlds subtests require sustained
attention in addition to their central demands for attentional control/switching.

The lack of a significant subtype difference on attentional control/switching measures is
similar to results of no subtype difference on these TEA-Ch subtests in other studies
(Heaton et al., 2001; Preston et al., 2009; West et al., 2002).

**Attention Summary**

The results of the present study have yielded two particularly noteworthy findings.
Firstly, both the ADHD-PI and ADHD-C subtypes were found to have deficits in
attentional control/switching and on most sustained attention tasks, with the latter group
also displaying some deficits in selective attention. This finding has theoretical
implications for Barkley’s (1997) model of ADHD. Barkley (1997) asserted that his
model does not apply to the ADHD-PI subtype because of fundamental differences in
attention deficits between subtypes, wherein the ADHD-PI had a selective attention
deficit, whereas a sustained attention deficit was present for the ADHD-C subtype. The
results of the study contrast to Barkley’s (1997) assertion, with a selective deficit found
for the ADHD-C but not for the ADHD-PI subtype, and both subtypes displaying
sustained attention deficits. This finding raises the question of whether Barkley’s (1997)
model of ADHD can also be applied to understanding the difficulties experienced by children and adolescents with the ADHD-PI subtype.

The second important result in the present study is that no significant differences were found between the ADHD-PI and ADHD-C groups on any of the TEA-Ch attention subtests. However, it is important to acknowledge the methodological limitations of the current study (e.g., small group size, medicated participants at testing) which may account for the lack of subtype difference found. Thus, the second result indicates only tentatively that the ADHD-PI and ADHD-C subtypes are similar in terms of core features, namely in their type of attention deficits. This finding adds to existing evidence against Milich et al.’s (2001) assertion that the ADHD subtypes are distinct and unrelated disorders, at least in the domain of attention deficits.

11.3 Memory
The third question of the present study considered memory, another fundamental building block of learning (Lezak et al., 2004; Webster et al., 1996), in ADHD and its subtypes. This question sought to ascertain whether specific deficits in different memory types exist for ADHD groups relative to controls and, if so whether the patterns of deficits between the ADHD-PI and ADHD-C groups are different. Three types of memory were investigated: working memory, explicit memory and implicit memory. In general, whilst no significant differences were found between groups (with the exception of the Digit Span Forward task) two general trends in performance were noted. Firstly, participants with ADHD-C obtained lower scores than the other groups on all memory tasks. Secondly, both ADHD groups displayed lower scores on the explicit and implicit memory tasks. The limitation pertaining to the small group size must be acknowledged as a possible reason for why significant group differences were not found on these memory tasks in the present study.

Working Memory
The Digit Span Forward and Digit Span Backward parts of the WISC-III Digit Span subtest were used in the present study to assess verbal working memory. The results of the present study found no significant difference between either ADHD group compared to control participants on Digit Span Forward or Digit Span Backward. This result contrasts to the majority of research studies (Engelhardt et al., 2008; Mariani & Barkley, 1997; McInnes et al., 2003; Mealer et al., 1996; Rapport et al., 2008; Schmitz
et al., 2002; Siklos & Kerns, 2004) reporting ADHD groups relative to controls to be impaired on various measures of working memory. However, the results of the present study are consistent with West et al.’s (2002) and some of McInnes et al.’s (2003) and Schmitz et al.’s (2002) findings of no differences in performance on working memory tasks between ADHD and control groups. The results of the present study using both Digits Forward and Backward suggest that neither subtype of ADHD in the current study had a working memory deficit.

An interesting finding emerged in the present study pertaining to the performance of the ADHD subtypes on the working memory tasks. Whilst the performance of the ADHD groups on Digit Span Backward did not differ, the ADHD-PI group performed significantly better on Digit Span Forward than their ADHD-C counterparts. Digit Span Forward is considered a measure of the capacity to briefly hold verbal information in mind, whereas both storage and manipulation components of working memory are assessed by Digit Span Backward. The results of the present study can be interpreted to indicate that the ADHD-PI subtype has a greater capacity to store verbal information compared to the ADHD-C subtype. However, when the manipulation of information is added to the storage component of working memory the ADHD subtypes no longer differ.

Diamond (2005) has strongly argued for the presence of a primary deficit in working memory for the ADHD-PI subtype. The results of the present study found no difference in performance for the ADHD-PI group on either Digit Span Forward or Digit Span Backward compared to control participants, which is inconsistent with Diamond’s (2005) proposal. The few past studies investigating verbal working memory in ADHD-PI and ADHD-C subtypes (Schmitz et al., 2002; West et al., 2002) also found no difference between these subtype groups on working memory tests. However, both of these studies combined the Digit Span Forward and Digit Span Backward scores to assess working memory. Differences between groups for Digit Span Forward and Digit Span Backward were computed separately in the present study, for which the ADHD-PI subtype displayed a significantly *better* performance than the ADHD-C group on the former task. This is contrary to Diamond’s (2005) assertion of the presence of a primary deficit in working memory for the ADHD-PI subtype.
The results of no subtype difference in Digit Span Backward for the present study, combined with previous research findings of no subtype difference on the combined Digit Span score, appears to be inconsistent with the strong performance of the ADHD-PI subtype on Digit Span Forward in the present study. These results may indicate a possible deficit in the manipulation component of working memory for the ADHD-PI subtype, which is compensated for by their high storage capacities such that Digit Span Backward and combined Digit Span scores of this group are comparable to their ADHD-C counterparts. However, this interpretation is highly speculative and requires further investigation.

From a theoretical perspective, Barkley’s (1997) model of ADHD, which applied only to the ADHD-C and ADHD-PHI subtypes, posited that deficits in both verbal (referred to in the model as internalisation of speech) and non-verbal working memory are present. In the current study, only verbal working memory was assessed wherein no significant difference was found between the ADHD-C group and the controls. This is contradictory to Barkley’s (1997) model. Moreover, while non-verbal working memory in ADHD and its subtypes was not assessed in the present study, one previous study assessed non-verbal working memory in ADHD subtypes and found no significant difference (Geurts et al., 2005). While further investigation of differences in verbal and non-verbal working memory between the ADHD subtypes is warranted, the findings from the few studies conducted to date are not supportive of Barkley’s (1997) posited working memory deficits in the ADHD-C subtype.

Explicit Memory
It was hypothesised that both ADHD groups would display poorer performance on the conceptually-based Category Cued Recall explicit memory task compared to controls, and that the two ADHD groups would perform comparably. In the present study, no difference in performance was found between either of the ADHD subtypes and the control group. The literature on explicit memory in ADHD has yielded mixed findings. Hence, whilst the results of the present study are consistent with past findings of participants with ADHD performing comparably to controls on explicit memory tasks (Ballesteros et al., 2007, Burden & Mitchell, 2005; Kaplan et al., 1998), they are contrary to other studies (Aloisi et al., 2004; West et al., 2002) reporting deficits in ADHD groups on such tasks. Possible explanations to account for the discrepancy between the results of the present study and those found in the latter two studies
include, that Aloisi et al. (2004) used a perceptually-based explicit memory task, whereas the current study used a conceptually-based task, and the West et al. (2002) study had a larger number of participants (n = 50) in their ADHD group.

Consistent with predictions, no difference was found in the present study between the performance of the ADHD-PI and ADHD-C groups on the Category Cued Recall task. This result is consistent with West et al.’s (2002) study which found no subtype difference on conceptual or perceptual explicit memory tasks. However, other studies (Barkley et al., 1991; Solanto et al., 2007) have found differences on such measures between subtypes. The findings of subtype differences in these studies, however, were contradictory, with Barkley et al. (1991) finding a deficit for the ADHD-PI subtype, whereas a deficit for the ADHD-C subtype was reported in Solanto et al.’s (2007) study. Such a high level of inconsistency in the research may suggest chance findings, small effect sizes that are not detected by small samples, and/or a high level of heterogeneity in samples across studies.

Implicit Memory
The literature on implicit memory in ADHD and its subtypes has also been mixed. However, Burden and Mitchell (2005) found participants with ADHD in their study to display a priming deficit on a conceptually-based implicit memory task relative to controls. On possible explanation for the differences in findings between Burden and Mitchell’s (2005) study and the present one, is that the former study involved a larger sample size of both participants with ADHD (n = 30) and controls (n = 48), compared to the group size of 20 participants in each group of the present.

The present study was the first to investigate differences between the ADHD-PI and ADHD-C subtypes on an implicit memory task. No difference between the performances of the ADHD groups on the Category Exemplar Generation task was found. However, the task used in the present study only assessed conceptually-based implicit memory. Future studies are warranted to investigate whether there is a difference between the ADHD-PI and ADHD-C subtypes on perceptually-based implicit memory measures.
Memory Summary
The results of the present study have yielded three important findings pertaining to memory in ADHD and its subtypes. Firstly, participants with ADHD-C were not found to display a significant impairment in verbal working memory, which contradicts the deficit in internalisation of speech (verbal working memory) present in Barkley’s (1997) model of ADHD.

The second noteworthy finding pertains to the higher performance of the ADHD-PI group on Digit Span Forward relative to the ADHD-C and Control groups (although only for the former group was this difference significant) with comparable performance for all groups on Digit Span Backward. It has been suggested that the ADHD-PI group may have a deficit in the manipulation component of working memory, which is masked in working memory tasks by their better storage capabilities.

The final important finding pertaining to the memory tasks of the present study is that on both the explicit and implicit memory tasks, there was no significant difference between the performance of the ADHD subtypes and control groups, nor between the ADHD subtypes. These findings raise the question of whether either ADHD subtype has a deficit in long-term memory or whether low power and/or the choice of non-standardised tasks of implicit and explicit memory in the present study did not allow for the detection of true deficits in the ADHD groups. Future studies with larger sample sizes are needed to further examine long-term memory in the ADHD subtypes.

11.4 The Utility of Attention and Memory Tasks in Predicting Group Membership
In the present study participants with ADHD were classified into subtype groups based upon professional diagnosis, where ADHD subtype was specified, as well as parent ratings on the ADHD Rating Scale-IV (DuPaul et al., 1998), a behavioural questionnaire. The fourth question of the present study asked which combination of attention and memory tests best discriminates the ADHD groups from controls, and the ADHD-PI and ADHD-C subtypes from one another. Two discriminant functions were computed using the performance of all participants on the nine TEA-Ch attention measures, four memory scores, and the SPM estimate of IQ. Together these two discriminant functions significantly accounted for 76% of variability between the three groups.
Discrimination of ADHD from Control Groups

Three measures were found to be good discriminators for separating the ADHD groups from control participants. These measures were the Opposite World-Same World condition, Opposite World-Opposite World condition, and Creature Counting subtests of the TEA-CH. The ADHD groups performed significantly more poorly on these subtests than controls. Interestingly, all of these subtests were purported by Manly et al. (1999) to assess attentional control/switching. In the research literature, all studies (Cepeda et al., 2000; Heaton et al., 2001; Koschack et al., 2003; Manly et al., 1999; Oades & Christiansen, 2008; Sutcliffe et al., 2006; West et al., 2002) investigating attentional control/switching in ADHD have found the ADHD group to display impaired performance on such tasks relative to controls.

The results of the present study highlight the importance of attentional control/switching in understanding the core cognitive characteristics of ADHD. However, in contrast to selective attention and sustained attention, attentional control/switching has received considerably less focus in empirical studies and theoretical models of attention and ADHD. For instance, whilst Mirsky et al. (1999) identified shift (which corresponds to attentional control/switching) as a component of their Restricted Taxonomy of Attentive Functions, no equivalent attention type was present in Posner and Peterson’s (1990) model of the Attention Systems of the Brain. Similarly, attentional control/switching is not mentioned to be impaired in Barkley’s (1997) and Sonuga-Barke’s (2002) models of ADHD. Only Sergeant (2000; 2005) alluded to task-switching difficulties experienced by children with ADHD in the Cognitive Energetic Model of ADHD. The importance of attentional control/switching measures in the discrimination of ADHD from control groups in the present study highlights the need for modifying theoretical models of attention, and more importantly of ADHD, to account for such deficits.

Discrimination of ADHD-PI from ADHD-C Groups

The second discriminant function of the present study separated the ADHD-PI and the ADHD-C groups. Two tasks were found to be good discriminators, namely, Digit Span Forward and Sky Search, on both of which the ADHD-C group displayed deficits relative to their ADHD-PI counterparts. At first glance these tasks appear to assess quite different abilities, with the former task purported to measure working memory and the latter task selective attention. However, the Digit Span subtests, and more specifically Digit Span Forward, have been used in a number of studies (Anderson, Jacobs, &
Harvey, 2005) and identified in Mirsky et al.’s (1991) model of attention as a selective attention measure. Anderson et al. (2005) raised the question of whether the Digit Span subtest would be better classified as a working memory as opposed to selective attention measure due to the Digit Span Backward part of the subtest. This re-classification of Digit Span as a working memory measure is consistent with Mirsky et al.’s (1999) assignment of this subtest to the encode component in their revision of the attention model. Whilst the Digit Span subtest and Digit Span Backward are purported to best assess working memory, to date no objections have been raised to Digit Span Forward being used as a selective attention measure.

The second discriminant function, although not significant, tentatively suggests a possible role of selective attention in discriminating the ADHD-PI and ADHD-C subtypes. Barkley (1997) has argued strongly for the importance of selective attention in distinguishing between these two subtypes of ADHD. However, the present results appear to be in the opposite direction posited by Barkley (1997), with the ADHD-C group displaying deficits on selective attention subtests relative to the ADHD-PI group. Future research with larger sample sizes is needed to further investigate the trend, whereby there are differences in performance on selective attention measure between the ADHD subtypes, as emerging in the current study.

Prediction of Group Membership Based on Attention and Memory Tasks
Participants in the present study were classified into the ADHD-PI, ADHD-C, and Control groups based upon professional diagnosis and parent ratings on a behavioural scale of ADHD symptoms. Two discriminant functions were derived from participants’ performance on attention, memory, and IQ tests. These two functions, which together were significant, correctly predicted the group membership of 67% of participants, which was considerably better than predictions made by chance.

For the ADHD-PI group, 60% of participants were correctly classified using the attention, memory, and IQ tests. These participants displayed significantly poorer performance than controls on attentional control/switching measures, but scored higher on the Digit Span Forward and Sky Search tasks than participants with ADHD-C. However, the performance of the remaining 30% and 10% of participants with ADHD-PI on the attention, memory, and IQ tasks in the present study were more characteristic of the ADHD-C and Control groups, respectively.
As noted previously, the heterogeneous composition of the ADHD-PI subtype raises the possibility that participants with ADHD-PI whose performance on tasks in the present study was more characteristic of the ADHD-C group, may have been sub-threshold cases of ADHD-C. Furthermore, it is possible that the 10% of participants with ADHD-PI resembling controls in terms of their task performance could be misdiagnosed as having ADHD-PI. This 10% of children with ADHD-PI have relatively intact attention and memory, but are perceived by their parents and professionals as displaying clinically significant inattention symptoms. Various learning disorders, as well as problems with vision and/or hearing, can often result in the appearance of attention problems. In addition, psychiatric disorders such as anxiety and depression can manifest as symptoms of inattention in the absence of the underlying pathology of actual deficits on attention tests.

Sixty-five percent of participants with ADHD-C were correctly classified using the attention, memory, and IQ tests of the present study. These participants displayed significant impairment on attentional control/switching tasks, and tended to perform more poorly on Digit Span Forward and the Sky Search subtest, relative to control and participants with ADHD-PI, respectively. The discriminant functions reclassified 15% of the remaining participants with ADHD-C to display performances that resembled that of the ADHD-PI group on tasks in the present study. For this subset of the ADHD-C group it may be possible that their parents and professionals exaggerated the presence and/or severity of hyperactive-impulsive symptoms displayed by these participants.

Surprisingly, 20% of the participants with ADHD-C performed similarly to controls on attention, memory, and IQ tasks. Similar to their ADHD-PI counterparts, questions can be raised pertaining to whether these participants with ADHD-C have been misdiagnosed as having ADHD. Parents and professionals perceived participants in this group as displaying clinically significant levels of both inattention and hyperactivity-impulsivity problems. A range of psychiatric disorders can mimic such problems including Oppositional Defiant Disorder, Conduct Disorder, and Autism Spectrum Disorder or Asperger's Syndrome. In addition, children with learning disorders and/or low IQ may also display such acting out behaviour due to frustration and/or to avoid tasks which are too difficult for them to comprehend or complete.
Seventy-five percent of control participants were correctly classified based on their performance on attention, memory, and IQ tasks in the present study. These participants performed better than their ADHD counterparts on all tasks, with the exception of Digit Span Forward wherein the ADHD-PI demonstrated a better, but not significant, performance. However, the discriminant functions differentiated control participants from the ADHD groups based on higher scores of the former group on attentional control/switching tasks.

Based on attention, memory, and IQ test performance the remaining 10% and 15% of control participants were re-classified as belonging to the ADHD-PI and ADHD-C groups, respectively. Whilst these children were not identified by their parents and professionals as having significant attention and hyperactivity-impulsivity problems on behavioural ratings scales, their performance on the tasks in the present study, particularly the attentional control/switching subtests, was impaired. These children may not be recognised as having attention problems for three reasons. Firstly, it is possible that parents and professionals misperceive these children as having a fairly laid-back or relaxed personality style. In this perception of these children, procrastination and disorganisation are viewed as a product of a personality style in which work is typically completed only when deadlines are imminent. A second reason for why the real attention deficits may not be recognised in these children lies in the possibility that they are misperceived by others in pejorative terms such as being lazy, unmotivated, and/or unwilling to apply themselves properly to their work. These children often appear to choose immediate rewards (e.g., having fun playing a game) over future rewards or consequences (e.g., getting an early start on an assignment due the following week). However, parents and/or professionals may not recognise that this apparent choice could be due to the underlying pathology of a biologically-based shortened delay reward gradient, as posited in the Delay Aversion Pathway of Sonuga-Barke’s (2002) Dual Pathway Model of ADHD. A third reason pertaining to why genuine attention deficits were not recognised in these children could be that such attention deficits were not yet causing significant impairments to learning or functioning in everyday life. Three types of children may fall into this category: 1) young children (pre-school to early primary school) for whom demands for attention and/or independent work are relatively low; 2) children and adolescents with high IQs that compensate for their attention deficits resulting in average academic performance or functioning; and 3) children and adolescents whose environments are implicitly shaped
to compensate for their attention deficits (e.g., parents organising their activities such that deadlines are met).

Utility of Attention and Memory Tasks in Predicting Group Membership Summary

In summary, the results from the discriminant analysis have yielded four important findings pertaining to the utility of attention and memory tasks in understanding the specific problems encountered by children with ADHD-PI and with ADHD-C. Firstly, the results show that performance on certain attention and memory tasks best discriminate between the ADHD-PI, ADHD-C, and Control groups of the present study. In particular, impairments in attentional control/switching separate participants with ADHD from controls, whereas poorer performance on Digit Span Forward and Sky Search tasks may be more characteristic of the ADHD-C than the ADHD-PI group.

The second important finding from the discriminant analysis lies in the heterogeneous nature of attention and memory in ADHD groups that were originally defined by professional diagnosis and/or parent ratings on behavioural scales of ADHD symptoms. Although 60% and 65% of the ADHD-PI and ADHD-C groups, respectively, were correctly classified, 22% of participants displayed task performances that were characteristic of the other ADHD group than the one to which they were originally assigned. This finding highlights that it would be inappropriate to assume that children and adolescents diagnosed with a particular subtype of ADHD will always display one specific set of attention and memory impairments.

Thirdly, the results of the discriminant analysis showed the performance of 10% of the ADHD-PI and 20% of the ADHD-C groups on attention and memory tasks to resemble that of control participants. No impairments on the tasks administered were found for such participants, suggesting that reasons other than attention and memory impairments (e.g., the presence of other psychological disorders) are needed to account for the inattention symptoms observed by raters.

The final important finding from the discriminant analysis lies in the presence of apparent attention and memory deficits for 25% of control participants in the present study. A number of reasons have been proposed for why these apparent deficits may have failed to be displayed in overt behaviour or overlooked by the parents and professionals caring for such children.
11.5 Theoretical Implications

The central aim of the present study was to examine the nature of and differences in attention and memory between the ADHD-PI and ADHD-C subtypes. However, the validity of the theoretical conceptualisation of the ADHD subtypes was also implicitly investigated. The results of the present study have two major implications for these theoretical conceptualisations.

Firstly, the finding of the ADHD groups displaying deficits on most types of attention relative to controls is important. This finding is consistent with theoretical models of ADHD (Barkley, 1997; Sergeant, 2000; Sonuga-Barke, 2002) that posit deficits in attention. However, the lack of findings of memory deficits among participants with ADHD in the present study raises possible questions pertaining to Barkley’s (1997) model of ADHD which explicitly states the presence of working memory deficits in ADHD.

The second implication of the results of the present study relate to the relative performance of the ADHD-PI and ADHD-C groups on attention and memory tests. No significant differences were found on any attention or memory measure, with the exception of Digit Span Forward, between these groups. This finding suggests similarity, rather than dissimilarity, of the ADHD-PI and ADHD-C groups. This finding provides strong evidence contrary to Milich et al.’s (2001) assertion that the ADHD subtypes are distinct and unrelated disorders. In addition, this similarity of the ADHD subtypes raises questions of whether it is appropriate for models of ADHD to continue to be non-applicable to the ADHD-PI subtype despite the presence of similar deficits. The results of similar attention profiles for the ADHD-PI and ADHD-C subtypes in the present study provide some support for a continuum view as opposed to a categorical view of ADHD. The ADHD subtypes could be conceptualised to lie on a continuum of attention problems with the ADHD-C group displaying problems in more types of attention than the ADHD-PI group. However, it is important to keep in mind that the interpretation of results of the present study is only tentative, due to the low power to detect differences between ADHD subtype groups gained from a small group size. A further result of the present study to note pertains to the deficit displayed by only the ADHD-C group on some of the selective attention subtests. This contrasts to the selective attention deficit specific to the ADHD-PI subtype proposed by Barkley (1997).
11.6 Clinical Implications

The results of the present study have implications for the diagnosis, assessment, and treatment of children and adolescents with ADHD. Children and adolescents are often diagnosed with ADHD based upon parent reports and ratings of the presence of clinically significant inattentive and/or hyperactive-impulsive symptoms during interviews and on behavioural rating scales, respectively. The present study employed a further method for assessment and understanding of inattention in ADHD using direct tests of different types of attention. Whilst such tests are helpful in identifying the presence of attention deficits in children and adolescents with ADHD, they may also be used to assist in differential diagnosis of ADHD from other psychological conditions. For example, questions may be raised about the appropriateness of an ADHD diagnosis and further assessment undertaken if a child or adolescent displaying clinically significant inattentive symptoms fails to show any impairment on attention tests. The inclusion of such neuropsychological tests (in addition to parent and teacher interviews and ratings on behavioural scales, classroom observations, and reviews of school reports) ensures a more comprehensive evaluation in order to establish a diagnosis of ADHD.

The results of the present study display the heterogeneous nature of attention and memory in ADHD, but also within each of its subtypes. Thus, although similar behavioural symptoms may be displayed by children or adolescents with the same subtype of ADHD, it is not valid to assume that they will display the same deficits in attention and memory. Thus attention and memory tests should be used to develop a learning profile of areas of relative strength and weakness for each child or adolescent assessed. In addition, these tests may be useful in pinpointing the barriers to learning experienced by a particular child. Treatment plans, informed by results of attention and memory tests, should be designed to enhance the strengths of a particular child, whilst providing strategies for improving areas of weaknesses and overcoming barriers to learning.

11.7 Limitations

It is important to acknowledge the presence of a number of limitations in the current study. Firstly, the small sample size of each group meant that only large effects could be detected, with only low statistical power to detect medium or small effects between groups. The size of the groups in the present study was considerably constrained by
difficulties recruiting suitable participants, but also due to the matched triples design of the present study. Other published studies (e.g., Heaton et al., 2001; Preston et al., 2009; West et al., 2002) which have also investigated subtype differences on attention and memory measures have employed a similarly small numbers of participants (i.e., n < 22) in their ADHD subtype groups. However, whilst each group in the current study was comprised of only 20 participants, confounding variables such as gender, age, and IQ were controlled for using a matched samples design (which helps to improve statistical power somewhat). The numerous significant differences between groups found suggest that group size in the present study was sufficient in so far as effects were found that may in effect be large.

A second limitation of the present study pertains to the fact that, unlike typical procedures, participants on ADHD medication were not requested to cease such medications prior to nor during testing. At test administration 45% of participants in each ADHD group of the present study were medicated. Some studies (Gardner et al., 2008; Hood, et al., 2005; Lajoie et al., 2005; Sutcliffe, et al., 2006) have reported medication to improve performance on cognitive tasks. Thus, it is possible that actual deficits on attention and memory tasks were masked by a study sample in which almost half of participants with ADHD were medicated. Analyses were conducted within each ADHD group to compare performance on attention and memory tasks of medicated with non-medicated participants. The majority of comparisons yielded no significant differences between groups, with the exception of a result contrary to expectations, wherein medicated participants in the ADHD-C group performed significantly worse than their non-medicated counterparts on the Sky Search, Digit Span Forward and Digit Span Backward tasks. Furthermore, significant differences were found between the ADHD groups and Controls on most attention subtests. This is an important finding in light of this limitation because it point to the potential severity of attention problems experienced by children with ADHD who still displayed impairments on attention tests even when medicated. However, it must be acknowledged that the use of medication may also have masked true deficits in memory for the ADHD groups. In terms of ADHD subtype differences, participants in the ADHD-PI and ADHD-C groups were matched on current medication status in order to control for the effects of medication on task performance.
The heterogeneity of the ADHD-PI group presents a further limitation in the current study. Whilst this group was found to be significantly different in terms of hyperactive-impulsive symptoms as rated on DuPaul et al.’s (1998) ADHD Rating Scale-IV to their ADHD-C counterparts, it is possible that some participants with ADHD-PI may have been sub-threshold ADHD-C. This limitation reflects a commonly acknowledged problem with the DSM-IV-TR criteria for the ADHD-PI subtype (Barkley, 2003).

A final limitation of the present study lies in the types of tasks used to assess attention and memory, and the testing environment in which these tasks were administered. Although the TEA-Ch battery of attention tests was chosen specifically because of its claimed ecological validity, these and the memory tests are still somewhat removed from classroom tasks that require attention and memory. In addition, tests were administered to participants in a small quiet room in which distractions were minimised. This environment is very different from the classroom environment in which participants with ADHD in the study are required to complete their work. It is acknowledged that these limitations may have resulted in better performances by participants on the tasks used in the present study than would be the case if typical classroom tasks were administered in the classroom environment.

11.8 Future Research

A number of avenues for future research have arisen out of the interpretation of the results of the present study. Firstly, further research needs to be undertaken to investigate attention and memory in ADHD and its subtypes, but using a larger, non-medicated sample of children with ADHD-PI and with ADHD-C to extend the results of the present study. In addition, future studies investigating such differences should take care in defining their ADHD-PI group, which may involve separating sub-threshold ADHD-C cases from purely inattentive individuals.

Future research may also be undertaken in the development of attention and memory tasks which tap and replicate the specific types of attention and memory used in common classroom activities. This would greatly assist in further understanding the nature of deficits displayed in the classroom, and also help to better target treatment interventions to these specific deficits.
A final avenue for future research pertains to the development of a theoretical model, if substantial differences between the ADHD-PI and ADHD-C subtypes are found, for understanding the difficulties experienced by children and adolescents with ADHD-PI. To date general theoretical models of ADHD and models pertaining only to the ADHD-C subtype have been proposed. Theoretical model for the ADHD-PI subtype need to be developed to assist researchers and clinicians better understand the particular, and potentially unique, difficulty experienced by this subtype. The development of such theoretical models may have important implications for both the assessment and treatment of children and adolescents with the ADHD-PI subtype.

11.9 Conclusion

The present study investigated the nature of and differences in the fundamental building blocks of learning - attention and memory - between the ADHD-PI and ADHD-C subtypes. At a group level the two ADHD subtypes have been found to display more similar than dissimilar impairments on attention, specifically in terms of sustained attention and attentional control/switching. Yet within each subtype group there is considerable heterogeneity in the pattern of attention and memory deficits. Therefore, membership for a specific diagnostic ADHD subtype group does not appear to imply a specific pattern of attention and/or memory deficit. The clinical implication of this is that an individualised approach needs to be employed when understanding the nature of problems with learning and formulating treatment plans to assist children with different subtypes of ADHD.
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Appendix A: Ethics Approval
Appendix A.1: Australian National University Human Research Ethics Approval

This is a system-generated email. Please do not reply. See below for email contact details.

Dear Ms Lisa Gates,

Protocol: 2008/474
ADHD: Exploiting the Attention, Memory and Learning Correlates between Subtypes.

I am pleased to advise you that your Human Ethics protocol received approval by the Chair of the Science & Med DEBC on 18/12/2008.

For your information:

1. Under the NHMRC/AVCC National Statement on Ethical Conduct in Human Research we are required to follow up research that we have approved. Once a year for shorter projects or as soon as possible for longer projects we shall request a brief report on any ethical issues which may have arisen during your research or whether it proceeded according to the plan outlined in the above protocol.

2. Please notify the committee of any changes to your protocol in the course of your research, and when you complete or cease working on the project.

3. Please notify the Committee immediately if any unforeseen events occur that might affect continued ethical acceptability of the research work.

4. The validity of the current approval is five years' maximum from the date shown approved. For longer projects you are required to seek renewed approval from the Committee.

All the best with your research,

Kim

Ms Kim Nissen
Ethics Manager
Office of Research Integrity
Research Office
Canberra 10B
The Australian National University
ACT 0200
Telephone: +61 2 6125 3427
Fax: +61 2 61254807

Kim.Nissen@anu.edu.au


CRICOS Provider Code: 00120C
Appendix A.2: ACT Department of Education and Training Ethics Approval

Ms Lisa Gomes
Building No. 39
School of Psychology
The Australian National University
CANBERRA ACT 0200

APPROVAL OF RESEARCH PROPOSAL

Dear Ms Gomes

Thank you for your application to conduct the proposed research titled Attention, Memory and Learning in Boys with Different Subtypes of ADHD. I am pleased to inform you that the ACT Department of Education and Training (DET) has approved your research.

This approval is given on the understanding that the research will be completed within twelve months of the date of this letter. Any extension of this timeframe must be approved in writing.

You may now directly approach the principals of the schools, with a copy of this approval letter, for permission to carry out your research. Departmental approval has been given for research in a sample of public primary and secondary schools in the ACT. It will be at the discretion of each principal as to whether your research can proceed.

As stated on the DET website, a person entering a school to conduct research is considered a visitor to a school. Visitors must comply with the Visitors in Schools Policy available at http://www.det.act.gov.au/policies/.

In any situation where the principal assesses that the nature of the activity and/or the type of contact with students may place students at risk, then the researcher will be required to be screened. The responsibility and associated costs of a criminal record check will be met by the researcher or sponsoring organisation. Any information that is provided will be treated by the Department in accordance with obligations under the Privacy Act 1988.
Appendix A.3: Canberra and Goulburn Catholic Education Office Ethics Approval

9 December 2008

Ms Lisa Gomes,
Building No. 39
The Australian National University
Canberra ACT 0200

Dear Ms Gomes,

I am writing in response to your request to undertake research titled Attention, Memory and Learning in Boys with Different Subtypes of ADHD at all schools in the Archdiocese of Canberra and Goulburn. Your request has been approved subject to the following:

1. The Principal gives final permission for research to be carried out in his/her school. This letter of approval should accompany any approach to schools or teachers.

2. Confidentiality of findings and anonymity of students is adhered to. The research must comply with the requirements of the Commonwealth Privacy Amendment (Private Sector) Act 2000.

3. If you undertake research with children in an unsupervised capacity, you are obliged to obtain a ‘Working with Children Check’ before you commence.

4. That upon completion of your research, a copy of your report is forwarded to me.

5. That Mrs Mary Dorian, Acting Head of Education Services in our Office, be contacted immediately should your research differ in any way from that proposed. Mrs Dorian’s contact details are:
   Telephone: (02) 9234 5412
   Fax: (02) 9234 5496
   Email: mary.dorian@cg.catholic.edu.au

I look forward to the results and wish you the best over the coming months.

Yours sincerely,

[Signature]

Maria Najdecki
Director
Appendix B: Parental Information Statement and Consent Form
B.1: Parental Information Statement

Parental Information Statement

Attention, Memory and Learning in Boys with Different Subtypes of ADHD

Dear Parent/Guardian,

I am a student at the Australian National University studying towards a Doctorate of Clinical Psychology. As part of this I am conducting research, which I would like you and your child to participate in.

The purpose of this study is to investigate how children with different subtypes of ADHD learn, in particular how they attend to and remember information. This study will contribute to our understanding of the difficulties children with ADHD experience at school. In addition, this information will help teachers to develop better ways of teaching children with ADHD. Your child has been selected to participate in the study because he is known not to have ADHD.

The study comprises of several components. Firstly, there is two short questionnaires for you to complete regarding your child’s learning and behaviour at home. In addition, if your child participates, he will take part in 2 testing sessions lasting approximately 1 hour. In these sessions your child will be asked to follow a series of instructions, remember information and complete some maths and language questions.

Your permission allowing your child to participate in the study would be greatly appreciated. Any information about your child that is collected in connection with this study will be treated as strictly confidential as far as the law allows.

On completion of the study I will write a dissertation which will contain a summary of the results of the study and will not identify individual children nor the schools they attend. In addition, on the completion of the project a personalised report summarising your child’s performance on these measures will be made available to you.

I would be happy to answer any questions you may have. You can contact me on (02) 6125 2804 or by e-mail: Lisa.Gomes@anu.edu.au

This project has been reviewed by the ANU Ethics Committee (Protocol No. 2008/474). If you have any concerns about the conduct of this study, please do not hesitate to contact myself on the details given above, my supervisor Dr Bernd Heubeck by e-mail Bernd.Heubeck@anu.edu.au or the ANU Human Research Ethics Committee on 6125 3427 or by e-mail Kim.Tiffen@anu.edu.au.

Participation in this study is voluntary, and you or your child may withdraw at any time. If you agree for your child to participate in this study, please complete the consent form attached.

Thank you very much

Lisa Gomes
Parental Consent Form

Attention, Memory and Learning in Boys with Different Subtypes of ADHD

I _____________________________ have read and understood the information form and give permission for my child ___________________________ to participate in the study ‘Attention, Memory and Learning in Boys with Different Subtypes of ADHD’. I understand that if I change my mind I am free to withdraw my child from this study at any stage. I understand that my child’s results will be kept confidential as far as the law provides. I understand that a report of my child’s performance will be made available to me.

Signed: ___________________________ Date: ________________
Appendix C: Diagnostic Questionnaire
ADHD RATING SCALE-IV – HOME VERSION

Child’s Name: ________________________________   Sex: M  F  Age: ____ Grade: ____
Completed by: Mother _____   Father _____   Guardian ____   Grandparent _____

Circle the number that best describes your child’s home behaviour over the last 6 months

<table>
<thead>
<tr>
<th></th>
<th>Never or rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fails to give close attention to details or makes careless mistakes in homework.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Fidgets with hands or feet or squirms in seat.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Has difficulty sustaining attention in tasks or play activities.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>Leaves seat in other situations in which remaining seated is expected (e.g., at the dinner table).</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>Does not seem to listen when spoken to directly.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6.</td>
<td>Runs about or climbs excessively in situations in which it is inappropriate.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>7.</td>
<td>Does not follow through on instructions and fails to finish work.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8.</td>
<td>Has difficulty playing or engaging in leisure activities quietly.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>Has difficulty or organising tasks and activities.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>Is “on the go” or acts as if “driven by a motor”.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>11.</td>
<td>Avoids tasks (e.g., schoolwork, homework) that require sustained mental effort.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>12.</td>
<td>Talks excessively.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>13.</td>
<td>Loses things necessary for tasks or activities.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>14.</td>
<td>Blurs out answers before questions have been completed.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>15.</td>
<td>Is easily distracted.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>16.</td>
<td>Has difficulty awaiting turn.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>17.</td>
<td>Is forgetful in daily activities.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>18.</td>
<td>Interrupts or intrudes on others.</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

From ADHD Rating Scale-IV: Checklists, Norms and Clinical Interpretation by George J. DuPaul, Thomas J. Power, Arthur D. Anastopoulos, and Robert Reid. Copyright 1998 by the authors. Permission to photocopy this scale is granted to purchasers of ADHD Rating Scale-IV for personal use only (see copyright page for details). ADHD criteria are adapted by permission from DSM-IV. Copyright 1994 by the American Psychiatric Association.
19. Have these difficulties existed for at least the past 6 months?

Yes ☐ No ☐

20. At what age did these difficulties first cause problems for your child?

Before age 7 ☐ At age 7 ☐
Between ages 7 and 8 ☐ Between ages 8 and 13 ☐
After age 13 ☐

21. During the past 6 months, have these difficulties caused problems for this child in any of these situations?

At home ☐ At school ☐
At after school care, vacation care or the babysitters ☐

22. Have these difficulties created problems or setbacks for your child in any of the following areas?

Relationship with parents ☐ Relationship with siblings ☐
Social relationships with peers ☐ Learning at school ☐
Academic achievement ☐ Other (e.g., leisure activities) ☐

Please complete next page
MEDICAL AND DEVELOPMENTAL HISTORY

A. Did you have a normal pregnancy?  Yes  No
   If no, please give details: ______________________________________________________

B. Was the birth of your child normal?  Yes  No
   If no, please give details: ______________________________________________________

C. Please list any significant problems (e.g., movement, speech, play) your child experienced in their:
   1st year of life: ________________________________________________________________
   2nd year of life: ________________________________________________________________
   3rd year of life: ________________________________________________________________
   4th year of life: ________________________________________________________________
   5th year of life: ________________________________________________________________

D. Have you consulted any health professionals (e.g., paediatrician, psychiatrist, psychologist, speech therapist, occupational therapist) about problems your child experiences with their attention, learning, language or other concerns?  Yes  No
   If yes, please give details: ______________________________________________________

E. Has your child ever been prescribed medication to improve their attention, learning, language or other problems?  Yes  No
   If yes, please give details: ______________________________________________________

F. Have you ever received communication from the school (e.g., in the form of school reports, notes in diary, etc) indicating that your child is experiencing problems with their attention, learning, language or other problems?  Yes  No
   If yes, please give details: ______________________________________________________

G. Does your child have difficulties completing their homework independently?  Yes  No
   If yes, please describe the difficulties experienced and assistance given:
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________

Thank you!
Appendix D: Parent Questionnaire
PART A: PARENT INFORMATION

Suburb: ________________________

Marital Status:

- Single  □
- De Facto  □
- Married  □
- Other  □  (please specify) ________________

Current Employment Status:

- You:      Your Partner:
  - Employed Full Time  □
  - Part Time  □
  - Looking for Work  □
  - Not Looking for Work  □
  - Other (please specify): ______________

- You:      Your Partner:
  - Employed Full Time  □
  - Part Time  □
  - Looking for Work  □
  - Not Looking for Work  □
  - Other (please specify): ______________

Highest Education Level completed:

- You:      Your Partner:
  - Year 10  □
  - Year 12  □
  - Undergraduate  □
  - Post-graduate  □
  - Other (please specify): ______________

- You:      Your Partner:
  - Year 10  □
  - Year 12  □
  - Undergraduate  □
  - Post-graduate  □
  - Other (please specify): ______________

Time spent with child:

Please list the number of hours spent per week doing homework or other educational activities with your child

- You: _____ hours per week  Your Partner: _____ hours per week

Please list the number of hours spent per week doing recreational activities (e.g., playing a board game, watching a movie, talking to your child)

- You: _____ hours per week  Your Partner: _____ hours per week
PART B: CHILD INFORMATION

Name of School your child is attending: ___________________________________

Country of Birth: ______________________

If your child was not born in Australia, when did he come to Australia? ______

Language(s) spoken at home:

First: ______________________

Other(s): ______________________________________________________________

ADD or ADHD Diagnosis:

To what extent does your child have Attention Deficit Disorder (ADD) or Attention Deficit Hyperactivity Disorder (ADHD)?

Not at all □ A little □ Somewhat □ Very much so □

Which, if any, professionals have you seen regarding attentional/behavioural problems you child may have and what was the diagnosis, if one was given?

<table>
<thead>
<tr>
<th>Professionals</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ General Practitioner</td>
<td>_________________________________</td>
</tr>
<tr>
<td>□ Paediatrician</td>
<td>_________________________________</td>
</tr>
<tr>
<td>□ Psychiatrist</td>
<td>_________________________________</td>
</tr>
<tr>
<td>□ Psychologist</td>
<td>_________________________________</td>
</tr>
<tr>
<td>□ Neuropsychologist</td>
<td>_________________________________</td>
</tr>
<tr>
<td>□ School Counsellor</td>
<td>_________________________________</td>
</tr>
<tr>
<td>□ Teacher</td>
<td>_________________________________</td>
</tr>
<tr>
<td>□ Other (please specify)</td>
<td>_________________________________</td>
</tr>
<tr>
<td>□ None</td>
<td>_________________________________</td>
</tr>
</tbody>
</table>

Medication:

Has your child ever taken medication prescribed for ADD or ADHD?

Yes □ No □

If yes, Which medication is it? ____________________________________________

How many milligrams per dose? ______________

How many times (doses) per day? ______________

How long has he been on it for? ______________

If your child ceased taking medication, how long ago?

1 – 6 days □ 1 – 2 months □
Learning Disorder Diagnosis:
Has your child ever been diagnosed with a Learning Disorder?
Yes ☐ No ☐

If yes, please give details: ________________________________________________________
__________________________________________________________________________

Special Education Programs:
Has your child ever been referred for special tutoring or a special education program at school?
Yes ☐ No ☐

If yes, please give details: ________________________________________________________
__________________________________________________________________________
PART C: ADHD RATING SCALE-IV – HOME VERSION

Circle the number that best describes your child’s home behaviour over the last 6 months:

<table>
<thead>
<tr>
<th></th>
<th>Never or rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Fails to give close attention to details or makes careless mistakes in schoolwork.</td>
<td></td>
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<tr>
<td>2.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Fidgets with hands or feet or squirms in seat.</td>
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<td></td>
<td></td>
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<tr>
<td>3.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Has difficulty sustaining attention in tasks or play activities.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Leaves seat in classroom or in other situations in which remaining seated is expected.</td>
<td></td>
<td></td>
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<tr>
<td>5.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Does not seem to listen when spoken to directly.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Runs about or climbs excessively in situations in which it is inappropriate.</td>
<td></td>
<td></td>
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<tr>
<td>7.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Does not follow through on instructions and fails to finish work.</td>
<td></td>
<td></td>
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<tr>
<td>8.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Has difficulty playing or engaging in leisure activities quietly.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>9.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Has difficulty or organising tasks and activities.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>10.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Is “on the go” or acts as if “driven by a motor”.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>11.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Avoids tasks (e.g., schoolwork, homework) that require sustained mental effort.</td>
<td></td>
<td></td>
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<tr>
<td>12.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Talks excessively.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Loses things necessary for tasks or activities.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>14.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Blurts out answers before questions have been completed.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Is easily distracted.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Has difficulty awaiting turn.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>17.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Is forgetful in daily activities.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Interrupts or intrudes on others.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From ADHD Rating Scale-IV: Checklists, Norms and Clinical Interpretation by George J. DuPaul, Thomas J. Power, Arthur D. Anastopoulos, and Robert Reid. Copyright 1998 by the authors. Permission to photocopy this scale is granted to purchasers of ADHD Rating Scale-IV for personal use only (see copyright page for details). ADHD criteria are adapted by permission from DSM-IV. Copyright 1994 by the American Psychiatric Association.
PART D: STRENGTHS AND DIFFICULTIES QUESTIONNAIRE  P or T

For each item, please mark the box for Not True, Somewhat True or Certainly True. It would help us if you answered all items as best you can even if you are not absolutely certain. Please give your answers on the basis of this young person’s behaviour over the last six months or this school year.

Child’s Date of birth …………………………………………… Male/Female

<table>
<thead>
<tr>
<th>Item</th>
<th>Not True</th>
<th>Somewhat True</th>
<th>Certainly True</th>
</tr>
</thead>
<tbody>
<tr>
<td>Considerate of other people’s feelings</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Restless, overactive, cannot stay still for long</td>
<td></td>
<td></td>
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<tr>
<td>Often complains of headaches, stomach-aches or sickness</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Shares readily with other young people, for example books, games, food</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Often loses temper</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Would rather be alone than with other young people</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generally well behaved, usually does what adults request</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Many worries or often seems worried</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Helpful if someone is hurt, upset or feeling ill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constantly fidgeting or squirming</td>
<td></td>
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<tr>
<td>Has at least one good friend</td>
<td></td>
<td></td>
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<tr>
<td>Often fights with other young people or bullies them</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Often unhappy, depressed or tearful</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generally liked by other young people</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easily distracted, concentration wanders</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Nervous in new situations, easily loses confidence</td>
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<td></td>
<td></td>
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<tr>
<td>Kind to younger children</td>
<td></td>
<td></td>
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<tr>
<td>Often lies or cheats</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Picked on or bullied by other young people</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often volunteers to help others (parents, teachers, children)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Thinks things out before acting</td>
<td></td>
<td></td>
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<tr>
<td>Steals from home, school or elsewhere</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gets along better with adults than with other young people</td>
<td></td>
<td></td>
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<tr>
<td>Many fears, easily scared</td>
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<td></td>
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<tr>
<td>Good attention span, sees work through to the end</td>
<td></td>
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</tbody>
</table>

Signature ………………………….. Date ……………………

Parent / Teacher / Other (Please specify):

Thank you very much for your help!  © Robert Goodman, 2002
Appendix E: Additional Statistical Analyses
The following additional statistical analyses were conducted for attention and memory tests because although participants were matched between groups as closely as possible on age and IQ some matches still had larger differences than were considered ideal. Firstly, correlations between age and IQ scores with performance on the TEA-CH subtests were checked. And secondly, ANCOVAs with age and IQ as covariates were computed.

### Attention Tests

**Selective Attention:**

A significant correlation was found only between age and performance on the Map Mission subtest ($r = .326$, $p = .011$). IQ was not significantly correlated with either selective attention subtests. The results of the ANCOVAs, where age and IQ were run as covariates, were similar to those found using the Paired Samples T-test, with the exception of the comparison between the ADHD-C and Control groups on Map Mission no longer approaching significance. Neither age nor IQ was a significant covariate for the Sky Search subtest. However, on the Map Mission subtest age was a significant covariate for comparisons between the ADHD-PI and ADHD-C groups ($F = 9.944$, $p = .003$), the ADHD-PI and Control groups ($F = 9.531$, $p = .004$), and approached significance for the ADHD-C and Control groups ($F = 6.027$, $p = .019$). In addition, IQ as a covariate for the comparison between the ADHD-C and Control groups on Map Mission ($F = 6.019$, $p = .019$) approached significance.

**Sustained Attention:**

Significant correlations were only found between age and participants’ performance on the Score ($r = -.27$, $p = .037$) subtest. In addition, IQ (SPM score) was significantly correlated with the Score ($r = .329$, $p = .01$), Score DT ($r = .333$, $p = .009$), and Code Transmission ($r = .385$, $p = .002$) subtests on the TEA-Ch. The results of the ANCOVAs yielded a similar pattern of results to those found using the Paired Samples T-test, with the exception of the ADHD-C group performing at a significantly poorer level than the Control group on the Walk Don’t Walk subtest ($F = 6.231$, $p = .017$). Age was not a significant covariate for any of the sustained attention subtests, and only approached significance for comparisons between the ADHD-C and Control groups on the Walk Don’t Walk subtest ($F = 5.179$, $p = .029$). IQ as a covariate approached significance for comparisons between the ADHD-PI and ADHD-C groups.
on Score ($F = 4.693, p = .037$), ADHD-PI and Controls on Score DT ($F = 4.297, p = .039$) and Code Transmission ($F = 4.748, p = .036$), and the ADHD-C and Control groups on Code Transmission ($F = 5.701, p = .022$).

**Attentional Control/Switching:**
Age was significantly correlated with Opposite World-Same World condition ($r = -.27, p = .037$), whilst IQ was significantly correlated with Opposite World-Same World condition ($r = .305, p = .018$), and Opposite World-Opposite World condition ($r = .264, p = .041$) on the TEA-Ch. The results of the ANCOVAs, where age and IQ were run as covariates, were similar to those found using the Paired Samples t-test. Neither covariate was significant for any of the attentional control/switching subtests.

**Memory Tests**

**Working Memory**
Age and IQ were not found to significantly correlate with either Working Memory measure. In addition, similar non-significant results between groups to the Paired Samples T-tests were found when ANCOVAs were conducted with age and IQ as covariates, with the exception of the comparison between the ADHD-PI and ADHD-C groups on Digits Forward ($F = 6.759, p = .013$). On Digits Backwards age ($F = 15.421, p < .001$) and IQ ($F = 7.051, p = .012$) were significant covariates for comparisons between the ADHD-PI and Control groups.

**Explicit Memory**
Only age significantly correlated with Category Cued Recall score ($r = .385, p = .002$). When age and IQ served as covariates in ANOVA analyses, no group comparisons yielded significant results, similar to the Paired Samples t-tests. Age was a significant covariate for comparisons between the ADHD-PI and ADHD-C groups ($F = 6.915, p = .012$), the ADHD-PI and Control groups ($F = 8.157, p = .007$) and the ADHD-C and Control groups ($F = 12.483, p = .001$).

**Implicit Memory**
Neither age nor IQ was found to significantly correlate with participants’ Absolute Priming score. When age and IQ served as covariates in ANOVA analyses, no group comparisons yielded significant results, similar to the Paired Samples t-tests. Neither age nor IQ were significant covariates on any comparisons between groups for Absolute Priming score.
Appendix F: Applied Clinical Research
Please contact the ANU Department of Psychology for access to this confidential appendix.