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An exploratory investigation of key clinical and neuropsychological characteristics in children and adolescents with Attention Deficit Hyperactivity Disorder (ADHD) and/or Obsessive Compulsive Disorder (OCD)

Submitted by

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A thesis submitted in fulfillment of the requirements for the degree of

Doctor of Psychology (Counselling)

Faculty of Life and Social Sciences
Swinburne University
Hawthorn, Victoria, 3122
Australia
January 2008
Statement of Authorship

I declare that this thesis does not incorporate without written acknowledgement any material previously submitted for a degree in any University, College of Advanced Education, or other educational institution; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

I further declare that the ethical principles and procedures specified in the National Health and Medical Research Council (NHMRC) document on human research and experimentation have been adhered to in the presentation of this thesis. All conditions pertaining to ethics clearance from Swinburne University, Royal Children’s Hospital, and the Catholic Education Department were properly met. Annual progress reports have been previously submitted to the Graduate Research Office at Swinburne University and the Royal Children’s Hospital Ethics Department.

Name: Marian Kolta

Signed:
Acknowledgements

This thesis would not have been possible without the generous support of a number of people. Firstly, I would like to extend my deepest appreciation and gratitude to my supervisor, Associate Professor Ann Knowles, whose cumulative wisdom was an integral component to this dissertation’s success. You have been an exemplar of the type of psychologist I strive to become one day. I would also like to thank my co-supervisor, Professor Alasdair Vance, for his enthusiasm, love of research and dedication to passing on his extensive knowledge of childhood psychiatric disorders, from a clinical and research perspective. Your help and support over the past 5 years has been invaluable.

This project would also not have been possible without the endless help from Karen Dally who provided substantial administrative support, as well as the research and clinical staff at the Royal Children’s Hospital who provided a great deal of support and assistance throughout the past 5 years. I would also like to take this opportunity to thank Professor Mike Kyrios and Dr. Maja Nedeljkovic for taking time out of their busy schedules to read through a draft of my thesis. I would also like to thank my friends and colleagues at the ACPU for their wonderful support. This thesis would have been considerably less fun without the constant wit and humour during debriefing sessions with Felicity Karsz, Jackie Yamada, Dominique Hall, and Amy Lee. I am also so very grateful to Nicky Hall who trained me in the administration of clinical assessments. She has always been an inspiration to me because of her down-to-earth nature, honesty and integrity.
I would also like to express my gratitude to all the children, adolescents and their families from the Royal Children’s Hospital who contributed their time to participate in this research study. I am grateful for their patience, and for all that I have learnt from these children and adolescents over the past four years. I am also grateful to the students and their families from various primary and secondary schools throughout Melbourne who gave their time and energy to participate in this project.

Last, but certainly not least, I wish to thank my parents, sister, extended family and friends, for their endless support and patience during this chapter in my life. My appreciation for their love and encouragement throughout a very long and sometimes stressful process is beyond description. In particular, I would like to offer a very special thank to my wonderful husband, Kerr, for his love, support, understanding, sensitivity and for generally making life much easier for me!
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FSIQ  Full Scale Intelligence Quotient
GABHS  Group A Beta-Haemolytic Streptococcal Infection
GAD  Generalized Anxiety Disorder
HSCL  Hopkins Symptom Checklist
ICD  International Classification of Diseases
IOR  Inhibition Of Return
IQ  Intelligence Quotient
MANCOVA  Multivariate Analysis of Covariance
MDD  Major Depressive Disorder
MRI  Magnetic Resonance Imaging
MTA  Multimodal Treatment Study of Children with ADHD
MTS  Matching to Sample Task
MZ  Monozygotic Twins
NET  Noradrenaline Transporter Gene 1
NIMH  National Institute of Mental Health
NP  Negative Priming
OAT  Object Alternation Test
OCD  Obsessive-Compulsive Disorder
OCSD  Obsessive-Compulsive Spectrum Disorders
ODD  Oppositional Defiance Disorder
PANDAS  Paediatric Autoimmune Neuropsychiatric Disorders associated with Streptococcal Infection
PD  Panic Disorder
PDD  Pervasive Developmental Disorder
PET  Positron Emission Tomography
PFC  Prefrontal Cortex
POTS  Paediatric OCD Treatment Study
PRM  Pattern Recognition Memory
PTSD  Post Traumatic Stress Disorder
rCBF  Regional Cerebral Blood Flow
RCFT  Rey Complex Figure Test

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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>RCMAS</td>
<td>Revised Children’s Manifest Anxiety Scale</td>
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<td>SAD</td>
<td>Separation Anxiety Disorder</td>
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<td>SOP</td>
<td>Social Phobia</td>
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<td>SP</td>
<td>Specific Phobia</td>
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<td>SPECT</td>
<td>Single Positron Emission Computer Tomography</td>
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<td>SRI</td>
<td>Serotonin Reuptake Inhibitor</td>
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<td>SRM</td>
<td>Spatial Recognition Memory</td>
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<td>SS</td>
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<td>SSRI</td>
<td>Selective Serotonin Reuptake Inhibitor</td>
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<td>SSRT</td>
<td>Stop Signal Reaction Time</td>
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<td>SWM</td>
<td>Spatial Working Memory</td>
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<td>TD</td>
<td>Tourette’s Disorder</td>
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<td>TEAch</td>
<td>Test of Everyday Attention in children</td>
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<td>TMT</td>
<td>Trail Making Test</td>
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<td>TOH</td>
<td>Tower of Hanoi</td>
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<td>TOVA</td>
<td>Test of Variables of Attention</td>
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<td>VCFS</td>
<td>Velocardiofacial Syndrome</td>
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<td>VSTM</td>
<td>Visuospatial Short-term Memory</td>
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<td>VSWM</td>
<td>Visuospatial Working Memory</td>
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<td>WCST</td>
<td>Wisconsin Card Sorting Test</td>
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<td>WISC</td>
<td>Wechsler Intelligence Scale for Children – Fourth Edition</td>
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<td>WHO</td>
<td>World Health Organisation</td>
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<td>WRAT</td>
<td>Wide Range Achievement Test</td>
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Thesis Abstract

Attention-Deficit Hyperactivity Disorder (ADHD) and Obsessive-Compulsive Disorder (OCD) are prevalent childhood disorders that are often comorbid. This thesis investigated demographic characteristics (including academic and intellectual functioning, parental psychopathology, family functioning, and social adversity status), clinical characteristics (parent and child-reported ratings of symptom severity), and the neuropsychological executive function profiles of visuospatial attention and memory constructs using a battery of computerised tests in age-matched children and adolescents between 7 to 16 years of age with a diagnosis of ADHD (n = 35), OCD (n = 29), comorbid ADHD and OCD (n = 34) compared with healthy control children (n = 32). The results indicate that children and adolescents with ADHD or OCD were qualitatively different on key phenomenological variables, while the comorbid ADHD and OCD group generally had additive symptomatology that reflected the independent contribution of symptomatic and functional impairment from each disorder. Children and adolescents with ADHD and/or OCD displayed shorter spatial spans compared to healthy control children. Relative to healthy control participants, both the ADHD group and comorbid ADHD and OCD group performed significantly worse on visuospatial spatial working memory and short-term recognition memory tasks, while the ADHD group and OCD group displayed attentional set shifting deficits relative to the healthy control group. The neuropsychological profiles of children with ADHD or comorbid ADHD and OCD are characterised by similar patterns of frontostriatal-linked dysfunction. Specific set-shifting and spatial span deficits in the OCD group contrasted with their intact performance on other tests of executive function, such as spatial working memory and visuospatial short-term memory recognition, and suggested only limited frontostriatal-linked dysfunction.
NOTE
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CHAPTER 1
ATTENTION-DEFICIT HYPERACTIVITY DISORDER

Introduction

Attention Deficit Hyperactivity Disorder (ADHD) has been defined as a chronic, heterogenous condition characterised by developmentally inappropriate levels of inattention, and/or hyperactivity-impulsivity inconsistent with the age of the child (American Psychiatric Association, 2000). Its estimated prevalence is approximately 3% - 7% in school-aged children (American Psychiatric Association, 2000). ADHD is frequently associated with common comorbid disorders and significant impairments in social, academic, and/or intellectual functioning that diminishes the quality of life of afflicted individuals (American Psychiatric Association, 2000). The purpose of this introductory chapter is to provide an overview of research regarding children and adolescents with ADHD with respect to its historical definitions, current nosological definition, epidemiology, course and prognosis, key comorbid conditions, aetiological risk factors, and treatment interventions.

Historical Overview

ADHD symptomatology has not changed dramatically since George Frederic Still (1902) first highlighted core characteristics (inattentiveness, hyperactivity and impulsiveness) as manifested in children from his clinical practice with “defects in moral control” (p. 1009). In a series of lectures to the Royal Academy of Physicians in London, Still (1902) described case histories of children who demonstrated an “abnormal incapacity for sustained attention, restlessness, fidgetiness, violent outbursts,
destructiveness, non-compliance, choreiform movements, and minor congenital anomalies” (p. 1166) as a result of defective “inhibitory volition” (p. 1008). Still theorised that people are not born with moral control but develop this capacity in childhood. He proposed that defects in moral control could occur due to brain damage, abnormal cerebral development or heredity (Still, 1902). He maintained that a ‘defect in moral control’ occurred independently of deficits of intellect, and focused on cases of children with normal intelligence. Therefore, Still’s work made an early contribution to identifying children with an ADHD-like behavioural pattern associated with supposed evidence of biological causation.

The encephalitis epidemic of 1917–1918 drew attention to the fact that similar behavioural problems (particularly hyperactivity and impulsivity) could result from brain infection in childhood. Similar behavioural observations were also associated with children who had experienced head trauma (as cited in Mash & Barkley, 1996; Spencer, 2002). The association of trauma, lesions, and encephalitis with inattention, impulsivity, and hyperactivity led clinicians to hypothesize that the behavioural symptoms were manifested because of ‘minimal brain damage’ (as cited in Mash & Barkley, 1996). However, as further evidence accumulated, the term was modified and replaced with the term ‘minimal brain dysfunction’ to emphasise that brain damage was not a necessary prerequisite to disturbed behaviour (as cited in Mash & Barkley, 1996; Spencer, 2002). It became apparent that a full spectrum understanding of the condition needed to consider genetic, biological, environmental and psychosocial factors.

In the 1950s and 1960s, clinicians began to describe and label children as hyperkinetic (as cited in Mash & Barkley, 1996). The terms ‘Hyperkinetic Behaviour
Syndrome’ and ‘Hyperkinetic Impulse Disorder’, closely resemble contemporary ADHD constructs and further propelled investigations into the disorder. The terms arose because of the discovery that stimulant medication decreased the symptoms of hyperactive children (Laufer & Denhoff, 1957). The second edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-II; American Psychiatric Association, 1968) was the first to officially recognise this manifestation of symptoms, and created the term *Hyperkinetic Reaction of Childhood Disorder*. The emphasis was on hyperactivity, restlessness, distractibility, and short attention span as the primary deficits (American Psychiatric Association, 1968). During this time, the psychoanalytic perspective shaped the definition of the disorder being children’s reaction to environmental and family factors (Mash & Barkley, 1996).

The third edition of DSM (DSM-III; American Psychiatric Association, 1980) added a new perspective that incorporated a more ‘factual based’ definition, in which research focussed on understanding key deficits in attention and impulse control (American Psychiatric Association, 1980). This conceptualisation was influential, with a change in the name to ‘Attention Deficit Disorder’ (ADD). The DSM III distinguished two types, ADD with hyperactivity and ADD without hyperactivity (American Psychiatric Association, 1980). The introduction of the term “ADD” caused concern that emphasis had shifted from important features of hyperactivity and impulsivity. The disorder was then renamed “Attention-Deficit Hyperactivity Disorder” (ADHD) in DSM-III-R (American Psychiatric Association, 1987) and ADD without hyperactivity was designated to “undifferentiated attention deficit disorder.” This reformulation marked a shift to a unified dimensional classification strategy based on the view that three key
domains were implicated (inattention, hyperactivity, and impulsivity). The term ‘ADHD’ was retained in DSM-IV (American Psychiatric Association, 1994), but differentiated to three defined subtypes: ADHD predominantly inattentive subtype, ADHD predominantly hyperactive and/or impulsive subtype, and ADHD combined subtype.

The development of the International Classification of Diseases (ICD) by the World Health Organization emphasised the importance of a dimensional view of behavioural symptomatology in contrast to the categorical classification of the DSM system. In 1967, ICD-8 classified the disorder as ‘Hyperkinetic Reaction of Childhood’ (World Health Organization, 1967). ICD-9 classified the disorder as a ‘Hyperkinetic Syndrome’ (World Health Organization, 1977), and ICD 10 as a ‘Hyperkinetic Disorder’ (World Health Organization, 1992). Thus, diagnostic systems for ADHD and Hyperkinetic Disorder continue to evolve, as knowledge of specific aspects of the condition(s). For both clinicians and researchers, this evolution of diagnostic categories has been both helpful, because of the improvements in reliability and validity of successive definitions, and confusing due to the uncertainty in generalising from one diagnostic system to another. Whether these two systems of classification are in fact identifying the same, or similar, groups of children and adolescents remains unanswered.
Section Summary

In the past century, researchers have worked hard to define and characterise ADHD core symptoms of inattentiveness, hyperactivity, and impulsiveness, and to determine aetiological factors. Aetiological theories have constantly shifted between different causal mechanisms, implicating a wide range of genetic, biological, environmental and psychosocial factors. Diagnostic labels have altered in line with shifting views about the nature and causes of ADHD symptomatology, and reflect deeper conceptual changes. Historically, early conceptualisations of ADHD were associated with executive function (EF) deficits as a result of dysfunction of the frontal lobes. At different times, the clinical domains of inattention, hyperactivity, and impulsivity have all been emphasised as the key characteristic symptoms of ADHD. The current operational definition of ADHD has become more specific and reliable with the use of standardised diagnostic criteria. These efforts have been successful to a degree, as both DSM-IV (ADHD-CT) and ICD-10 (Hyperkinetic Disorder) nosologies recognise a pervasive pattern of inattention, hyperactivity and impulsiveness, with onset in early childhood.

Definition

Core Symptoms

ADHD is a chronic and pervasive condition characterised by developmentally inappropriate levels of inattention, hyperactivity and/or impulsivity (American Psychiatric Association, 2000). From the publication of DSM-IV, ADHD and its diverse manifestations have been considered in terms of variations on separate continuums of inattention, hyperactivity and impulsivity, or by a combination of problems in these sections.
domains. This conceptualisation is consistent with factor analytic studies that have consistently identified these three broad distinguishable behavioural dimensions as underlying the behavioural symptoms thought to characterise ADHD (Burns, Boe, Walsh, Sommers-Flanagan, & Teegarden, 2001; Pillow, Pelham, Hoza, Molina, & Stultz, 1999).

The term ADHD was developed in North America, and currently is widely used in other English speaking countries, for example, Australia and New Zealand. The corresponding term for ADHD used more widely in Europe is *Hyperkinetic Disorder*. In the current edition of the ICD-10 (World Health Organization, 1992), the criteria for *Hyperkinetic Disorder* are similar to the criteria for ADHD combined type in DSM-IV in that specific symptoms of the three dimensions of inattention and hyperactivity-impulsivity are required for a diagnosis.

**Diagnostic Systems**

The main diagnostic systems currently used to classify and diagnose ADHD are the DSM-IV (American Psychiatric Association, 2000) and the ICD-10 (World Health Organization, 1992). These systems both group symptoms and signs into diagnostic categories according to descriptive criteria.

**DSM-IV Diagnostic Criteria**

The most recent diagnostic criteria for ADHD as defined in DSM-IV are set out in Appendix C. DSM-IV differentiates three diagnostic subtypes of ADHD that are characterised by maladaptive levels of presenting symptoms; predominantly ADHD inattentive subtype, predominantly ADHD hyperactive-impulsive subtype, and ADHD
combined subtype. The present study focussed exclusively on children and adolescents diagnosed with ADHD combined subtype which consists of both inattentive and hyperactive-impulsive symptoms. DSM-IV requires that five criteria be met before a diagnosis for ADHD is made. First, either six (or more) of nine symptoms of inattention or hyperactivity-impulsivity need to have persisted for at least six months to a degree that is maladaptive and inconsistent with the child’s developmental level. Second, diagnostic criteria specify that the onset of hyperactive-impulsive or inattentive symptoms that cause impairment are present before the age of 7 years. DSM-IV further specifies that the onset of functional impairment due to the primary symptoms must also occur before the age of 7 years. Third, some impairment from the symptomatology must be present in two or more settings (e.g., at school, home or in the wider environment, for example, a youth group or shopping centre). This criterion ensures that the disorder will be pervasive, and not merely situational. Fourth, there must be clear evidence of clinically significant impairment in social, academic, or occupational functioning. Fifth, the symptoms must not occur exclusively during the course of a pervasive developmental disorder, schizophrenia, or other psychotic disorder and must not be accounted for by another mental disorder (e.g., Mood Disorder or Anxiety Disorder).

**ICD-10 Diagnostic Criteria**

The ICD-10 does not recognise predominantly inattentive and predominantly hyperactive-impulsive subtypes. Instead, children with these subtypes of symptoms would be considered subthreshold cases in this classification schema. In addition, the ICD-10 is more stringent than DSM-IV requiring direct observation of symptoms by the
clinician, not simply the report of symptoms by the parents and teacher, and requires the onset before the age of 6 years. Symptom duration of at least six months and aetiology not solely due to mental retardation (i.e., Full Scale IQ above 70) are similar in both classification systems (World Health Organization, 1992).

Summary

The DSM-IV and ICD-10 both identify inattentiveness and impulsivity/hyperactivity as the core behavioural symptoms in both ADHD and Hyperkinetic Disorder. They both require these symptoms to be pervasive in two or more situations, but differ in two important ways. In ‘Hyperkinetic Disorder’, the ICD-10 requires that inattentiveness, hyperactivity and impulsivity must be severe and symptoms in each domain are rated separately. In ADHD, symptoms from the domains of inattentiveness, hyperactivity and impulsivity are combined. Finally, both the DSM-IV and ICD-10 discourage the diagnosis of ADHD or ‘Hyperkinetic Disorder’ in the presence of pervasive developmental disorders, affective disorders, or schizophrenia.

Epidemiology

Prevalence

The prevalence of ADHD is estimated to occur in 3% - 7% of school-aged children (American Psychiatric Association, 2000), although these prevalence rates vary depending on gender, age, socioeconomic status and ethnicity. Some epidemiological studies have yielded prevalence rates among school-aged children as high as 20% (Barbaresi, Katusic, Colligan, Pankratz, Weaver, Weber et al., 2002; Barkley, 2006;
Wolraich, Hannah, Baugaertel, & Feurer, 1998). Recently, the prevalence of ADHD in Australia was estimated at 6% - 8% (Gomez, Harvey, Quick, Scharer, & Harris, 1999; Graetz, Sawyer, & Baghurst, 2005; Graetz, Sawyer, Hazell, Arney, & Baghurst, 2001). Several key factors often associated with ADHD such as gender, socioeconomic status, ethnic and cultural factors will be briefly explored.

**Gender**

Males are more likely than females to be diagnosed with ADHD, with the gender ratio reported as 9 to 1 for clinical samples, and 4 to 1 for epidemiological samples (American Psychiatric Association, 2000). These gender ratios may reflect a selective gender bias since females suffer less from hyperactive and impulsive symptoms and behavioural problems that frequently initiate earlier referrals in males (American Psychiatric Association, 2000; Biederman, Mick, Faraone et al., 2002; Gaub & Carlson, 1997; Gershon, 2002). In addition, males are significantly more likely to have comorbid ODD and/or CD (Faraone, Biederman, & Monuteaux, 2001). It is noteworthy that meta-analytic reviews of gender differences in ADHD have found females do not differ markedly from males on core symptoms, levels of comorbidity, social skills, intelligence, or academic achievement (Gaub & Carlson, 1997; Gershon, 2002; Graetz, Sawyer, & Baghurst, 2005). Deficits in EF have also been identified in both males and females with ADHD when compared to healthy control children (Castellanos et al., 2000; Rucklidge & Tannock, 2002; Seidman et al., 2005).
**Socioeconomic Factors**

The parents’ education, occupation, income, and marital status signify socioeconomic status (Mueller & Parcel, 1981). For children diagnosed with ADHD, a family’s low socioeconomic status itself may be associated with numerous other risk factors that expose them to environmental or psychosocial stressors (Reid et al., 2001). The risk factors most often associated with low socioeconomic status include parental psychopathology, negative or controlling parenting, marital conflict, parental stress, and a difficult temperament (Biederman, Faraone, & Monuteaux, 2002; Biederman, Milberger, Faraone et al., 1995a; Biederman, Milberger, Faraone et al., 1995b; Pfiffner et al., 1999).

**Ethnic and Cultural Factors**

There is little research on the role of ethnic and cultural factors in ADHD (Reid, DuPaul, & Power, 1998). In past decades, investigators from all regions of the world attempted to define the prevalence of ADHD in their countries. Several recent literature reviews have reported highly variable rates worldwide, ranging from as low as 1% to as high as nearly 20% among school-age children (Faraone, Sergeant, Gilberg, & Biederman, 2003; Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007; Skounti, Philalithis, & Galanakis, 2007). These conflicting results may be explained by methodological differences across studies, such as method of ascertainment, diagnostic criteria, assessment methods, informants, and the population studied (Skounti, Philalithis, & Galanakis, 2007). Alternatively, these findings may reflect ‘real’ differences in the prevalence rates of ADHD worldwide.
Course and Prognosis

Age of Onset

ADHD symptomatology is often first identified in the preschool years, typically at ages 3 to 4 years, and more generally at ages 6 to 7 years old (Applegate et al., 1997). Age of onset appears to be heavily dependent on the ADHD subtype. Younger children demonstrate the pattern of ADHD hyperactive-impulsive symptoms, giving that subtype the earliest age of onset. The ADHD combined subtype appears to emerge in the first few grades of primary school, typically from ages 5 to 8 years old, most likely due to the requirement that both hyperactivity and inattention are present. The ADHD predominantly inattentive subtype appears to emerge a few years later from ages 8 to 12 years old (Applegate et al., 1997; Hart, Lahey, Loeber, Applegate, & Frick, 1995). Although there are three subtypes of ADHD recognised by the DSM-IV, 80% of children display symptoms in all three domains (Buitelaar, 2002).

Course

ADHD symptoms reportedly persist into adolescence in 50% - 80% of children identified in primary school (Barkley, Fischer, Smallish, & Fletcher, 2002), and into adulthood in 30% - 60% of these children (Biederman, 1998; Biederman, Mick, Faraone, 2000). Thus, this condition frequently persists over many years. Difficulties with work completion, productivity, distraction, forgetfulness, planning, organisation, and meeting deadlines associated with home, school, or social commitments are also likely to persist into adolescence and adulthood (Barkley, DuPaul, McMurray, 1990; Schachar & Tannock, 2002). Behavioural, cognitive, emotional, social, academic, intellectual and
neurological areas of functioning are also often impaired in children and adolescents diagnosed with ADHD (see Frazier, Demaree, & Youngstrom, 2004; Gaub & Carlson, 1997; Mariani & Barkley, 1997). These are often referred to as secondary problems.

Section Summary

ADHD is a childhood-onset, clinically heterogeneous disorder of inattention, hyperactivity, and impulsivity with an estimated prevalence of 3% - 7% in children and adolescents. Males are more likely than females to be diagnosed with ADHD, with the gender ratio estimated at 9 to 1 in clinical samples, and 4 to 1 in epidemiological samples. Worldwide prevalence rates of ADHD vary considerably from 1% - 20% depending on the country assessed. Ethnic, cultural and socioeconomic factors may also account for variability across studies. ADHD symptomatology typically first manifests in children from ages 5 to 8 years old, but this depends on the ADHD subtype. In most cases, symptoms persist into adolescence and adulthood. This indicates the long-term impact of ADHD symptomatology on individuals’ emotional, social, academic and intellectual functioning.

Key Comorbid Conditions

ADHD is often accompanied by comorbid conditions (for reviews see Barkley, 2006; Biederman, Faraone, & Lapey, 1992; Biederman, Newcorn, & Sprich, 1991; Jensen, Martin & Cantwell, 1997; Tannock & Brown, 2000). The key comorbid conditions most often associated with ADHD, and that may play a significant role in the manifestation of ADHD symptomatology, are explored below.
Disruptive Behavioural Disorders

The most common comorbid disorders with ADHD are oppositional defiant disorder (ODD) and, to a lesser extent, conduct disorder (CD). ODD symptoms may often emerge in approximately 40% - 70% of children diagnosed with ADHD (Barkley, 2006). Early forms of ODD may then evolve into symptoms of CD in 25% - 45% of children with ADHD (Barkley, 2006; Jensen, Martin, & Cantwell, 1997; Kuhne, Schachar, & Tannock, 1997). Familial associations are consistently identified among children and adolescents with ADHD and disruptive behavioural disorders (Biederman et al., 1992; Faraone et al., 2001). Comorbid ADHD with either ODD and/or CD in children is associated with increased social dysfunction, increased levels of aggression, anxiety, reduced levels of self-esteem, family dysfunction and poor long-term prognosis (Kuhne et al., 1997). A number of recent studies found that EF deficits remain in children with ADHD even when symptoms of ODD or CD (and IQ) are statistically controlled (Clark, Prior, & Kinsella, 2000; Nigg, 1999; Oosterlaan, Scheres, & Sergeant, 2005). In the present study, children and adolescents diagnosed with CD were excluded. This point is discussed further in the method chapter.

Anxiety Disorders

Epidemiological and clinical studies of children and adolescents with ADHD often report high comorbid prevalence rates of approximately 40% - 60% with one or more anxiety disorders, [agoraphobia (AGOR); generalized anxiety disorder (GAD); obsessive-compulsive disorder (OCD); panic disorder (PD); post-traumatic stress disorder (PTSD); separation anxiety disorder (SAD); social phobia (SOP); and specific
phobia (SP)] (Biederman, Newcorn, & Sprich, 1991; Pliszka, 1998; Tannock, 2000; Vance & Luk, 2000). General population studies of children and adolescents, however, suggest approximately 25% may have comorbid ADHD and anxiety (Angold, Costello, Erkanli, 1999; Sanders, Aduca, Karamitsios, Boots, & Vance, 2005). The relationship between ADHD and anxiety disorders appears to be robust with emerging evidence for a subgroup of children that continue to exhibit comorbid ADHD and anxiety into adolescence (Vance, Costin, Barnett, Luk, Maruff, & Tonge, 2002). OCD is one of the most common anxiety disorders that is comorbid in children and adolescents with ADHD, although comorbidity rates vary widely from 10% - 50% (Geller et al., 2003a; Geller et al., 2000; Geller et al., 2004; Moll et al., 2000). The relationship between comorbid ADHD and OCD will be discussed in more detail in Chapter Three.

**Depressive Disorders**

The prevalence of comorbid depressive disorders [either dysthymic disorder (DD) and/or major depressive disorder (MDD)] in children diagnosed with ADHD ranges between 15% - 75%, although estimates of comorbidity vary widely depending on age and sample characteristics (see Angold et al., 1999; Sanders et al., 2005; Schachar & Tannock, 2002). Research indicates that children and adolescents with comorbid ADHD and DD display greater ADHD symptomatology, poorer academic and social functioning (Biederman, Faraone, Mick, Moore, & Lelon, 1996; Connor et al., 2003), and may confer an additive propensity for developing MDD (Vance, Harris, Boots, Talbot, & Karamitsios, 2003) and/or ODD (Vance, Sanders, & Arduca, 2005). In the present study, children and adolescents diagnosed with MDD were excluded. This point is discussed further in the method chapter.
**Tic Disorders**

ADHD and tic disorders are commonly comorbid with up to 18% of children likely to develop a motor tic in childhood, declining to approximately 2% in adolescence, and less than 1% by adulthood (Peterson, Pine, Cohen, & Brook, 2001). Tourette’s Disorder (TD) is a more severe tic disorder involving multiple motor and vocal tics which occurs in less than 0.4% of the population (Peterson et al., 2001). A diagnosis of ADHD in children and adolescents does not increase the risk for a diagnosis of tics or TD (Peterson et al., 2001). In contrast, children with OCD or TD have a marked increased risk for ADHD ranging from 35% - 71% (Comings, 2000a). Individuals with comorbid ADHD and TD often have increased anxiety, depressive, behavioural, social and cognitive deficits (Spencer, Biederman, Harding, O'Donnell, Wilens, Faraone et al., 1998).

**Learning Disorders**

ADHD children frequently score lower than healthy control children on standardised achievement tests (Barkley, 2006; Barkley, DuPaul, & McMurray, 1990; Mariani & Barkley, 1997; Pliszka, 1998). Several studies have reported between 19% - 30% rates of comorbid learning disorders, conservatively defined as a significant delay in reading, spelling, writing and/or arithmetic among children with ADHD (Barkley, 2006; Pliszka, 1998). The risk of a child or adolescent developing comorbid ADHD and reading disorder is approximately 16% - 39%, spelling disorder is 24% - 27%, and arithmetic disorder is 13% - 33% (August & Garfinkel, 1990; Casey, Rourke, Del Dotto, 1996; Frick et al., 1991; Semrud-Clikeman et al., 1992). A high prevalence of speech and language disorders has also been documented in ADHD children, typically ranging from 30% - 64% (see Tannock & Brown, 2000).
Developmental Coordination Disorder

The presence of Developmental Coordination Disorder characterised by fine motor difficulty, coordination deficits, poor control over movements and balancing and excessive motor overflow, ranges from 30% - 50% in children diagnosed with ADHD (Kadesjo & Gillberg, 1998; Pitcher, Piek, & Hay, 2003; Sergeant, Piek, & Oosterlaan, 2006). Compared to children with ADHD alone, children diagnosed with comorbid ADHD and developmental coordination disorder tend to have significantly more problems with school adjustment, letter knowledge, letter segmentation, and reading comprehension (Kadesjo & Gillberg, 2001). Similarly, children with both ADHD and developmental coordination disorder are at higher risk for motor dysfunction, behavioural and other developmental disorders, (Kadesjo & Gillberg, 1998; 2001; Tervo, Azuma, Fogas, & Fiechtner, 2002).

Section Summary

In children and adolescents diagnosed with ADHD, comorbid conditions occur at a greater than chance level. The most common comorbid disorders with ADHD include disruptive behaviour disorders like ODD, CD, anxiety disorders, depressive disorders, tic disorders, learning disorders and developmental coordination disorder. The high rates of comorbid conditions in children and adolescents with ADHD need to be considered because they may independently affect the manifestation of ADHD symptomatology and a given child’s EF. This also highlights the importance of systematically addressing comorbid conditions in studies of ADHD rather than examining ‘pure’ ADHD populations that are the minority of cases in both clinical and epidemiological samples.
**Aetiology**

The past decade has produced an exponential increase in research that has examined various biological, genetic, environmental and psychosocial risk factors that affect ADHD symptomatology. Conceptions of possible underlying mechanisms must be able to account for a wide range of problems including those in the academic, cognitive, behavioural, social, and family domains. These aetiological factors indicate that heterogeneity of ADHD is associated with dysfunction of frontostriatal neural networks, although its definitive pathophysiology remains elusive (Vance & Luk, 2000). A review of key aetiological risk factors and their association with ADHD follows.

**Biological Factors**

Aetiological models of ADHD have been relatively elusive, although recent advances in research methodology have emphasised and helped to define a neurobiological basis of the disorder. Research into biological aetiological factors of ADHD has focused on neural circuits in the prefrontal cortex and striatum, as well as on the catecholamine systems that innervate this circuit. Information from key neuropsychological studies, neurological studies, neurochemical studies, and pharmacological studies are discussed in reference to impairments in the prefrontal-striatal regions that may play a key role in determining the cause of OCD.

**Neuropsychological Studies**

A large body of neuropsychological evidence supports the existence of a biological vulnerability resulting in executive function (EF) deficits among children and adolescents
with ADHD. Impairment in EF has now become an important aspect of the clinical manifestation of ADHD. Numerous studies using neuropsychological tests of frontal lobe functions support the existence of EF deficits in children and adolescents with ADHD (Barkley et al., 2001a; Kempton et al., 1999; Martinussen et al., 2005; Nigg et al., 2002; Oosterlaan, Scheres, & Sergeant, 2005; Seidman et al., 1997; Sergeant, Geurts, & Oosterlaan, 2002; Stins et al., 2005; Vance et al., 2006; Willcutt et al., 2005). A recent meta-analysis by Willcutt et al. (2005) concluded that EF deficits were consistently associated with ADHD in both community and clinical samples of children and adolescents.

The systematic investigation of EF impairments strongly supports evidence that children and adolescents with ADHD have poor inhibitory control (Barkley, 2006; Fischer, 2005; Nigg, 2001; Scheres, 2004; Willcutt, 2005), working memory deficits (Barnett, Maruff, & Vance, 2005; Barnett et al., 2001; Kempton et al., 1999), attentional set shifting and planning deficits (Grodzinsky & Barkley, 1999; Scheres et al., 2004). Similar EF deficits on neuropsychological tests have been identified in adults with ADHD (Barkley, Murphy & Bush, 2001b; Murphy et al., 2001).

Several researchers have combined neuropsychological tests and test scores in order to increase diagnostic sensitivity and specificity (Doyle, Biederman, Seidman, Weber, & Faraone, 2000; Grodzinsky & Barkley, 1999; Perugini et al., 2000). However, given the heterogeneous nature of ADHD, it would appear that no clear pattern of EF deficits unique to ADHD adequately reflects the myriad of symptoms or distinguishes it from other disorders (Doyle et al., 2000). In a recent review of ADHD literature, Sergeant, Geurts, and Oosterlaan (2002) found that few studies examined differences...
between children and adolescents with ADHD and other clinical groups. They suggested that this had limited the current understanding of the EF processes involved in ADHD. Comparing children with ADHD to children with other diagnoses that may also have EF deficits may aid differential diagnoses between disorders. This is an important point given that the primary aim of the present study was to examine for the first time the shared and combined neuropsychological profile of children with ADHD and/or OCD. To date, no previous studies have investigated the neuropsychological profiles of children and adolescents with ADHD and/or OCD.

Recent neuropsychological studies have demonstrated that EF deficits in children and adolescents are not the result of comorbid disorders such as ODD, or depressive disorders such as dysthymic disorder (Barkley, Edwards, Laneri et al., 2001a; Barkley, Murphy, & Bush, 2001b; Clark, Prior, & Kinsella, 2000; Klorman et al., 1999; Nigg, Hinshaw, Carte, & Treuting, 1998). In contrast, CD and major depressive disorder have shown to be independent and lead to significant EF deficits. Hence, the present study excluded these comorbid disorders in the investigation of EF deficits in ADHD. In summary, the evidence from neuropsychological studies strongly supports the notion that cognitive deficits in EF are central to ADHD. EF deficits associated with ADHD will be examined in more detail in Chapter 4.

**Neurological Studies**

Neurological studies point to abnormalities in frontal networks (e.g., frontostriatal dysfunction) and in networks that control attention and motor intentional behaviour in children and adolescents diagnosed with ADHD (Castellanos & Swanson, 2002b; Clarke, Prior, & Kinsella, 2000; Seidman et al., 1997; Tannock & Brown, 2000). In an effort to
clarify the underlying neurological causes of persistent symptoms of inattention, hyperactivity and impulsivity in children and adolescents with ADHD, researchers have used neuroimaging techniques such as structural and functional magnetic resonance imaging (MRI), positron emission tomography (PET), single photon emission computerised tomography (SPECT). Numerous neuroimaging studies have demonstrated abnormalities in the size of certain anatomical regions involved in attention and EF, glucose metabolism, and cerebral blood flow in the prefrontal cortex regions in children and adolescents with ADHD. The association between the metabolic activity of certain brain regions and symptoms of ADHD are critical to substantiating a connection to cognitive dysfunction associated with brain activity deficits in ADHD.

**Structural Neuroimaging Studies**

Structural neurological studies consistently point to structural abnormalities in the prefrontal cortex in children and adolescents with ADHD compared to control groups (for review see Giedd, Blumenthal, Molloy & Castellanos, 2001). Recent studies have identified smaller total cerebral volume and smaller prefrontal cortex evident in the right and left hemispheres of children and adolescents with ADHD than in healthy controls. In addition, there appear to be abnormalities to the corpus callosum, caudate, pallidum, and cerebellum (Castellanos et al., 2001; Castellanos et al., 1996; Castellanos et al., 2002a; Filipek et al., 1997; Hill, Yeo, Campbell, Hart, Vigil, & Brooks, 2003; Motofsky, Cooper, Kates, Denckla, & Kaufmann, 2002; Seidman, Valera, & Makris, 2005; Sowell et al., 2003). These prefrontal cortex abnormalities, particularly in the right prefrontal region, have often been associated with EF deficits in children and adolescents with ADHD, (Casey, Castellanos, Giedd et al., 1997; Semrud-Clikeman et al., 2000).
**Functional Neuroimaging Studies**

Functional neuroimaging studies using functional MRI, PET and SPECT techniques have implicated abnormalities in the prefrontal cortex and basal ganglia regions. These studies have consistently identified decreased cerebral blood flow and metabolic activity in prefrontal cortex in children with ADHD compared to healthy control children (Gustafsson, Thernlund, Ryding, Rosen, & Cederblad, 2000; Hendren, De Backer, & Pandina, 2000; Konrad et al., 2006; Rubia et al., 1999; Vance & Luk, 2000; Vance et al., 2007). A number of SPECT and PET studies have collectively suggested that EF deficits associated with ADHD may be caused by hypofrontality (decreased right and left anterior prefrontal cortex activity and decreased anterior cingulate gyrus activity), and decreased basal ganglia activity (Bush, Valera, & Seidman, 2005; Rubia et al., 1999; Silk, Vance, Rinehart et al., 2005; Solanto, 2002). Structural and/or biochemical changes in prefrontal cortex, such as delayed myelination (Sieg, Gaffney, Preston, & Hellings, 1995) or dopamine deficiencies (Pennington & Ozonoff, 1996) are implicated as causes of hypofrontality.

**Electroencephalogram (EEG) Studies**

Numerous electroencephalogram (EEG) studies have showed that slow EEG activity is a significant characteristic of children diagnosed with ADHD. In particular, findings include increased theta waves, particularly in the frontal lobe, and decreased beta activity, indicative of a pattern of reduced frontal lobe arousal and reactivity in ADHD compared to healthy controls (Clarke, Barry, McCarthy, & Selikowitz, 2001; Kuperman, Johnson, Arndt, Lindgren, & Wolraich, 1996; Monastra, Lubar, & Linden, 2001; Snyder
& Hall, 2006). The EEG literature also supports neuropsychological and neuroimaging findings that children and adolescents with ADHD are characterised by hypoarousal of the prefrontal cortex in approximately 80% of cases when compared with healthy control children (Chabot, Prichep, & John; 2001; Barry, Clarke, & Johnstone, 2003; Monastra, Lubar and Linden, 2001). Research shows that psychophysiological abnormalities of the prefrontal regions of the brain are related to poorer performance on EF tests, and are corrected by stimulant medication (Johnstone, Barry, & Anderson, 2001; Pliszka, Liotti, & Woldorff, 2000; Kuperman et al., 1996). This further supports the evidence for frontal lobe dysfunction in ADHD.

**Neurochemical Studies**

Evidence from neurochemical studies of children and adolescents with ADHD implicate the involvement of both the dopamine and noradrenaline (neurotransmitters classified as catecholamines) systems. Both dopamine and noradrenaline are known to play an important part in the normal functioning of the prefrontal cortex that aids the regulation of motor control and EF in children and adolescents with ADHD (see Coming et al., 2000c; Denckla, 2003; Kempton et al., 1999; Pliszka, McCracken, & Maas, 1996; Solanto, 2002, for a review). Changes in the functional levels of these neurotransmitters are central to the core symptoms of ADHD. This is evidenced by the reduction of ADHD core symptoms through the modulation of dopamine and noradrenaline using stimulant medications (Castellanos et al., 2002a). Decreased levels of the serotonin neurotransmitter has also been implicated in EF deficits of children and adolescents with ADHD (Spivak, Vered, & Yoran-Hegesh, 1999). Taken together, these findings support
the notion that dysfunction in the balance between levels of different neurotransmitters of the catecholamine system is involved in ADHD in which subsequent EF deficits may result from aberrant activation of the prefrontal cortex (Castellanos & Tannock, 2002c; Solanto, 2002).

Neuropharmacological Studies

Neuropharmacological studies investigating the neurochemical basis of ADHD demonstrate a decrease in the symptoms of inattention, impulsivity, and hyperactivity when stimulant medication is taken (Greenhill et al., 2002; Santosh & Taylor, 2000; Swanson et al., 2008; Swanson et al., 1993). The stimulant medications release and inhibit the uptake of the catecholamines dopamine and noradrenaline, thereby enhancing the activity of these neurotransmitter systems, and reducing ADHD symptomatology. Given the sensitivity of the prefrontal cortex to its neurochemical environment, disruption of the catecholamine systems can lead to frontostriatal dysfunction and profound associated EF deficits in children and adolescents with ADHD (Castellanos & Tannock, 2002c; Pliszka, McCrakeen, & Maas, 1996; Solanto, 2002). Pharmacological interventions, therefore, have the potential to ameliorate both behavioural symptoms and cognitive EF dysfunction in children and adolescents with ADHD (Kempton et al., 1999). Thus, investigation of the effect of stimulant medication on the level of neurochemical neurotransmitters in the frontostriatal system supports the hypothesis that this region is involved in EF deficits in children and adolescents with ADHD.
**Genetic Factors**

There is now abundant evidence that ADHD is strongly heritable (Edelbrock, Rende, Plomin, & Thompson, 1995; Levy et al., 1997; Sherman, Iacono, & McGue, 1997). Evidence from family, adoption, and twin studies have provided evidence regarding the influence of genetic factors on ADHD (for a detailed review see Pennington, 2002). In addition, molecular genetic studies have started to investigate individual key candidate genes (Comings et al., 2000a; Comings et al., 2000b).

**Family Studies**

Numerous family studies have noted the elevated prevalence of ADHD among mothers and fathers of children with ADHD that provides further support for the familiality of the disorder (see Faraone & Doyle, 2000; Khan & Faraone, 2006; Waldman & Gizer, 2006). Indeed, evidence has shown that approximately 10% - 57% of the immediate family members (parents and siblings) of children with ADHD are also likely to have ADHD (Biederman, Faraone, Mick et al., 1995a; Faraone, Biederman, Mick et al., 2001; Faraone, Biederman, & Friedman, 2000). Family studies of ADHD suggest that its relationship with other comorbid conditions may help to clarify its genetic heterogeneity. Studies of children and adolescents have shown that ADHD and major depressive disorder share common familial vulnerabilities (Faraone & Biederman, 1997), while children with ADHD who have CD may compromise a distinct familial subtype (Faraone, Biederman, Monuteaux, 2000; Faraone, Biederman, Jetton, & Tsuang, 1997). Moreover, research indicates that ADHD may be familially independent of both anxiety disorders (Braaten et al., 2003), and learning disabilities (Faraone et al., 1993).
Adoption Studies

Adoption studies have further suggested that the aetiology of ADHD has a stronger genetic than environmental component (Barkley, 2006). The relative influence of genetic factors can be estimated by comparing the prevalence of ADHD among adoptive and biological relatives of children and adolescents with ADHD. In the few adoptions studies available in the literature, information was unavailable regarding the biological parents of the adoptee (Sprich, Biederman, Crawford, Mundy, & Faraone, 2000; Van der Valk, Verhulst, Stroet, & Boomsma, 1998). The studies strongly indicate, however, that biological siblings and parents of non-adopted children with ADHD exhibit significantly higher rates of ADHD symptomatology, whereas adoptive parents of adopted children with ADHD were not significantly different from parents of children without ADHD. These findings provide further evidence that ADHD has a genetic basis, and suggests that when a familial risk is identified it may be due to genetic rather than shared environmental factors (Sprich et al., 2000).

Twin Studies

Twin studies comparing the similarity of monozygotic (MZ) twins (who share all of their genes) to dizygotic (DZ) twins (who share half of their genes) provide direct estimates of the extent to which a trait is due to genetic influences, shared environmental factors, and non-shared environmental factors (Plomin & Asbury, 2005). Numerous twin studies have employed large epidemiological samples to determine the extent to which individual differences in ADHD symptoms are the result of genetic and/or environmental factors (see review by Tannock, 1998). Twin studies to date have reported concordance rates of ADHD at approximately 51% - 82% in MZ twins versus 29% - 38% in DZ twins.
(Levy et al., 1997; Saudino, Ronald, & Plomin, 2005; Sharp et al., 2003; Sherman et al., 1997; Silberg et al., 1996). The largest of these studies by Levy, Hay, McStephen, Wood, & Waldman (1997) found concordance rates for the diagnosis of ADHD for MZ and DZ twins were 82.7% and 37.9%, respectively, while the contribution of shared environment was not significant. Twin studies of children with ADHD have confirmed the higher correlation of ADHD symptoms in MZ compared to DZ twins, again suggesting a high degree of heritability (Saudino, Ronald, & Plomin, 2005).

**Molecular Genetic Studies**

Published molecular genetic studies have tested for an association between ADHD and 27 different candidate genes, and a series of studies by one group has examined over 20 additional candidate genes in a sample of children and adolescents with ADHD (Comings et al., 2000a; Comings et al., 2000b). The majority of the candidate genes studied underlie various facets of the dopamine, noradrenaline, and serotonin neurotransmitter systems due to evidence that these neurotransmitters may play a role in the pathophysiology of ADHD. The candidate genes that have been investigated most frequently in relation to ADHD include dopamine D4 receptor gene (DRD 4), dopamine D5 receptor gene (DRD 5), dopamine transporter gene (DAT 1), and noradrenaline transporter gene (NET 1) (see Daly, Hawi, Fitzgerald, & Gill, 1999; Faraone, Doyle, Mick & Biederman, 2001). More recently, the hypothesised role of a dysfunctional dopamine pathway in the development of symptoms of ADHD has encouraged the investigation of candidate genes involved with the catechol-O-methyltransferase (COMT) gene region (Eisenberg et al., 1999). The COMT, encoded by
a gene located on chromosome 22, catalyses the degradation of catecholamines, most importantly dopamine.

Environmental Risk Factors

Pregnancy and Birth Complications

Several studies suggest that prenatal or perinatal complications have a small, but significant association with ADHD (Breslau et al., 1996; Milberger, Biederman, Faraone, Guite, & Tsuang, 1997). Pregnancy and birth complications include prematurity or lower birth weight, higher prevalence of short or long labour, foetal distress, low forceps delivery, toxaemia or eclampsia, and family problems during pregnancy (Breslau et al., 1996; Milberger et al., 1997; Sykes et al., 1997; Szatmari, Saigal, Rosenbaum, & Campbell, 1993). In addition, several studies report that mothers of ADHD children are younger when they conceive these children than mothers of healthy control children and that such pregnancies may have a greater risk of adversity and complications (Linnet et al., 2003; Mick, Biederman, Faraone, Sayer, & Kleinman, 2002). These findings suggest that while certain pregnancy and/or birth complications may act in an additive or interactive manner with genetic influences to increase risk for ADHD, this is not a major aetiological component in ADHD (Swanson et al., 2000).

Dietary Factors and Toxins

A few studies have suggested exposure to elevated lead levels may play a causal role in the development of ADHD (Minder, Das-Smaal, Brand, & Orlebeke, 1994; Wasserman et al., 1998). However, controlled studies have found no significant
association between a clinical diagnosis of ADHD or developmental delay and blood lead levels (Kahn, Kelly, & Walker, 1995). Food additives (colourings, flavourings and preservatives) have also been implicated as contributing factors to the development of ADHD (Schab & Trinh, 2004). In addition, children with ADHD are significantly more likely than comparison children to have been exposed prenatally to alcohol (Mick et al., 2002) and/or tobacco (Milberger et al., 1996a, 1996b). Importantly, these studies demonstrated that smoking and alcohol use during pregnancy significantly predicted the later development of ADHD even when parental ADHD was controlled. However, extensive reviews have provided little support for the proposal that ADHD is caused by dietary factors or exposure to toxins, although these factors may play a contributing role in the exacerbation or precipitation of symptoms (Schab & Trinh, 2004).

**Psychosocial Risk Factors**

**Adverse Life Events**

Numerous studies report that psychosocial factors involving social adversity may serve as exacerbating factors, determinants of comorbidity, and/or contributors to the persistence of ADHD (Johnson, Cohen, Kasen, Smailes, & Brook, 2001; Johnston & Mash, 2001; Pfiffner, McBurnett, & Rathouz, 2001). ADHD has been associated with elevated levels of psychosocial adversity factors such as lower income, increased parental psychopathology, elevated levels of parenting stress, decreased sense of parenting competence, and increased conflict between ADHD children, their parent(s) and/or siblings (Biederman, Faraone, & Monuteaux, 2002; Biederman et al., 1995a; Biederman et al., 1995b; Johnston & Mash, 2001; Pfiffner et al., 1999).
Family Factors

Numerous studies report that psychosocial factors involving family functioning may also negatively impact on children and adolescents with ADHD. The classic study by Rutter and his colleagues (1975) provided compelling evidence of how psychosocial risk factors influence child psychopathology. The findings revealed six factors within the domain of family functioning that correlated significantly with childhood conditions. These factors included severe marital conflict, low social class, large family size, paternal criminality, maternal psychopathology, and foster care placement. This work found that it was the aggregate of adversity factors, rather than the presence of any single factor that led to impaired development (Rutter, Yule, Quinton, Rowlands, Yule, & Berger, 1975). Several studies also found that as the number of adverse family psychosocial conditions accumulated, the risk of poor outcomes for children increased proportionally (Biederman, Faraone, & Monuteaux, 2002; Biederman, Milberger, Faraone et al., 1995a; 1995b). These studies also identified a positive association between Rutter’s adversity index and measures of ADHD psychopathology, cognitive and psychosocial dysfunction.

Section Summary

ADHD appears to have a heterogeneous aetiology with various developmental pathways. Evidence reviewed from recent research has identified several key biological, genetic, and environmental risk factors. A critical review of biological factors linked to ADHD from neuropsychological, neurological, neurochemical and neuropharmacology studies consistently implicate dysfunction of the frontostriatal neural networks. In particular, the findings from numerous studies have identified structural and functional abnormalities that disrupt dopamine, noradrenaline, and serotonin neurotransmitter
systems in the prefrontal cortex, with efficacious pharmacological treatments targeting these neurotransmitter systems further supporting these theories.

Family, twin and adoption studies provide support to the notion that genetic factors are associated with the development of ADHD in children and adolescents. Molecular genetic studies have identified a few key candidate dopamine and noradrenaline genes associated with the metabolism and modulation dysfunction in the prefrontal cortex that are associated with ADHD. Environmental risk factors such as pregnancy and birth complication, food additives, toxins and psychosocial risk that such parental psychopathology, negative parenting styles, marital dysfunction are associated with a poorer prognosis and may increase the vulnerability of children to ADHD. Taken together, research findings have further strengthened the evidence for biological and genetic aetiological factors associated with ADHD, while reducing support for purely environmental or psychosocial risk factors.

Treatment

A variety of treatment interventions have attempted to ameliorate the cognitive, behavioural, academic and social problems that accompany ADHD. The heterogeneity of symptoms and frequent comorbidity with other psychological conditions contribute to the difficulty in treating ADHD. The most common treatments include pharmacological, cognitive-behavioural and multi-modal treatment strategies. A review of these various treatment approaches utilised in children and adolescents with ADHD is provided below.
Pharmacological Intervention

Stimulant medication is one of the most common treatments for children and adolescents with ADHD (Vance & Luk, 2000). Two related but pharmacologically distinct stimulant medications are available for restricted prescription in Australia, methylphenidate (MPH, also commonly known as Ritalin), and dexamphetamine (Dexedrine), which are available in short and long acting forms. Stimulant medications are thought to increase the concentrations of dopamine and noradrenaline, thereby increasing the levels and functional availability of these neurotransmitters and ameliorating ADHD symptoms (Castellanos & Tannock, 2002c; Pliszka, McCracken, & Maas, 1996; Solanto, 1998). The increased use of stimulant medication to manage the symptoms of ADHD and the apparent increase in the diagnosis of ADHD, combined with evidence of widely different rates of stimulant medication utilisation, have prompted increasing research to inform guidelines for the prescription of stimulant medication (Greenhill et al., 2002).

Positive effects of Stimulant Medication

Stimulant medication is the most common and effective treatment in modifying and reducing core ADHD symptoms with a positive response rate of 75% - 95% in children and adolescents (Conners et al., 2001; Greenhill, 2002; MTA Cooperative Group, 1999a; MTA Cooperative Group, 1999b; Spencer et al., 1996). Clinician and/or parental reports often indicate that the child’s academic, social and family functioning (Carlson, Pelham, Milich, & Dixon, 1992; Swanson et al., 1993; Vance, Maruff, & Barnett, 2003) improves markedly once the child is placed on stimulant medication. In
addition, several studies have also shown that stimulant medications improve cognitive functioning on EF tasks (Barnett et al., 2001; Bedard, Ickowicz, Logan, Hogg-Johnson, Schachar, & Tannock, 2003; Kempton et al., 1999; Vance, Maruff, & Barnett, 2003).

**Negative effects of Stimulant Medication**

Treatment responsiveness to stimulant medication in children and adolescents with ADHD can vary according to many factors such as the severity of ADHD symptoms, medication dose, or the presence of comorbid disorders (Buitelaar, van der Gaag, Swaab-Barneveld, & Kuiper, 1996; Denney & Rapport, 1999; DuPaul, Barkley, & McMurray, 1994). Nonetheless, between 79% - 90% of children and adolescents experience negative effects with stimulant medication (Barkley, 1990b). These include physiological effects such as decreased appetite, headaches, insomnia, gastrointestinal problems, increased tic disorders, and affective adverse effects such as mood instability, dysphoric mood, social withdrawal and aggression (Charach, Ickowicz, & Schachar, 2004; Vance & Luk, 2000). A number of studies have also questioned the effect of stimulant medication on EF, with no improvement observed or with some participants adversely affected (Tannock, Ickowicz, & Schachar, 1995; Tannock, Schachar, & Logan, 1995). While stimulant medication may temporarily help some children, adverse effects exist and the long-term prognosis is still poor, possibly because underlying biological and/or genetic causes remain present.
Psychosocial Interventions

The role of a variety of psychosocial cognitive and behaviours interventions in the treatment of children and adolescents with ADHD has also been much studied. These methods include cognitive interventions (i.e., psychotherapy training); behavioural interventions (i.e., parent training and counselling, academic training, and social skills training); and cognitive-behavioural combined with other interventions (Klein et al., 2004; MTA Cooperative, 1999a, 1999b). The premise of many of these interventions is to develop self-control skills and problem-solving strategies presumed to be deficient in children with ADHD. However, when employed as a primary treatment, cognitive interventions have produced disappointing results and possibly should be used in combination with pharmacological interventions such as stimulant medication (MTA Cooperative Group, 1999a; 1999b). Children diagnosed with ADHD typically require more powerful and continuous reinforcers of their behaviour than children without ADHD. Extensive research has identified that providing parents with behavioural interventions training that allows them to use positive reinforcement and withdrawal of negative consequences is effective (Klein et al., 2004; Pelham, Wheeler, & Chronis, 1998). However, both parents and teachers need appropriate training to implement the same behavioural interventions in the home and school settings. This allows the maintenance of treatment effects (Pelham, Wheeler, & Chronis, 1998).
**Combined Interventions**

The limited efficacy of cognitive and behavioural interventions alone has led to combined trials with stimulant medications. The multimodal approach (stimulant medication and cognitive-behavioural intervention strategies) has been shown to be the most effective treatment of ADHD in children and adolescents (Hinshaw, Klein, & Abikoff, 1998; Klein et al., 2004; MTA Cooperative Group, 1999a; 1999b). The National Institute of Mental Health (NIMH) conducted the Multimodal Treatment Studies (MTA) (MTA Cooperative Group, 1999a; 2004a) and the Multimodal Psychosocial Treatment study (Klein et al., 2004) that examined the unitary and combined effects of pharmacological and psychosocial treatments on ADHD symptoms and associated impairments in social and academic functioning.

These large-scale, randomised clinical trials indicate the efficacy of combined long-term stimulant medication treatment and psychosocial interventions on behavioural, social and academic functioning, whereas single treatment interventions (stimulant medication only or psychosocial intervention only) were not as superior in children and adolescents with ADHD. The studies also show that these differential benefits extend for at least 14 months. In addition, this combined form of intervention treatment allowed children to be successfully treated over the course of the study with lower doses of medication, compared to the stimulant medication-only group (MTA Cooperative Group, 1999a; 2004a). To date, the multimodal perspective appears to be the optimal treatment approach for children and adolescents with ADHD. Such treatment can be tailored to the specific needs of individuals based upon their unique developmental pathways, which again points to the heterogenous nature of ADHD.
Impact of Comorbid Disorders on the Treatment of ADHD

Given the high rates of comorbidity in ADHD, it is not surprising that considerable effort has been devoted to understanding how comorbid conditions affect the treatment of ADHD. The landmark MTA study found a number of important moderating effects of comorbidity on the treatment of ADHD (Jensen et al., 2001). This study compared stimulant medication treatment, behavioural treatment, and the combination of the interventions in children and adolescents with ADHD. With respect to comorbidity, the authors describe three important results. First, children and adolescents with comorbid ADHD and anxiety disorders (but not ODD/CD) were likely to respond equally well to behavioural and stimulant medication treatments to reduce core ADHD symptoms. Second, children with ADHD only or comorbid ADHD and ODD/CD (but without anxiety disorders) responded best to treatment with stimulant medication with or without behavioural treatments. Third, children with multiple comorbid disorders (anxiety and ODD/CD) responded optimally to the combination of stimulant medication and behavioural treatments (Jensen et al., 2001). This is a very important finding partly because of its implications for understanding and treating ADHD in children and adolescents, and partly because it illustrates the importance of conducting analyses in which comorbidity is acknowledged. To effectively treat ADHD and associated comorbid conditions, clinicians must assess and implement treatment aimed to reduce symptoms of each condition, and improve important functional domains (Pelham & Fabiano, 2001). This allows clinicians and researchers to determine how to match specific treatments with specific medication and psychosocial characteristics of individuals.
**Section Summary**

ADHD is a complex, heterogeneous condition characterised by impairments in social, academic, and/or intellectual functioning. Despite varying degrees of success, no single treatment intervention has been effective in the long-term treatment of children and adolescents with ADHD. Pharmacological interventions have been shown to be the most effective short-term intervention as evidenced by the reduction of core ADHD symptomatology, but insufficient in addressing the long-term impairment in social, academic and/or intellectual function. Likewise, psychosocial treatment interventions that mostly involve cognitive and/or behavioural strategies with the parent(s), teacher, and child with ADHD have been effective in producing specific cognitive and behavioural changes in the short-term, but maintenance and generalisation of any improvements has proven problematic. The impact of common comorbid disorders associated with ADHD also needs to be taken into account in the consideration of appropriate treatment intervention(s).
Chapter Summary

The purpose of this introductory chapter has been to provide a general framework for understanding ADHD. Historical definitions, current diagnostic criteria, phenomenology, epidemiology, course and prognosis, key comorbid conditions, aetiological risk factors, and treatment intervention were discussed. ADHD is a condition characterised by persistent, developmentally inappropriate patterns of inattention, and/or impulsiveness and hyperactivity, with full symptomatology evident in ADHD-combined subtype. ADHD is the most common childhood-onset disorder, affecting approximately 3% - 7% in school aged-children. Understanding of ADHD has evolved significantly over the past century with significant shifts in the focus on core symptoms and aetiological theories. Contemporary concepts and definitions of ADHD in the DSM-IV and ICD-10 facilitate global exploration of clinical and research information.

Common comorbid disorders often associated with ADHD include ODD, CD, depressive disorders, anxiety disorders, learning disorders, tic disorders and developmental coordination disorder. In addition, ADHD is also associated with impairments in academic, cognitive, social, and family functioning. Research over the past decade has elucidated various key biological, genetic, environmental and psychosocial aetiological risk factors that may affect ADHD symptomatology. Neuropsychological, neuroimaging, and neurochemical studies strongly support the notion that structural and functional abnormalities in the prefrontal cortex are implicated in deficits in EF. Neuropharmacological studies have shown that the administration of stimulant medication modulates dopamine, noradrenaline and serotonin levels that improve the core symptoms of ADHD. Several key candidate genes associated with
dopamine and noradrenaline regulation in children and adolescents with ADHD have also been identified. These findings provide support for the involvement of the prefrontal cortex region in the expression of core symptoms of ADHD, and emphasise the role of biological factors in the onset and severity of ADHD. Despite varying degrees of success, no single specific treatment has shown long-term effectiveness in children and adolescents across individual and developmental periods. The current gold-standard approach to the treatment of ADHD has been the combined use of both stimulant medications and psychosocial intervention strategies.
CHAPTER 2
OBSESSIVE-COMPULSIVE DISORDER

Introduction

Obsessive Compulsive Disorder (OCD) in children and adolescents is a chronic psychiatric condition characterised by recurrent, intrusive thoughts (obsessions) and repetitive, stereotyped behaviours (compulsions) (American Psychiatric Association, 2000). Its estimated prevalence is approximately 1% - 2.3% in children and adolescents (American Psychiatric Association, 2000). OCD is frequently associated with common comorbid disorders and significant impairment in social, academic, and/or intellectual functioning that diminishes the quality of life of children and adolescents. The purpose of this chapter is to provide an overview of research regarding children and adolescents with OCD with respect to its historical definitions, current nosological definition, epidemiology, course and prognosis, key comorbid conditions, aetiological risk factors, and treatment interventions.

Historical Overview

A number of French and German psychiatrists introduced and defined the symptoms of OCD in the early part of the nineteenth century. Early theorists used terms such as ‘obsessionality’ and ‘compulsivity’ to describe a condition that involved involuntary intrusive thoughts (Berrios, 1996). One of the first authors to describe features of OCD was Esquirol (1838) who described OCD symptomatology as thoughts that were “involuntary” or “irresistible”. He stressed that the two characteristics of OCD were the continuous fight against obsessive thoughts, and the accompanying awareness of
their irrational nature (cited in Berrios, 1996, p.143). Likewise, Westphal (1878) considered genetics to be the primary aetiological factor in OCD. He considered OCD to be a condition of the intellect and conceptualised obsessions as abnormal ideas that enter a person’s consciousness against their will and that could not easily be dismissed (as cited in Spitzer & Sigmund, 1997). Westphal (1878) also noted a link between obsessions and compulsive behaviour in which he described OCD as an anxiety to the reaction of obsessions. These descriptions of OCD paved the way for the psychological perspective that was to emerge from the beginning of the twentieth century.

Psychological theories of OCD were consolidated at the beginning of the twentieth century through the writings of Pierre Janet (1903) and Sigmund Freud (1909). Drawing on previous research, French psychiatrist Janet was the first to put forward the psychological view of ‘obsessive-compulsive neurosis’ (as cited in Tallis, 1995). He proposed that obsessional illness progressed through a three-stage process. Implicit in Janet’s stages was the existence of an obsessional continuum ranging from normal obsessional behaviour, through obsessive personality to symptomatic obsessional ‘neurosis’. Janet also highlighted the ‘abnormal’ personality features of individuals with the disorder, including anxiety, excessive worrying, lack of energy and doubting, lack of perseverance, indecision, checking, hesitancy and the tendency for introspection and depersonalisation (Berrios, 1996).

Largely based on the ideas of Freud (1896), OCD was conceptualised to be on a continuum ranging from ‘normal’ neurotic behaviour to ‘obsessive neurosis’, thought to be largely caused by early traumatic experiences or environmental factors (as cited in van Groothest et al., 2005). In Freud’s (1909) revolutionary psychoanalytic theory, he
emphasised the role of early, perhaps traumatic, sexual exposure and overstimulation, the failure to resolve ‘oedipal conflicts’ and the subsequent ‘regression to anal-sadistic conflicts’. Freud also defined the central role of ‘ambivalence’, and the importance of defences such as ‘intellectualisation’, ‘reaction formation’, and ‘isolation’ (as cited in McGehee, 2005, p.214). Instead of medical treatment typical of the early twentieth century, Freud advocated psychoanalysis to resolve past conflicts in the afflicted individual by addressing unconscious processes. However, this form of treatment did little to improve the outcome of OCD patients (Jenike, 2001).

The conceptualisation of OCD has remained relatively constant across the twentieth century and in the various editions of the Diagnostic and Statistical Manual of Mental Disorders (DSM) (American Psychiatric Association, 1968, 1980, 1987, 1994, 2000). Succeeding editions of DSM have made minor revisions to the way obsessions and compulsions are defined, with an increased emphasis on the relationships between obsessions, compulsions and anxiety and in the shift away from insight as being constant in OCD. However, despite such revisions, it is apparent that the essential features of OCD have remained remarkably unchanged. Similarly, the definition of OCD has remained constant across the various editions of the International Classification of Diseases (ICD) (World Health Organization, 1967, 1977, 1992). The systematic evaluation of OCD in recent years has substantially increased awareness of the condition and led to higher estimates of the prevalence rate in children and adolescents (American Psychiatric Association, 2000).
Section Summary

Throughout the past century, obsessions and compulsions have been defined and characterised as core symptoms of OCD. Investigations have led to the development of different aetiological theories that have shifted between biological, genetic, learning, environmental, and psychoanalytic risk factors associated with OCD. The current diagnostic criteria for OCD have a long, consistent history with many OCD symptoms described and recognised for over a hundred years. Recently, the operational definition of OCD has become more specific and reliable with the use of standardised diagnostic criteria validated through field trials using clinical and epidemiological samples.

Definition

Core Symptoms

OCD is a chronic and debilitating condition characterised by recurrent obsessive thoughts and compulsive repetitive behaviours that commonly affects children and adolescents (American Psychiatric Association, 2000). Research employing factor analysis has repeatedly identified obsessions and compulsions as the two core distinct behavioural dimensions underlying the symptom variance characterised in OCD (Geller, Biederman, Faraone, Agranat, Cradock, Hagermoser et al., 2001a; Stewart, Rosario, Brown, Carter, Leckman, Sukhodolsky et al., 2007). The most frequent types of obsessions in childhood are fear of contamination, pathological doubt, somatic obsessions, need for symmetry, and sexual and aggressive obsessions. Well-known compulsions are repetitive checking, cleaning, counting, symmetry/exactness and hoarding. OCD symptoms are remarkably diverse and the clinical presentation can vary both within and across individuals over time (Stewart et al., 2007).
Diagnostic Systems

Contemporary attempts to classify OCD are now governed by two systems, the DSM-IV (American Psychiatric Association, 2000) and the ICD-10 (World Health Organization, 1992). These systems both group symptoms and signs into diagnostic categories according to descriptive criteria. Both the ICD-10 and DSM-IV define OCD in terms of its core characteristic symptoms of obsessions and compulsions. In addition, OCD is also classified with anxiety disorders in both diagnostic systems (American Psychiatric Association, 2000; World Health Organization, 1992).

DSM-IV Diagnostic Criteria

The most recent diagnostic criteria for children and adolescents with OCD as defined in DSM-IV (American Psychiatric Association, 2000) are set out in Appendix D. The DSM-IV describes OCD according to four diagnostic criteria. The principle features of OCD are: (a) recurrent thoughts, images or impulses termed ‘obsessions’ that are considered intrusive and cause significant distress; and (b) ritualistic behaviours termed ‘compulsions’ that typically engaged to neutralise obsessive thoughts in order to prevent or alleviate distress. The DSM-IV also maintains that the obsessions or compulsions must cause marked distress, are time consuming (take at least one hour/day), or significantly interfere with a child’s normal routine, academic, or social functioning (American Psychiatric Association, 2000). Diagnosis of OCD is not applicable if the content of the obsessions or compulsions are restricted to another disorder (e.g., eating disorder, trichotillomania), or if symptoms are due to the direct physiological effects of a substance or general medical condition (American Psychiatric Association, 2000).
Unlike adults, children and adolescents with OCD are not required to acknowledge that their obsessions or compulsions are excessive or unreasonable. A specification of poor insight may be added if the child or adolescent does not recognise that the obsessions and compulsions are excessive or unreasonable (American Psychiatric Association, 2000).

**ICD-10 Diagnostic Criteria**

The ICD-10 and DSM-IV definitions of OCD are similar, although, there are three differences between the diagnostic systems with regard to the classification of OCD. First, the ICD-10 (World Health Organisation, 1992) coding system explicitly recognises three OCD subtypes: predominantly obsessional thoughts or ruminations, predominantly compulsive acts, and mixed obsessional thoughts and acts. The DSM-IV system does not require children to suffer from both obsessions and compulsions, although there is no formal way to characterise the predominance of obsessions and/or compulsions in an individual’s symptom profile. Second, ICD-10 and DSM-IV differ in their emphasis on the importance of resistance for the diagnosis of OCD. The ICD-10 requires the child to show resistance to both obsessions and compulsions, while the DSM-IV requires resistance only to obsessions and is diagnosed even if the child does not resist compulsions (Andrews & Slade, 2002). Evidence suggests that the DSM-IV definition of OCD with regards to resistance in children is more accurate (Catapano, Sperandeo, Perris, Lanzaro, & Maj, 2001). Third, the ICD-10 does not include a benchmark to compare levels of impairing distress and/or time wasting, nor does it state how to determine whether obsessions and/or compulsions are not the result of other conditions, for example, mood disorders or schizophrenia.
Section Summary

The DSM-IV and ICD-10 both identify recurrent and intrusive obsessions, and ritualistic compulsions as core symptoms that cause significant distress in children and adolescents with OCD. In addition, the diagnostic criteria for both systems require that the obsessions or compulsions cause marked distress, are time consuming, and significantly interfere with a child’s normal routine, academic or social functioning. The presence of insight is required in both diagnostic systems to some extent. The diagnosis of OCD using the DSM-IV system is not applicable if symptoms are due to the direct physiological effects of a substance or general medical condition, or are restricted to the presence of another Axis I disorder.

Epidemiology

Prevalence

Community based epidemiological studies estimate the lifetime prevalence of OCD in children and adolescents is approximately 1% - 2.3% (American Psychiatric Association, 2000; Vallen-Basile et al., 1994; Vallen-Basile et al., 1996; Zohar, 1999). Knowledge about the prevalence rate for pre-pubertal children is limited, although prevalence rates appear to increase with age (Piacentini & Bergman, 2000). One of the only studies to date that has examined prevalence rates of OCD in a clinical sample (Fireman, Koran, Leventhal, & Jacobson, 2001) found that one-year prevalence of OCD in children and adolescents was .08%. The vast difference in prevalence rates reported in community versus clinical samples suggests that many children and adolescents suffering with OCD may not receive accurate diagnosis or seek treatment for their symptoms.
Gender Factors

In childhood, OCD is more common in males than in females with a ratio of approximately 3 to 2 (American Psychiatric Association, 2000). Gender-related differences in clinical features (age at onset of OCD symptoms and disorder, type of onset, life events and type of course) have been identified in children and adolescents with OCD. The male profile with OCD tends to include prepubescent age of onset, gradual onset, chronic course, and occurs in a relative high proportion of males with comorbid phobias and/or tic disorders. Females more frequently show an acute pubertal onset of OCD, an episodic course, and they also report more frequent precipitating stressful event(s) prior to onset. A history of anxiety disorders with onset preceding OCD is significantly more common among males, while females more frequently exhibit a history of eating disorders (Bogetto et al., 1999; Chabane et al., 2005; Fontenelle, Marques, & Versiani, 2002; Geller, 2006; Hemmings et al., 2004; Lochner et al., 2004).

Ethnic and Cultural Factors

Studies from diverse ethnic and cultural groups reveal similar prevalence rates and consistency in the content and forms of obsessions and compulsions (for reviews see 2006; Fontenelle et al., 2004; Horwath & Weissman, 2000; Kyrios, Sanavio, Bhar, & Liguori, 2001; Okasha et al., 1994; Zohar, 1999). While the exact symptoms of OCD may reflect ethnic and cultural factors, there is no consistent evidence that any particular factor has a causal role. Data on the lifetime prevalence rates, age at onset, symptom profiles, and comorbidity of OCD in seven countries: United States, Canada, Puerto Rico, Germany, Taiwan, Korea, and New Zealand, were recently reviewed. The lifetime
prevalence rates were remarkably consistent among these countries, ranging from 1.1% - 1.8% with the exception of Taiwan, which had a substantially lower prevalence rate of 0.4% (Horwath & Weissman, 2000). In terms of Australian statistics, the prevalence of OCD in children and adolescents is not known. However, the *Mental Health and Wellbeing Survey* conducted in 1997 estimated the prevalence of OCD in Australia was 0.4% in adults (Andrews, Henderson, & Hall, 2001; Crino, Slade, & Andrews, 2005).

**Course and Prognosis**

**Age of Onset**

The literature indicates a bimodal distribution of age at onset of OCD, with one peak in early childhood and another peak in adulthood. The mean age for symptom onset is 10 years old, ranging from 6 to 15 years (Chabane et al., 2005; Geller, 2006; Geller et al., 2001b; Geller et al., 2001a; Millet et al., 2004). Different symptom and neurological profiles have been identified by research into early-onset and late-onset OCD. Early prepubertal age of onset is characterised by higher male preponderance, higher rate of comorbid tic disorder, familial risk, and chronic course (Chabane et al., 2005; Hemmings et al., 2004; Millet et al., 2004; Rosario-Campos et al., 2005; Zohar, 1999).

**Type of Onset**

OCD onset is typically gradual, but acute onset has been noted in some cases (American Psychiatric Association, 2000). Particular significance has focussed on the role of stressful or traumatic life event(s). Precipitating factors identified in childhood onset OCD include the loss of a family member, a severe medical condition, family
dysfunction, or school related stress such as change of school or transition from primary to high school (Cromer, Schmidt, & Murphy, 2007; de Silva & Marks, 1999; Lochner et al., 2002; Pynoos, Steinberg, & Piacentini, 1999; Sukhodolsky, 2005). However, it is important to note that these variables are correlates and not causal factors of OCD.

**Course**

The majority of children and adolescents typically experience a chronic waxing and wanning course, with some fluctuation in the severity of symptoms related to stress (Farrell, 2006; Geller, 2006; Geller et al., 2001a). Approximately 5% of children and adolescents with OCD have an episodic course or a deterioration of symptoms between episodes, while approximately 15% exhibit progressive deterioration in social and/or academic functioning (American Psychiatric Association, 2000). The remission rates of OCD are relatively low with symptoms among children and adolescents persisting into adulthood in approximately 10% - 15% of cases (Skoog & Skoog, 1999; Stewart et al., 2004; Wewetzer et al., 2001; Zohar, 1999). Childhood onset OCD is often associated with the development of comorbid disorders, typically, anxiety or depressive disorders in 50% - 70% of children and adolescents (Brown et al., 2001; Stewart et al., 2004; Wewetzer et al., 2001; Zohar, 1999).

**Section Summary**

OCD is a common childhood condition that develops in approximately 1% - 2.3% of children and adolescents. Early onset occurs between 6 to 15 years old, and is more common in males than females. OCD childhood onset is typically gradual, however, precipitating stressful or traumatic events sometimes appear to trigger onset. Most
children and adolescents present with a chronic waxing and waning course with some fluctuation in the severity and type of symptoms that often persists into adulthood. Cross-cultural studies have identified relatively stable prevalence rates and symptoms of OCD across different ethnic and cultural groups. Current prevalence rates probably underestimate the true frequency of childhood OCD in both clinical and community populations as many children and adolescents do not seek treatment, or do not receive an accurate diagnosis or treatment when they do seek help. Given the fact that childhood onset predicts adult morbidity, identifying effective interventions in child and adolescent populations are imperative.

**Key Comorbid Conditions**

OCD is often accompanied by comorbid conditions (for review see Brown et al., 2001; Geller, 2006; Ivarsson, 2008; Yaryura-Tobias et al., 2000; Zohar, 1999). The key comorbid conditions most often associated with OCD, and that may play a significant role in the manifestation of OCD symptoms, are detailed below.

**Disruptive Behavioural Disorders**

OCD is often comorbid with disruptive behavioural disorders like Attention Deficit Hyperactivity Disorder (ADHD), Oppositional Defiant Disorder (ODD), and to a lesser extent Conduct Disorder (CD) in children and adolescents (Arnold et al., 2005; Geller et al., 2002; Geller et al., 1996; Geller et al., 2003a; Geller et al., 2007a; Masi et al., 2006; Moll et al., 2000). The prevalence of comorbid OCD and disruptive behavioural disorders vary widely. Estimates of disruptive behaviour disorder in a recent
study identified that in children and adolescents with OCD approximately 25% also presented with ADHD, 13% with ODD, and 11.7% with CD (Masi et al., 2006). In an earlier study, Geller et al. (1996) found that 33% of children and adolescent with OCD also met criteria for ADHD, and 43% met criteria for ODD. The onset of disruptive behaviour disorders generally appear to predate the onset of OCD (Geller et al., 1996). Comorbid OCD and disruptive behavioural disorders has been associated with increased impairments in domains of emotional, family, social and academic functioning (Arnold et al., 2005; Sukhodolsky et al., 2005). Given that ADHD is by itself a risk factor for ODD and/or CD (Masi et al., 2006), the risk of worsening disruptive behavioural disorders with comorbid OCD needs careful consideration. As the focus of this thesis is to investigate the clinical and cognitive characteristics associated with comorbid ADHD and OCD, these characteristics will be discussed in more detail in Chapter 3.

**Anxiety Disorders**

OCD shares the same diagnostic classification with other anxiety disorders [agoraphobia (AGOR); generalized anxiety disorder (GAD); panic disorder (PD); post-traumatic stress disorder (PTSD), separation anxiety disorder (SAD), social phobia (SOP); and specific phobia (SP)] (American Psychological Association, 2000). Estimates indicate that approximately 30% - 70% of children and adolescents with OCD have a current or past history with another anxiety disorder(s) (Brown et al., 2001; Carter et al., 2004; Crino & Andrews, 1996; Curray, March, & Hervey, 2004; Geller et al., 1996). A comprehensive retrospective study by Geller et al. (1996) identified that 70% of children and adolescents with OCD received at least one additional comorbid anxiety disorder diagnosis and 43% at least two others. The most common comorbid anxiety disorders
with OCD were SAD (33%), PD (28%), AGOR (23%), SP (17%), and SOP (10%). The emergence of other anxiety disorders often predate OCD onset (Geller et al., 1996). Comorbid OCD with other anxiety disorders is associated with greater negative impact on emotional, behavioural, academic and social functioning (Welkowitz, Struening, Pittman, Guardino, & Welkowtiz, 2000). Evidence of diagnostic comorbidity between OCD and anxiety disorders indicates that these disorders are sufficiently related to suggest they may share common underlying characteristics (Brown et al., 2001).

**Depressive Disorders**

Depressive disorders [dysthymic disorder (DD) and/or major depressive disorder (MDD)] are the most common comorbid conditions with OCD. The lifetime prevalence of comorbid OCD and depressive disorders ranges from 20% - 73% in children and adolescents (Brown et al., 2001; Carter et al., 2004; Geller et al., 1996; Hong et al., 2004). The persistent and debilitating effect of OCD often precedes the onset of depressive disorder(s) that contribute and exacerbate OCD symptoms (Crino & Andrews, 1996). Severe levels of depressive symptoms in children and adolescents with OCD are associated with poor response to treatment in comparison to post-treatment gains in children without comorbid depressive disorder(s) (Abramowitz, Franklin, Street, Kozak, & Foa, 2000; see review by Steketee & Shapiro, 1995). Similarly, MDD has been implicated in the executive function deficits observed in adults with OCD (Abramowtiz et al., 2000; Moritz et al., 2001a; Moritz et al., 2003). To distinguish executive function abilities in children and adolescents with OCD from those with comorbid MDD, participants with MDD will be excluded from the present study.
Tic Disorders

The incidence of OCD in children and adolescents with Tic Disorder, particularly Tourette’s Disorder (TD) is relatively high, with prevalence rates ranging from 35% - 50% (Pauls et al., 1995; Peterson, Pine, Cohen, & Brook, 2001; Storch et al., 2007b). The incidence of TD in OCD is lower, with estimates ranging from 5% - 7% (American Psychiatric Association, 2000). Approximately 20% - 30% of children and adolescents report a current or lifetime history of tics that range from simple, mild, transient tics to TD (American Psychiatric Association). The involuntary and unintentional stereotyped motor behaviour associated with Tic disorders, especially TD, can be clearly distinguished from children and adolescents that feel compelled to perform ritualistic behaviours to reduce distress associated with obsessions (Hanna et al., 2002; Sheppard, Bradshaw, Purcell, & Pantelis, 1999). The elevated rates of OCD in first-degree relatives of individuals with TD indicates the condition is familial (Pauls et al., 1995). OCD and TD share a substantial overlap of clinical features with ADHD (Amat et al., 2006; Hanna et al., 2002; Peterson et al., 2001; Sheppard, Bradshaw, Purcell, & Pantelis, 1999; Storch et al., 2007b). The characteristics commonly associated with comorbid OCD, TD, and ADHD are detailed in Chapter 3.

Obsessive Compulsive Spectrum Disorders

There is increasing recognition of a broad range of psychological and neuropsychiatric disorders categorised in the DSM-IV (American Psychiatric Association, 2000) that share phenomenological similarities to OCD and are often referred to as the obsessive-compulsive spectrum disorders (OCSDs). OCSDs include
somatoform disorders (body dysmorphic disorder, hypochondriasis), eating disorders (anorexia and bulimia), and impulse control disorders (trichotillomania, kleptomania, self-injurious behaviour) (Bienvenu et al., 2000; Goldsmith et al., 1998; Hollander, 2005; Hollander et al., 2007). This group of disorders are thought to share common phenomenological and aetiological features, course, family history, comorbidity, and treatment response with OCD (Goldsmith et al., 1998; Hollander et al., 2007). However, the comorbidity rate for OCSD is generally not as high as the comorbid rates of depressive or other anxiety disorders in children and adolescents with OCD (for reviews see Goldsmith et al., 1998; Hollander, 2005; Hollander et al., 2007).

**Pervasive Developmental Disorders**

Children with pervasive developmental disorders (PDD) (such as autism spectrum and related disorders) often manifest stereotypic behaviours and routines, as well as unusual preoccupations and fixed interests often described as obsessive and compulsive (Geller, 2006; Geller et al., 1998; Muris et al., 1998; Volkmar et al., 2004). There appears there is a distinct pattern of comorbidity with PDD with high rates of OCD in first-degree relatives (Geller et al., 1998), although the prevalence of comorbid OCD and PDD in children is not known. The cognitive and language difficulties characteristic of PDD, however, frequently make it difficult to assess the extent to which the child regards preoccupations and repetitive behaviours as intrusive, excessive, or problematic. Children with OCD, however, share common features with PDD, although despite being a source of functional impairment, characteristics like the rigid insistence on routines usually occur in the context of a demand for sameness and difficulty with transition and
do not often cause distress to the child (American Psychiatric Association, 2000). Many children with PDD do not meet the full criteria for OCD, although the relationship between the symptomatology of OCD to PDD requires clarification.

**Neurological Medical Conditions**

OCD is sometimes comorbid with neurological conditions like Sydenham’s Chorea (SC) in children (Asbahr et al., 2005; Asbahr et al., 1998; Swedo et al., 1998). SC is the neurological variant of rheumatic fever and is a response to a Group A beta-hemolytic streptococcal (GABHS) infection. Neurological models implicate acquired basal ganglia dysfunction caused by misdirected antibodies or other immune mechanisms (Asbahr et al., 2005; Asbahr et al., 1998; Swedo et al., 1998). These findings have led to a description of a syndrome described under the acronym PANDAS (Paediatric Autoimmune Neuropsychiatric Disorders Associated with Streptococcal Infections) (Swedo et al., 1998). This syndrome is characterised by abrupt prepubescent onset of OCD and/or tic disorder, episodic symptom severity, acute exacerbation following a GABHS infection, and the presence of neurological abnormalities such as hyperactivity, choreiform movements or tics (Swedo et al., 1998).

**Section Summary**

Patterns of comorbidity in children and adolescents with OCD show high rates of disruptive behavioural, anxiety, depressive, tic, obsessive-compulsive spectrum, pervasive developmental, and neurological medical conditions. In particular, OCD shows a key distinct association with ADHD. The high rates of comorbid conditions in children and adolescents with OCD may independently affect the manifestation of OCD.
symptomatology and a given child’s executive function abilities, and therefore need careful consideration. This also highlights the importance of systematically addressing comorbid conditions in studies of OCD rather than examining ‘pure’ OCD populations that are rare in both clinical and community epidemiological samples.

Aetiology

Numerous theories have emerged that attempt to explain the aetiology of OCD in children and adolescents. These models have occurred in the fields of various biological, genetic, environmental and psychosocial risk factors. There have also been influential psychological, cognitive, behavioural and developmental risk factors associated with OCD. Theories of underlying mechanisms must account for the wide range of problems that children and adolescents encounter like impairment in academic, behavioural, cognitive, family, and social domains of functioning. A review of key aetiological risk factors and their association with OCD follows.

Biological Factors

Current theoretical models implicate abnormalities in the prefrontal cortex, especially the orbitofrontal cortex, anterior cingulate cortex, dorsolateral prefrontal cortex, and the basal region (including head of the caudate nucleus and the thalamus) may have a prominent role in the onset of OCD (see Aouizerate, 2004). Advances in research methodology have emphasised and helped to define a key biological basis of OCD. Information from key neuropsychological studies, neurological studies, neurochemical studies, and pharmacological studies are discussed with reference to impairments in the prefrontal region that may play a key causal role in OCD.
Neuropsychological Studies

Systematic neuropsychological investigations have led to theoretical models that implicate the orbitofrontal cortex, anterior cingulate cortex, and the basal ganglia in the underlying pathophysiology of executive function (EF) deficits in children, adolescents, and adults with OCD (for review see Andres et al., 2007; Aouizerate et al., 2004; Chamberlain et al., 2005; Greisberg & McKay, 2003; Kuelz, Hohagen, & Voderholzer, 2004). However, the nature of these EF deficits in children and adolescents remains poorly understood, and there is debate concerning which functions, if any, are impaired (Chamberlain et al., 2005; Kuelz, Hohagen, & Voderholzer, 2004). In the limited literature available, children and adolescents with OCD have shown cognitive profiles of strength and weakness similar to adults with OCD (Andres et al., 2007; Shin et al., 2008).

The key EF deficits identified in children and adolescents with OCD have been on attentional set shifting and visuospatial working memory tasks (Andres et al., 2007; Beers et al., 1999; Cox, 1997; Shin et al., 2008). Evidence from adult studies substantiate the findings of attentional set shifting deficits (for reviews see Bannon et al., 2006; Chamberlain et al., 2005; Greisberg & McKay, 2003; Kuelz, Hohagen, & Voderholzer, 2004). However, investigations into visuospatial working memory deficits have led to inconsistent results among child, adolescent and adult populations with OCD.

Deficits in visuospatial working memory have been implicated in children in recent studies (Andres et al., 2007; Shin et al., 2008). Similarly, studies have also identified visuospatial working memory deficits in adults with OCD (see Barnett et al., 1999; Purcell et al., 1998a; 1998b), although on certain tasks adults with OCD have not exhibited deficits in working memory (Galderisi et al., 1995; Martin et al., 1995).
Despite the limited findings with children and adolescents, EF deficits on neuropsychological tasks generally reflect dysfunction in the prefrontal cortex in children, and adults (Andres et al., 2007; Shin et al., 2008). As the neuropsychological approach is central to this thesis, Chapter 4 will focus on evidence regarding key EF deficits.

**Neurological Studies**

Neurological models of OCD have also emphasised that abnormalities in the prefrontal cortex circuits play a key role in children and adolescents with OCD (Friedlander & Desrocher, 2006; Giedd et al., 2000; Rotge et al., 2008; Szeszko et al., 2004; Viard et al., 2005; Whiteside, Port, & Abramowitz, 2004; Woolley et al., 2008). Recent neuroimaging studies have demonstrated structural and functional abnormalities in the anatomical regions of the prefrontal cortex that are involved in EF in children and adolescents with OCD. To clarify underlying neurological causes of OCD, researchers have employed various neuroimaging techniques such as structural and functional magnetic resonance imaging (MRI), positron emission tomography (PET), and single photon emission computerised tomography (SPECT).

**Structural Neuroimaging Studies**

Prior structural neuroimaging studies have consistently identified structural abnormalities indexed by anatomical abnormalities in the volume of prefrontal cortex regions in children and adolescents with OCD using structural MRI techniques (Friedlander & Desrocher, 2006; Rotge et al., 2008; Szeszko et al., 2004; Whiteside, Port, & Abramowitz, 2004). Findings of structural abnormalities in regions of the prefrontal
cortex have also been replicated in numerous studies of adults with OCD (Grachev et al., 1998; Jenike et al., 1996; Menzies et al., 2007; Pujol et al., 2004). It has been theorised that structural abnormalities in the orbitofrontal cortex, anterior cingulate cortex, and the basal ganglia region play a key role in the manifestation and mediation of OCD. In particular, structural imaging studies have elucidated increased anterior cingulate and thalamic volumes, but have identified reduced striatal (especially caudate nucleus) volumes in children and adolescents with OCD (Friedlander & Desrocher, 2006; Gilbert et al., 2000; Rosenberg, MacMillan, & Moore, 2001; Rotge et al., 2008; Szeszko et al., 2004). Evidence indicates that abnormalities in orbitofrontal and basal ganglia regions identified in children and adolescents with OCD may represent distinct structural profile compared to anxiety and depressive disorders (Brambilla et al., 2002).

**Functional Neuroimaging Studies**

Functional MRI studies support the notion that structural abnormalities in key prefrontal cortex regions may contribute to the functional disruptions in cerebral regions identified in children and adolescents with OCD (Friedlander & Desrocher, 2006; Rauch et al., 2007; Viard et al., 2005; Woolley et al., 2008). Functional abnormalities have been identified in the key prefrontal cortex regions including the orbitofrontal cortex, anterior cingulate cortex, and the basal ganglia region (especially the caudate nucleus, gyrus, and thalamus). PET and SPECT studies substantiate findings of functional abnormalities in glucose metabolism and regional cerebral blood flow (rCBF) in children and adolescents (Busatto et al., 2000; Busatto et al., 2001; Castillo et al., 2005; Diler, Kiba, & Avci, 2004; Whiteside, Port, & Abramowitz, 2004).
Functional neuroimaging studies have consistently identified hyperfrontality (increased right and left anterior prefrontal cortex activity and increased anterior cingulate gyrus activity) and increased basal ganglia activity in children and adolescents with OCD (Busatto et al., 2000; Busatto et al., 2001; Castillo et al., 2005; Diler, Kiba, & Avcı, 2004; Friedlander & Desrocher, 2006; Whiteside, Port, & Abramowitz, 2004; Woolley et al., 2008). In contrast to OCD, children and adolescents with different anxiety disorders like social anxiety often exhibit abnormal activation of the amygdala and hippocampus (Kent & Rauch, 2004; Stein et al., 2002; Tillfors et al., 2002). These findings indicate that the pathophysiology of OCD in childhood differs from other anxiety disorders (Kent & Rauch, 2004; Mataix-Cols & van den Heuvel, 2006).

Electroencephalogram (EEG) Studies

The findings of the quantitative EEG studies have been limited to OCD adult populations. The findings of recent EEG studies in adults with OCD have identified considerable increases in delta and theta activity and decreases in beta activity of the left prefrontal cortex region (Bucci et al., 2004; Desarkar et al., 2007; Karadag et al., 2003; Leocani et al., 2001; Shin et al., 2004; Tot et al., 2002). Furthermore, EEG studies also support the notion that OCD is a hyperfrontal condition, with key abnormalities in the left prefrontal regions and with the right hyperfrontal condition being part of a compensatory mechanism (Shin et al., 2004).
Neurochemical Studies

The serotonin and dopamine networks densely connect most regions involved in OCD (Carlsson, 2000; 2001; Denys, Zohar, & Westenberg, 2004; Hesse et al., 2005). Neurochemical studies of OCD have revealed a key serotonin dysfunction in children and adolescents with OCD with some research that implicates reduced serotonin (Stengler-Wenzke et al., 2004), while others research implicates increased serotonin (Pogarell et al., 2003; Tallis, 1995). Support for the serotonin hypothesis is drawn from pharmacotherapy studies that show a significant reduction of OCD symptoms following treatment with serotonin reuptake inhibitors (SRIs) (Abramowitz, Whiteside, & Deacon, 2005; Geller et al., 2003b; Grados, Seahill, & Riddle, 1999; Micallef & Blin, 2001; Simpson et al., 2008). Further support for a serotonin hypothesis of OCD comes from studies that have demonstrated decreased density of the platelet serotonin transporter in children and adolescents with OCD, compared to children and adolescents with TD (Sallee et al., 1996; Weizman et al., 1992). Despite the fundamental role played by serotonin in OCD, there is emerging evidence that serotonin may not play as important a role compared to other neurotransmitters (Denys, Zohar, & Westenberg, 2004). The most widely accepted alternative neurochemical theory for OCD suggests that the dopamine neurotransmitter system may also be important in the pathophysiology of OCD (Carlsson, 2000, 2001; Denys, Zohar, & Westenberg, 2004; Hesse et al., 2005).

Neuropharmacological Studies

Neuropharmacological studies have implicated several central neurotransmitter systems in the pathophysiology of OCD. The strongest pharmacological evidence
concerns the serotonin system and the well-established efficacy of serotonin reuptake inhibitors in the treatment of OCD (Ackerman & Greenland, 2002; Geller et al., 2003b; Micallef & Blin, 2001; Simpson et al., 2008). In children and adolescents, studies have provided strong support for the involvement of the serotonin system in the pathophysiology of OCD. Treatment studies have identified that serotonin reuptake inhibitors (SRI) and selective serotonin reuptake inhibitors (SSRI) pharmacological interventions ameliorate abnormalities in the prefrontal cortex in children, adolescents, and adults with OCD (see Ackerman & Greenland, 2002; Geller et al., 2003b; Micallef & Blin, 2001; POTS, 2004; Simpson et al., 2008). Although there is persuasive evidence for the effectiveness of serotonin in treatment of OCD, the ineffectiveness of serotonin medication in some children and adolescents has substantiated the notion that dopamine neurotransmitters may also be involved in the pathophysiology of OCD (Denys, Zohar, & Westenberg, 2004; Flament & Cohen, 2000; Hesse et al., 2005). The most compelling evidence for the involvement of dopamine in OCD comes from the treatment benefits obtained through the administration of dopamine blockers and SRIs in a subset of OCD (Abramowitz, Whiteside, & Deacon, 2005; Carlsson, 2001; Hemmings et al., 2003; Shafran, 2001).

**Genetic Factors**

Genetic factors historically have been thought of as important in increasing the susceptibility to OCD, and results from family, twin, and key candidate molecular genetic studies suggest that the transmission and the expression of OCD is genetically mediated (Hanna et al., 2005; Nestdat et al., 2000; Pauls, 2008). Adoption studies are generally
rare, and no such studies have been published on OCD. Taken together, recent genetic findings implicate the basal ganglia as a key brain region in OCD, and which also appears to be genetically linked to other disorders, such as tic disorders (Asbahr et al., 2005; Hollander et al., 2007; Storch et al., 2007b; Swedo et al., 1998). Key genetic findings will now be discussed.

**Family Studies**

A number of family studies of children and adolescents with OCD have provided evidence for genetic patterns. The findings of five early family studies have suggested that OCD tends to run in families and that childhood onset OCD appears to have a stronger familial nature than adult onset (Bellodi et al., 1992; Black, Noyes, Goldstein, & Blum, 1992; Lenane et al., 1990; Pauls et al., 1995; Riddle et al., 1990). Familial associations between children and adolescents with OCD and first-degree relatives have been demonstrated in more recent studies (Albert et al., 2002; Bienvenu et al., 2000; Grabe et al., 2006; Hanna et al., 2005; Nestadt et al., 2000; do Rosario-Campos et al., 2005). The risk for OCD in first degree relatives of those with OCD is 3 to 12 times higher than in the general population (Grados, Walkup, & Walford, 2003). Prevalence rates of OCD in first-degree relatives of children and adolescents with OCD vary from 8.7% - 25% (Bellodi et al., 1992; Grabe et al., 2006; Hanna et al., 2005; Lenane et al., 1990; Nestadt et al., 2000; do Rosario-Campos et al., 2005).

Even though the threshold for defining early onset OCD varies across studies, family studies provide strong evidence that childhood-onset of OCD is familial among first-degree relatives (Geller et al., 1998; Nestadt et al., 2000; Rosario-Campos et al.,
Additional investigations have also supported the hypothesis that OCD and tic disorders share some common genetic background. Familial factors (genetic or environmental) contribute significantly to OCD symptoms in families with TD, and the familial OCD phenotype may represent an alternate expression of tic disorders (Leckman et al., 2003; Pauls et al., 1995; Rosario-Campos et al., 2005).

**Twin Studies**

Only a few twin studies of OCD have been conducted to date. The literature from twin studies published to date indicate that concordance for OCD traits is higher in MZ than in DZ twins, with rates at approximately 67% for MZ twins and 31% for DZ twins in samples of children and adolescents (Andrews et al., 1990; Eley et al., 2003; Hudziak et al., 2004; van Grootheest et al., 2005). Twin studies of adults using a dimensional symptom approach also indicate that symptoms are heritable with rates for obsessions and compulsions ranging from 27% - 47% (Jonnal et al., 2000; Kim et al., 1990; Pauls, 2008; van Grootheest et al., 2005). In conclusion, twin studies of children and adults provide support for the hypothesis that genetic factors play a significant role in manifestation of OCD.

**Molecular Genetic Studies**

While research in the field of molecular genetics is still in its infancy, there have been promising findings emerging in the literature for identifying possible candidate genes associated with OCD (for review see Mundo, Zanoni, & Altamura, 2006). Molecular genetic studies have primarily considered genes of the serotonin and dopamine
systems, with promising results for the serotonin 1Dβ receptor gene (5HT1Dβ), serotonin transporter gene (SCL6A4) that encodes for the serotonin transporter protein (5-HTT), and the dopamine receptor 4 (DRD4) (see Hemmings & Stein, 2006; Hemmings et al., 2003; Pauls, 2008). The microdeletions on the gene encoding for catecholamine-O-methyl-transferase (COMT) located on chromosome 22, which leads to a rare congenital malformation (velo-cardio-facial syndrome) has also been associated with the OCD (Mundo et al., 2006). More recently, some interesting data on the possible involvement of glutamate system genes also have been published (Hemmings & Stein, 2006). Most of the genetic studies appear to be heterogeneous with respect to the variables that clinically define children and adolescents with OCD (i.e., age at onset, symptom profile, familial versus sporadic cases). This heterogeneity may be a significant source of variability of the results, thus suggesting the need to better define OCD in more biologically homogenous subgroups.

**Psychological Factors**

**Cognitive and Behavioural Models**

Cognitive models offer the most widely accepted psychological account of OCD as it presents in children and adolescent populations (Frost & Steketee, 2002; March & Mulle, 1998; Matthews, Reynolds, & Derisley, 2007; Turner, 2006). Current psychological models of OCD within a cognitive framework propose that the way in which children and adolescents interpret normal intrusive thoughts is a key maintaining factor (Frost & Steketee, 2002; Salkovskis, 1999; Salkovskis, Forrester, & Richards, 1998; Turner, 2006). The essence of the cognitive model is that there is an “inflated
belief in the probability of being the cause of serious harm to others or self, or failing to avert harm where this may have been possible” (Salkovskis, 1985, p. 575). This leads to increased discomfort and anxiety, increased salience of intrusive thoughts, and neutralising behaviours. However, there is little evidence to suggest these beliefs play a causal role in the aetiology of OCD, although accumulating evidence suggests that a range of beliefs including responsibility, the need to control thoughts, and thought-action fusion may play a maintaining role (Frost & Steketee, 2002; March & Mulle, 1998; Matthews, Reynolds, & Derisley, 2007).

Behavioural models of OCD propose that compulsive behaviours are a form of avoidance that maintain obsessions to reduce or prevent anxiety, and to block opportunities for habituation to feared objects and situations (Kozak, Foa, & Clark, 2001). Subsequently, compulsions in children and adolescents become established and maintained through the reduction of subjective anxiety. Given that children and adolescents with OCD are often unable to recall a specific triggering event associated with symptom onset, behavioural conceptualisations have focussed on key factors like modelling, observation, and informational learning to explain the development of OCD in children and adolescents (Turner, 2006). A wide variety of evidence supports the addition of the cognitive component to the behavioural model and the perception of responsibility among children with OCD (Frost & Steketee, 2002; Salkovskis, 1999; Salkovskis, Forrester, & Richards, 1998). As a thorough review of cognitive and behavioural models findings is beyond the scope of this thesis, interested readers are directed to Turner (2006) for a recent review of these models in children and adolescents.
**Psychoanalytic Factors**

Psychoanalytic aetiological models of OCD emphasise the role of early sexual exposure and over-stimulation, the failure to resolve oedipal conflicts and the subsequent regression to anal-sadistic conflicts during the anal state of development during which toilet training typically occurs. Psychoanalytic theories also emphasise the central role of ambivalence, and defenses such as reaction formation, intellectualisation, and isolation. This reportedly lead to later characteristics of rigidity and over-control among other traits in OCD (Bhar & Kyrios, 2007; Bram & Björgvinsson, 2004; Kempke & Luyten, 2007; McGehee, 2005). This model, however, does not offer a full aetiological account of OCD because there is a lack of empirical support for the major tenets of the theory, and in light of the poor response that patients with OCD have to psychoanalytic forms of treatment (Steketee & Nishith, 1995).

**Psychosocial Risk Factors**

**Adverse Life Events**

Compelling evidence from a variety of studies suggests that early adverse life stress constitutes a major risk factor for the development and persistence of OCD (Cromer, Schmidt, & Murphy, 2007; de Silva & Marks, 1999; Heim & Nemeroff, 2001; Lochner et al., 2002). For example, early parental loss, prenatal stress, child neglect or sexual, physical or emotional abuse has been found to be related to OCD, beyond familial or genetic factors. This does not mean that the events are in themselves causal, but rather that life events can trigger factors for children or adolescents who might be predisposed biologically or genetically to OCD. In addition, the content of OCD symptoms may
increase as stress levels rise in response to life situations. The type of event is probably less important than how it is experienced by the child or adolescent (Cromer, Schmidt, & Murphy, 2007; de Silva & Marks, 1999).

**Family Factors**

Family psychosocial factors like socioeconomic status, exposure to parental or child psychopathology, family conflict and cohesiveness, marital discord/divorce, number of siblings and birth order have been implicated in the onset or exacerbation of OCD (Chambless et al., 2007; Hirshfeld-Becker et al., 2004). However, results from recent findings do not provide evidence that psychosocial adversity factors in families play a direct causal role in the onset of OCD in children and adolescents (Hirshfeld-Becker et al., 2004). There is strong evidence, however, to indicate that there are adverse impacts of OCD on families in a number of ways such as worry, the burden of care, and distress of parents at their limited ability to help the child or adolescent with OCD. In some cases, family accommodation to children’s rituals is often at significant cost to family members in terms of effort, time, and distress (Storch et al., 2007a).

**Section Summary**

Numerous aetiological risk factors have been implicated in the onset of OCD. These factors include key biological factors identified by neuropsychological, neuroimaging, neurochemical, and pharmacological studies. Biological models of OCD indicate that dysfunction in the orbitofrontal cortex, anterior cingulate cortex, and the basal ganglia region plays a key role in the manifestation and mediation of OCD. These
dysfunctions appear to play an essential role in the presentation of EF deficits, particularly in visuospatial working memory and attentional set shifting tasks. However, the exact nature of EF deficits in children and adolescents with OCD remains poorly understood. In addition, biological studies have identified abnormalities in the serotonin and dopamine systems. Genetic family and twin studies have provided key evidence that OCD tends to run in families. Findings of familial association have been substantiated by recent molecular genetic studies that have identified several candidate serotonin and dopamine genes. Psychosocial risk factors such as family dysfunction, stressful life events, and parental psychopathology are likely to exacerbate OCD symptomatology, but are unlikely to play a major aetiological role.

**Treatment**

The extensive evidence available regarding the treatment of childhood or adolescent OCD has helped to identify two effective treatment approaches, cognitive-behavioural interventions and pharmacotherapy medication. This section briefly examines the literature on these two approaches to the treatment of OCD in children and adolescents. The efficacy of psychodynamic, supportive, and family therapy, as well as other non-CBT psychosocial approaches have yet to demonstrate treatment effectiveness in children and adolescent OCD and therefore will not be addressed.
Cognitive and Behavioural Interventions

Cognitive-behavioural therapy (CBT) has emerged as the most efficacious psychosocial treatment to date for children and adolescents with OCD (Franklin et al., 1998; Freeman et al., 2007; March & Mulle, 1998; March, Franklin, Nelson, & Foa, 2001; Piacentini et al., 2002; Turner, 2006; Wagner, 2003). CBT interventions are based on the premise that beliefs, feelings, and thoughts are key determinants of behaviour. In particular, exposure and response prevention (ERP) has proven to disrupt the negative reinforcement cycle and allows for habituation of anxiety by systematically triggering the obsession through imaginal exposure, while simultaneously encouraging the child to refrain from ritualising (March & Mulle, 1998; March, Franklin, Nelson, & Foa, 2001; Turner, 2006; Wagner, 2003).

Multiple controlled trials have provided strong evidence regarding the efficacy of CBT in the treatment of children and adolescents, yielding response rates ranging from 60% - 100%, and symptom reduction rates of 50% - 67%, with maintenance of treatment benefits lasting for up to 18 months (see March, Franklin, Nelson, & Foa, 2001, for reviews; Silverman & Hinshaw, 2008; Turner, 2006; Watson & Rees, 2008). One recent Australian randomised controlled trial found that group CBT family therapy was as effective as individual CBT treatment in children and adolescents with benefits lasting for up to 18 months post-treatment (Barrett, Healy-Farrell, & March, 2004).

Pharmacotherapy Interventions

The pharmacological interventions used by children and adolescents with OCD have recently been reviewed (Abramowitz, Whiteside, & Deacon, 2005; Fineberg & Gale, 2005; Geller et al., 2003b; Kobak et al., 2004; Watson & Rees, 2008). Arguments for the
biological basis of OCD hypothesise that abnormal serotonin metabolism causes symptoms as the result of abnormally triggered brain activity. In particular, it has been demonstrated that serotonin reuptake inhibitors (SRIs) and selective serotonin reuptake inhibitors (SSRIs) are effective in addressing OCD symptoms in children and adolescents.

**Effectiveness of Medications**

Numerous meta-analyses of pharmacotherapy studies have demonstrated significant reductions in the symptoms of children and adolescents with OCD (for meta-analysis reviews see Abramowitz, Whiteside, & Deacon, 2005; Fineberg & Gale, 2005; Geller et al., 2003b; Kobak et al., 2004; Watson & Rees, 2008). Randomised clinical trials have focused largely on SRIs (clomipramine), as well as SSRIs (sertraline, fluoxetine, paroxetine, or fluvoxamine). Pharmacological treatments appear to be significantly superior to placebo with positive treatment outcomes in up to 61% of children and adolescents, but the SRI clomipramine has been associated with significantly greater mean reduction of OCD symptoms compared to SSRI’s (Abramowitz, Whiteside, & Deacon, 2005; Fineberg & Gale, 2005; Kobak et al., 2004; Watson & Rees, 2008). No significant differences amongst the SSRIs have been identified (Geller et al., 2003b).

**Adverse effects of Medication**

Common adverse effects of SRI and SSRI pharmacological medication include nausea, diarrhoea, insomnia, loss of appetite, sedation, tremor, disinhibition, and mania in children and adolescents with OCD (March, Frances, Kahn, & Carpenter, 1997). For most pharmacological medications, the discontinuation of treatment is associated with
symptomatic relapse, irrespective of treatment duration (Abramowitz, Whiteside, & Deacon, 2005; Geller et al., 2003b; Swanson et al., 2008), although reinstatement of medication often results in improvement to a level close to pre-discontinuation. The Expert Consensus Guidelines (March et al., 1997) recommended pharmacotherapy maintenance for 3 to 6 months after treatment, reserving long-term treatment only for subsequent relapses. Recent studies strongly emphasise the importance of long-term treatment, with recommendations by some researchers of at least one year of continued treatment following successful treatment outcomes (Leonard et al., 2005).

**Combined Interventions**

Combined CBT and pharmacotherapy treatments have been demonstrated to be the most effective strategy in the reduction of symptoms in children and adolescents with OCD (see Abramowitz, Whiteside, & Deacon, 2005; Foa et al., 2005; Kobak et al., 2004; POTS, 2004; Simpson et al., 2008; Watson & Rees, 2008). Recent meta-analyses of treatment using randomized controlled studies in children and adolescents with OCD have found that the combination of CBT and pharmacotherapy is the most efficacious treatment intervention with remission and treatment completion response rates, respectively at approximately 70% and 79% (Abramowitz, Whiteside, & Deacon, 2005; Foa et al., 2005; POTS, 2004; Watson & Rees, 2008). The management of OCD with CBT interventions is maximised when combined with pharmacotherapy, therefore giving a child or adolescent the necessary “tool kit” to manage their condition and protect against treatment loss (March & Mulle, 1998). These findings support the use of CBT as the first-line treatment of choice with the addition of medication only if necessary (Watson & Rees, 2008).
Impact of Comorbid Disorders on the Treatment of OCD

Many children and adolescents with OCD also meet diagnostic criteria for comorbid conditions such as disruptive behavioural, depressive, anxiety, and tic disorders. The results of two recent studies show that comorbid conditions adversely impact on treatment response to CBT and pharmacotherapy, and significantly increase the risk of relapse in children and adolescents with OCD (Geller et al., 2003c; Storch et al., 2008). The study by Storch et al. (2008) identified that the number of comorbid conditions (particularly disruptive behaviour disorders and major depressive disorder) was negatively related to CBT treatment response, and lower remission rates (Storch et al., 2008). Similarly, the pharmacotherapy treatment study by Geller et al. (2003c) identified that treatment response to SSRIs in children and adolescents with comorbid ADHD (56%), ODD (39%), or tic disorder (53%) were significantly less than children and adolescents with OCD only (75%). The number of comorbid conditions was also related to high relapse rates of up to 56% in comparison to relapse rates of 32% in children with OCD only. These findings elucidate the need for appropriate individual assessment before treatment of OCD to treat comorbid conditions before or during CBT to improve treatment outcomes in children and adolescents (Storch et al., 2008).

Section Summary

OCD is a heterogeneous condition characterised by impairments in social, academic, and intellectual functioning. CBT interventions have proven to be the efficacious treatment ascertained through symptom reduction, and low relapse rates. Pharmacological interventions have also shown to be effective as evidenced by the
reduction of OCD symptoms, but insufficient in the provision of long-term treatment outcomes and high relapse rates following discontinuation of medication. The first-line treatment approach for children and adolescents with OCD is CBT, with the combination of pharmacotherapy if necessary. The impact of common comorbid disorders associated with OCD need to be taken into account in the consideration of appropriate treatment intervention(s).
Chapter Summary

OCD is a common childhood condition characterised by recurrent obsessive thoughts and repetitive compulsions that significantly interfere with the child’s social, academic, and intellectual functioning. Prevalence studies indicate that OCD affects between 1% - 2.3% of children and adolescents. Early onset often occurs between the ages of 6 to 15 years, and is more prevalent in males than females. For the most part, onset is gradual with a chronic waxing and waning course that often persists late into adulthood. OCD is further complicated by comorbid conditions such as disruptive behavioural disorders, anxiety disorders, depressive disorders, tic disorders, obsessive-compulsive spectrum disorders, pervasive developmental disorder, and neurological medical conditions. Evidence from neuropsychological, neuroimaging, neurochemical, and pharmacological studies collectively implicate key functional and structural abnormalities within the orbitofrontal cortex, anterior cingulate cortex and the basal ganglia regions. Biological models also suggest that abnormalities in the serotonin and/or dopamine systems in the prefrontal cortex are linked to EF deficits in children and adolescents with OCD. Key genetic aetiological risk factors indexed through family and twin studies indicate that early onset of OCD in childhood is frequently familial. Findings from molecular genetic studies implicate various serotonin and dopamine transporter and receptor genes. Even though OCD most likely has a biological or genetic basis, psychosocial, cognitive and behavioural models offer useful frameworks for understanding the maintenance of OCD. Treatment using CBT interventions, along with pharmacotherapy, have proved to constitute the first-line treatment option for children and adolescents with OCD.
CHAPTER 3
COMORBID ATTENTION DEFICIT HYPERACTIVITY DISORDER
AND OBSESSIVE-COMPULSIVE DISORDER

Introduction

Attention Deficit Hyperactivity Disorder (ADHD) and Obsessive Compulsive Disorder (OCD) are common childhood conditions that share key clinical, behavioural and cognitive correlates. The association between comorbid ADHD and OCD has been documented multiple times (Arnold et al., 2005; Geller et al., 2002; Geller et al., 2003a; Geller et al., 2004; Masi, 2006; Sukhodolsky et al., 2005). The systematic investigation of key characteristics of comorbid ADHD and OCD has been relatively neglected in the literature of childhood disorders. The purpose of this chapter is to provide an overview of research regarding children and adolescents with comorbid ADHD and OCD with respect to the definition of comorbidity, key artifactual and factual explanations to account for the presence of comorbid ADHD and OCD, epidemiology, course and prognosis, key comorbid conditions, aetiological risk factors, and treatment interventions.

Definition of Comorbidity

The term comorbidity was first introduced in the literature by Feinstein (1970) to refer to “any distinct additional entity that has existed or that may occur during the clinical course of a patient who has the index disease under study” (p. 467). There has been considerable controversy since that time regarding the use of the term comorbidity. The primary reason for this concern is highlighted in the definition provided by Caron and Rutter (1991) that comorbidity is the “simultaneous occurrence of two or more
unrelated conditions” (Caron & Rutter, 1991, p. 1063). Without knowledge regarding the aetiology of coexisting disorders, one cannot be certain that children and adolescents who meet diagnostic criteria for more than one disorder actually have unrelated conditions. Another problem is the terms comorbidity, co-occurrence, and covariance have been used interchangeably in the literature even though they actually refer to three separate conditions. For the purpose of the present discussion the term comorbidity will be used to refer to the coexistence of two or more categorically defined and distinct disorders in the same child or adolescent at a rate higher than expected by chance alone (Jensen, 2003; Lilienfeld, 2003).

**Explanation of Comorbidity**

ADHD and OCD are common childhood conditions, although in many regards they appear to be different with respect to behavioural and cognitive impairments. Despite considerable evidence for the prevalence of comorbidity of these two conditions, the reasons behind this overlap have yet to be fully understood. Numerous potential reasons have been advanced to explain the comorbidity between two disorders such as comorbid ADHD and OCD in the general domain of psychopathology. These reasons will be reviewed, although full descriptions of these reasons will not be reiterated in this thesis. Fuller considerations of the reasons for comorbidity are provided in more detail elsewhere (see Caron & Rutter, 1991; Keiley et al., 2003; Neale & Kendler, 1995; Rhee et al., 2005). Diagnostic comorbidity is the rule rather than the exception in both DSM-IV and ICD-10. Two types of comorbidity include true factual comorbidity (genuine causal relation between clinically distinct
entities) and artifactual comorbidity (a by-product of an inaccurate observation, effect, or result from scientific investigations, or from the DSM/ICD strategy to split categorical diagnoses) (Caron & Rutter, 1991).

**Artifactual Explanations**

Comorbidity may often be seen as an artefact for several reasons. First, artifactual comorbidity may be a result of shortcomings associated with referral or informant biases, which are particularly relevant to clinical populations where the rate of comorbidity tends to be greater than in the general population (Angold, Costello, & Erkanli, 1999). This is often because children or adolescents with more than one disorder are more likely to seek treatment. Therefore, some comorbid disorders observed in clinical samples may simply be a product of bias given the combined probabilities for referral of each disorder. In this study, a multi-method assessment and diagnosis of ADHD and OCD, involving a varied cross section of parent, child, and clinician respondents, using categorical and dimensional sources offers the most reliable, comprehensive and informative approach.

Second, artifactual comorbidity may result from the type of definitions used in a classification system (categorical or dimensional) because some systems do not distinguish or discriminate well between clinical disorders (Caron & Rutter, 1991). The association between two disorders may actually be the result of overlapping diagnostic criteria or the result of arbitrary diagnostic distinctions between different syndromes that may be variations of the same underlying disorder. The present study tried to avoid ‘nosological confusion’ by using the current gold-standard approach for ensuring valid
diagnostic information of ADHD and OCD through the integration of categorical and
dimensional approaches (Cantwell, 1996; Clark, Watson, & Reynolds, 1995).

Third, one disorder may, through its effects and severity, cause the other disorder
by influencing the developmental trajectory and placing a child or adolescent at increased
risk for further difficulties (Caron & Rutter, 1991). Therefore, comorbid ADHD and
OCD may be the result of severe psychopathology of the primary disorder that results in
the development of a secondary disorder. In the present study, children and adolescents
with comorbid ADHD and OCD were put into a group to ascertain whether symptom
severity had an additive impact on functional impairment compared to children and
adolescents with ADHD or OCD. Fourth, artifactual comorbidity may also result from
the fact that, especially with younger children, what looks like comorbidity may reflect
relatively non-specific expressions of psychopathology that is associated with lowered
levels of cognitive development, as opposed to more clearly articulated examples of
psychopathology that are more likely to be seen in older children and adolescents.
Artifactual reasons for comorbidity need to be ruled out before attempting to understand
the aetiological underpinnings of comorbid disorders.

Factual Explanations

Several factual explanations have also been put forward to account for the general
comorbidity between two disorders like comorbid ADHD and OCD (Caron & Rutter,
1991; Neale & Kendler, 1995). First, the comorbidity between two disorders may be
explained by shared underlying aetiological causal risk factors (biological, genetic, and/or
environmental) that are consequently not specific to either disorder. Second, the presence
of one disorder may cause symptoms or constitute a risk factor for the development of the second disorder (Geller et al., 2002, 2003a). Third, the comorbidity of two disorders may represent a hybrid disorder that shares the unique characteristics of each disorder. Fourth, the comorbidity of two disorders may represent a distinct homogenous subtype of the primary disorder. Fifth, the comorbidity of two disorders may represent a third unique disorder with different aetiological risk factors and differential level of impairment. The additive combination of the symptoms presented by both disorders may distinguish it compared to when two single homogenous clinical disorders occur alone. Detailed explanations of factual models of comorbidity are contained in Neale and Kendler (1995).

**Section Summary**

Comorbidity is the term used to refer to the coexistence of two or more categorically defined and distinct disorders in the same child or adolescent. Numerous artifactual and factual explanations have been put forward to explain how a child or adolescent can present with two different disorders simultaneously. A comparison between key artifactual (sampling bias, problems with diagnostic systems, symptom severity) and factual explanations (the association between causal risk factors) of comorbidity is important in understanding the key implications that comorbid ADHD and OCD has on diagnosis, prognosis, and treatment response in children and adolescents compared to pure forms of ADHD or OCD.
Definition

Core Symptoms

A diagnosis of comorbid ADHD and OCD requires the child or adolescent to meet the diagnostic criteria for both disorders as defined in DSM-IV (American Psychiatric Association, 2000). ADHD is a chronic and pervasive condition characterised by developmentally inappropriate levels of inattention, hyperactivity and/or impulsivity. OCD is a chronic and debilitating condition characterised by recurrent obsessive thoughts and compulsive repetitive behaviours (American Psychiatric Association, 2000). Several recent studies have identified that children and adolescents with comorbid ADHD and OCD have more impaired social, family, academic, and intellectual functioning as compared to children and adolescents with either ADHD or OCD alone (Arnold et al., 2005; Geller et al., 2002; Geller et al., 2003a; Geller et al., 2004; Masi et al., 2006; Sukhodolsky et al., 2005). These studies strongly indicate that the presence of comorbid ADHD and OCD reflects the independent contribution of core symptoms and affiliated functional psychosocial impairments from both disorders.

Epidemiology

Prevalence

As previously stated, ADHD and OCD are two of the most common childhood conditions with prevalence rates between 3% - 7%, and 1% - 2.3%, respectively (American Psychiatric Association, 2000). The prevalence rates of comorbid ADHD and OCD in children and adolescents varies widely. Numerous studies of children and adolescents with OCD have reported rates of ADHD ranging between 10% - 50% (Geller
et al., 1996; Geller et al. 2000; Geller et al., 2001a; Geller et al., 2003a; Hanna, 1995; Masi et al., 2006; Sukhodolsky et al., 2005; Vallen-Basile et al., 1994). However, the prevalence rate of OCD among children and adolescents with ADHD is estimated to be 8% - 11% (Arnold et al., 2005; Jensen et al., 2001; Jensen, Martin, & Cantwell, 1997). Clearly, there is a greater than chance association of ADHD and OCD.

**Gender**

Comorbid ADHD and OCD in children and adolescents is associated with a higher rate of males than females, with gender ratios as high as 9 to 1 (Geller et al., 2002; Geller et al., 2003a; 2003b; Masi, 2006; Sukhodolsky et al., 2005). The male profile is associated with early pre-pubescent onset, familial association, and comorbid tic disorder, while the female profile is associated with pubertal or adolescent onset (Arnold et al., 2005; Geller et al., 2002). These findings are consistent with prevalence rates of male and female children with ADHD or OCD alone (American Psychiatric Association, 2000).

**Cultural and Ethnic Factors**

The role of cultural and ethnic factors in the diagnosis of comorbid ADHD and OCD has not been extensively examined. The few studies that have investigated cultural or ethnic factors have identified that the population sample has been mostly Caucasian, making it difficult to generalise findings to other cultural or ethnic populations (Geller et al., 2007a; Sukhodolsky et al., 2005).
Socioeconomic Factors

Studies investigating the role of socioeconomic status have revealed that families of children and adolescents with comorbid ADHD and OCD do not differ from children with ADHD or OCD on four key socioeconomic factors. These factors include education, occupation, income or marital status (Geller et al., 2002; Geller et al., 2003a; Geller et al., 2004; Geller et al., 2007a; Sukhodolsky et al., 2005). However, families of children with comorbid ADHD and OCD reportedly have significantly lower levels of socioeconomic status than healthy control children (Geller et al., 2002).

Course and Prognosis

Age of Onset

The onset of ADHD often precedes the onset of OCD (Geller, 2002, 2003a; Geller, 2004; Masi, 2006). The mean age at onset for ADHD of approximately 4 years is significantly lower than the age at onset of OCD at approximately 6.8 years (Geller et al., 2002). These findings indicate that childhood early onset OCD may represent a developmental subtype of OCD characterised by high levels of comorbidity with ADHD, male preponderance, and stronger familial association than late onset (Geller et al., 2003a; Geller et al., 2007a). Despite these findings, it has been argued that ADHD symptoms of inattentiveness and distractibility may represent secondary symptoms due to the interference caused by obsessive thoughts from OCD psychopathology. However, because ADHD symptoms typically appear several years before the onset of OCD symptoms in childhood OCD cases, the contention that ADHD symptoms are simply secondary symptoms of OCD is not generally supported (Geller et al., 2002; Geller et al., 2003a).
**Course**

The functional impairment associated with comorbid ADHD and OCD is reflected in the number of social, family, academic, and intellectual deficits. In addition, comorbid ADHD and OCD is associated with additional comorbid disorders and poorer treatment outcomes relative to children and adolescents with ADHD or OCD alone (Arnold et al., 2005; Geller et al., 2003a; Masi et al., 2006; Sukhodolsky et al., 2005). The hypothesis that children with comorbid ADHD and OCD are afflicted with the full additive psychosocial burden of each disorder, and display greater impairment relative to children with ADHD or OCD only has received strong support (Arnold et al., 2005). The natural course of comorbid ADHD and OCD remains unclear, making it difficult to disentangle the contribution of each disorder to impairment and outcomes. Whether OCD moderates the symptoms of ADHD, or whether ADHD moderates the symptoms of OCD, and thereby substantially changing the presentation and course of both disorders remains to be explored.

**Section Summary**

Comorbid ADHD and OCD are both childhood onset disorders. The prevalence rate of ADHD ranges from 10% - 50% in OCD populations, while the prevalence of OCD ranges between 8% - 11% in ADHD populations. Onset of ADHD by 4 years often precedes the onset of OCD by 7 years. The development of comorbid ADHD and OCD is also associated with male prevalence, additional comorbid disorders, and familial association. Clinical features such as cultural factors have not been thoroughly examined, although the low parental socioeconomic status of children with comorbid
ADHD and OCD is similar to the parental socioeconomic status of children with either ADHD or OCD. While little is known about the course outcome of comorbid ADHD and OCD, evidence supports the argument that children experience the full burden of each disorder with additive effects on academic, social, and family functioning. This suggests poorer treatment outcomes relative to children and adolescents with ADHD or OCD.

**Key Comorbid Conditions**

Children and adolescents with comorbid ADHD and OCD have been shown to have significantly higher rates of additional comorbid disorders. Additional comorbid disorders affect treatment outcomes and elevate the level of impairment in social, emotional, behavioural and cognitive functioning (Geller et al., 2002; Geller et al., 2004; Masi et al., 2006). Key comorbid conditions associated with comorbid ADHD and OCD will be discussed next.

**Disruptive Behavioural Disorders**

The most common additional disorders with comorbid ADHD and OCD are oppositional defiant disorder (ODD) and, to a lesser extent, conduct disorder (CD). The prevalence of ODD in children and adolescents with comorbid ADHD and OCD varies between 37% – 61.7% (Arnold et al., 2005; Geller et al., 2003a; Geller et al., 2004; Masi et al., 2006; Sukhodolsky et al., 2005). CD is significantly less prevalent, but prevalence rates vary considerably between 0% - 17% in children and adolescents with comorbid ADHD and OCD (Geller et al., 2003a; Geller et al., 2004; Sukhodolsky et al., 2005). The presence of comorbid disruptive behaviour disorders in children and adolescents with
comorbid ADHD and OCD is associated with more pronounced social, academic, and intellectual impairments, as well as poorer treatment outcomes compared to children with ADHD or OCD alone (Geller et al., 2003a; Geller et al., 2003c; Geller et al., 2004; Masi et al., 2006). The high rates of ODD and/or CD may reflect the increased anxiety, but decreased behavioural inhibition experienced simultaneously by children and adolescents with comorbid ADHD and OCD. Therefore, OCD may moderate the expression of ODD and/or CD in children with comorbid ADHD and OCD (Geller et al. 2003a).

**Anxiety Disorders**

The presence of one or more additional anxiety disorders [agoraphobia (AGOR); generalized anxiety disorder (GAD); panic disorder (PD); post-traumatic stress disorder (PTSD); separation anxiety disorder (SAD); social phobia (SOP); and specific phobia (SP)] in children and adolescents with comorbid ADHD and OCD is high with prevalence rates estimated at approximately 37% (Sukhodolsky et al., 2005). Recent studies that have examined the specific classifications of different anxiety disorders estimate the prevalence of comorbid GAD (37.5%), PD (12.5% - 14.9%), SOP (17.4% - 25%), SP (12.5% - 29.8%), AGOR, (31.9%), SAD (20.8% - 44.7%) is high in children and adolescents with comorbid ADHD and OCD (Geller et al., 2004; Masi et al., 2006). The presence of additional comorbid anxiety disorders has been shown to exacerbate emotional, social, academic, and intellectual impairments in children and adolescents with comorbid ADHD and OCD (Geller et al., 2004; Masi et al., 2006; Sukhodolsky et al., 2005). The comorbidity of anxiety disorders appears to be uniquely associated with OCD, and is not necessarily affected by the presence of comorbid ADHD (Masi et al., 2006).
Depressive Disorders

Children and adolescents with comorbid ADHD and OCD have shown higher rates of comorbid depressive disorders [either dysthymic disorder (DD) and/or major depressive disorder (MDD)] with estimates ranging from 16.7% - 33% (Masi et al., 2006; Sukhodolsky et al., 2005). A recent study identified that prevalence rates for MDD are estimated at 41.2% and DD at 8.8% in children and adolescents with comorbid ADHD and OCD (Geller et al., 2004). The relationship between comorbid ADHD and OCD and depressive disorders reflects the notion that additional disorders impact more significantly on a child or adolescents’ social, academic, and intellectual functioning (Arnold et al., 2005; Geller et al., 2004; Masi et al., 2006; Sukhodolsky et al., 2005).

Tic Disorders

Tic disorders are most prevalent in children and adolescents with comorbid ADHD and OCD with estimate rates ranging based on the presence of simple tics (8.8% - 10.6%) or chronic tics (5.9% - 8.5%), and with significantly higher rates of Tourette’s disorder (TD) (26.5% - 58%) (Geller et al., 2003a; Geller et al., 2004; Masi et al., 2006; Moll et al., 2000; Peterson et al., 2001; Sukhodolsky et al., 2005). Children and adolescents with tic disorders have increased rates of both ADHD and OCD in first-degree relatives which supports speculation than these disorders share common aetiological risk factors (Peterson et al., 2001; Sheppard, Bradshaw, Purcell, & Pantelis, 1999). TD in children and adolescent with comorbid ADHD and OCD is more often characterised by higher frequency aggressive behaviour and explosive outbursts, independent of age or tic severity (Stephens & Sandor, 1999). The pattern of
comorbidity indicates that TD may be responsible for a spectrum of disorders, including ADHD and OCD, but also that ADHD and OCD can exist independently with their own aetiologies (Sheppard et al., 1999).

Section Summary

The key comorbid disorders most often associated with the presence of comorbid ADHD and OCD are disruptive behaviour, anxiety, depressive, and tic disorders. Evidence from numerous comorbidity studies suggest the rate of additional comorbid disruptive behavioural, anxiety, depressive and tic disorders among children and adolescents with comorbid ADHD and OCD is less than those with either ADHD or OCD only. The presence of additional complex comorbid states in children and adolescents who present with comorbid ADHD and OCD has important clinical and research implications. It also stresses both the relevance of exclusionary criteria in research studies and the development of homogenous diagnostic classifications for both ADHD and OCD.

Aetiology

Various biological, genetic, and psychosocial risk factors have been implicated in the development of ADHD or OCD. A review of the literatures that focuses only on key aetiological risk factors associated with the development of comorbid ADHD and OCD will now be explored.
Biological Factors

The biological basis of comorbid ADHD and OCD is still poorly understood. However, key biological factors that implicate structural and functional abnormalities in the prefrontal cortex and connected regions have been associated with the development of comorbid ADHD and OCD in children and adolescents (Bradshaw & Sheppard, 2000; Carlsson, 2000; 2001; Schatz & Rostain, 2006). Information from neuropsychological studies, neurological studies, neurochemical studies, and pharmacological studies are discussed with reference to impairments in the prefrontal region that may play a key causal role in the development of comorbid ADHD and OCD.

Neuropsychological Studies

Neuropsychological studies that compare measures of executive function (EF) in children and adolescents with comorbid ADHD and OCD with children with either ADHD or OCD have not been conducted. Only one known study investigated EF inhibitory control abilities in children and adolescents with comorbid ADHD and OCD when compared to children with ADHD only and with healthy controls (Arnold et al., 2005). This study identified that both children with ADHD and children with comorbid ADHD and OCD had inhibitory control deficits as evidenced by increased scores on the Stop Signal Reaction Time (SSRT) paradigm compared with the healthy control group (Arnold et al., 2005). Several research studies have hypothesised that comorbid ADHD and OCD is a separate disorder with different patterns of cognitive deficits that are distinct from those of children and adolescents with ADHD or OCD alone (Geller, 2002, 2003a; Geller, 2004). On the other hand, there may also be significant overlap between
cognitive abnormalities present in ADHD or OCD (Schatz & Rostain, 2006). The present study sought to differentiate the neuropsychological profiles common and specific to children and adolescents with ADHD, OCD and comorbid ADHD and OCD relative to healthy control participants.

**Neurological Studies**

Neurological models of comorbid ADHD and OCD have emphasised the role of structural and functional abnormalities in key regions of the prefrontal cortex in children and adolescents with ADHD or OCD. Few studies have examined abnormalities in children and adolescents with comorbid ADHD and OCD. Studies have employed various neuroimaging techniques to ascertain the nature of the frontostriatal abnormalities in children and adolescents with comorbid ADHD and OCD. These include structural and functional magnetic resonance imaging (MRI), positron emission tomography (PET), and single photon emission computerised tomography (SPECT).

**Structural Neuroimaging Studies**

Explanations for the comorbidity and shared pathophysiology of ADHD and OCD implicate the involvement of structural frontostriatal and subcortical abnormalities (Bradshaw & Sheppard, 2000; Carlsson, 2001). In particular, the dorsolateral, orbitofrontal, and the anterior cingulate prefrontal cortices have been identified as in the development of comorbid ADHD and OCD (Carlsson, 2001). The aforementioned prefrontal systems are also thought to regulate the basal ganglia, particularly the striatum, in the pathology of comorbid ADHD and OCD (Bradshaw & Sheppard, 2000; Carlsson,
Investigations have led to the hypothesis that the striatum has both a direct excitatory pathway and an indirect inhibitory pathway (Bradshaw & Sheppard, 2000). The hypothesis that ADHD may be due to reduced frontostriatal activation in the dorsolateral and anterior cingulate prefrontal cortex regions, while OCD may result from poorly regulated inhibitory input to the orbitofrontal cortex has been put forward numerous times (Bradshaw & Sheppard, 2000; Carlsson, 2000, 2001; Schatz & Rostain, 2006). Future research should investigate the individual and shared structural abnormalities in children and adolescents with ADHD, OCD and comorbid ADHD and OCD.

*Functional Neuroimaging Studies*

The relationship between comorbid ADHD and OCD has supported speculation that the conditions may share common pathophysiology (Pauls et al., 1986b; Peterson & Klein, 1997). Abnormal activation in circuits of the prefrontal cortex, particularly cortical regions of the striatum and thalamus circuits, have been demonstrated for both disorders in functional neuroimaging studies, although the specific brain regions activated differ between ADHD and OCD (Fitzgerald, McMaster, Paulson, & Rosenberg, 1999; Sheppard, Bradshaw, Purcell, & Pantelis, 1999). An integrative theory of the above findings also postulates that subtle abnormalities in the prefrontal cortex circuit connecting the striatum and wider basal ganglia region (globus pallidus, thalamus, amygdala, caudate nucleus) are shared between ADHD and OCD, which in turn causes abnormal functional activity changes in the orbitofrontal cortex (Bradshaw & Sheppard, 2000; Carlsson, 2000, 2001; Schatz & Rostain, 2006).
Many indices of brain function appear to indicate that children and adolescents with ADHD have left hemisphere hypofunction (decreased anterior and dorsolateral prefrontal cortex activity and decreased anterior cingulate gyrus activity), and decreased basal ganglia activity. On the other hand, in OCD there may be left hemisphere hyperfunction (increased anterior and orbitofrontal cortex activity and increased anterior cingulate gyrus activity), and increased basal ganglia activity (Bradshaw & Sheppard, 2000; Carlsson, 2001). This theory is substantiated by findings from MRI and PET studies that have identified tic and TD in children and adolescents with comorbid ADHD and/or OCD. Each of these disorders involves impaired behavioural inhibition, possibly due to dysfunction within key prefrontal cortex circuits (Amat et al., 2006; Greenberg et al., 2000; Plessen et al., 2007; Rauch et al., 2001). Certain researchers believe that substantial post-pubertal reductions in the striatum in boys are linked to differences in the male predominance of OCD, along with TD and ADHD. This theory is consistent with the above assertions that basal ganglia pathology is central to both ADHD and OCD (Clayton, Richards, & Edwards, 1999; Schatz & Rostain, 2006).

**Electroencephalogram (EEG) Studies**

Electroencephalogram (EEG) studies of children and adolescents with comorbid ADHD and OCD have not been undertaken to date. However, independent EEG studies on ADHD (Snyder & Hall, 2006) and OCD (Desarkar, Sinha, Jagadheesan, & Nizamie, 2007) have identified increased delta and theta waves, but decreased beta activity waves. The similarity points towards a shared electrophysiological dysfunction in children and adolescents with comorbid ADHD and OCD. This particular hypothesis needs to be investigated in future EEG studies.
**Neurochemical Studies**

Detailed studies of children and adolescents with ADHD or OCD implicate underlying pathophysiological mechanisms involving interactions between dopamine, serotonin, and glutamate neurotransmitter systems (Carlsson, 2000; Hesse et al., 2005; Micallef & Blin, 2001; Solanto, 2002). Enhanced dopamine function in the prefrontal cortex is thought to cause hyperfunction in children and adolescents with OCD. In ADHD, reduced dopamine and glutamate function (perhaps the by product of fatigued cortico-striatal neurotransmitters) in the prefrontal cortex appear to cause hypofunction (Carlsson, 2000, 2001). Three possible explanations have been proposed to explain the neurochemical association of comorbid ADHD and OCD in children and adolescents. First, comorbid ADHD and OCD may exist in children and adolescents due to unstable prefrontal dopamine, serotonin, and glutamate systems fluctuating between hyperactivity, producing OCD symptoms, and hypoactivity, producing ADHD symptoms. Second, selected prefrontal dopamine, serotonin, and glutamate neurotransmitters may lead to hyperfunction, while simultaneously others lead to hypofunction. Third, dopamine, serotonin, and glutamate neurotransmitters in the prefrontal cortex may experience exhaustion following periods of hyperactivation and may intermittently lead to hypoactivation, hence causing ADHD symptomatology (Carlsson, 2000, 2001).

**Neuropharmacological Studies**

Pharmacological interventions have facilitated inferences about the neurobiological underpinnings of ADHD and OCD. Given that the most important treatments for ADHD (stimulant medications), and OCD (serotonin reuptake agents) do
not overlap, a careful diagnosis of each disorder can improve the effectiveness of
treatment of children and adolescents with comorbid ADHD and OCD (Geller et al.,
2004). An important mechanism of serotonin reuptake inhibitor (SRI) clomipramine and
selective serotonin reuptake inhibitors (SSRIs) in OCD is to decrease prefrontal and
caudate metabolism following clomipramine or SSRI treatment (Carlsson, 2000; Saxena
et al., 1998). Conversely, stimulant medications used to treat ADHD enhance dopamine
and glutamate activity primarily in the prefrontal cortex and striatum (Carlsson, 2000).

Preliminary evidence suggests that the presence of comorbid disruptive behaviour
disorders in children with OCD is associated with poorer treatment response to standard
SSRIs than children without disruptive behaviour disorders (Geller et al., 2003c).
Similarly, some theorists have hypothesised that children and adolescents with ADHD
treated with stimulant medications enhance dopamine function in the prefrontal cortex.
This may result in the enhanced activation of dopamine neurotransmitters, which in turn
adversely affect children and adolescents with OCD (Carlsson, 2000; Kouris, 1998).
Future pharmacological studies need to investigate the role of dopamine, serotonin, and
 glutamate in treatment studies of children with comorbid ADHD and OCD.

**Genetic Factors**

Both ADHD and OCD are common childhood disorders that share certain general
pathophysiological and aetiological features. Evidence from recent family studies (Geller
et al., 2007a, 2007b) and molecular genetic studies (Gothelf et al., 2007; Michaelovsky et
al., 2008) have provided strong evidence for the role of genetic aetiological factors in the
development of comorbid ADHD and OCD.
Family Studies

Family studies indicate that genetic risk factors are likely to play a major role in the aetiology of comorbid ADHD and OCD (Arnold et al., 2005; Geller et al., 2007a; Geller et al., 2007b). Two key family studies by Geller et al. (2007a, 2007b) helped clarify the familial nature of comorbid ADHD and OCD in children and adolescents by examining patterns of aggregation in first-degree relatives. These studies identified that the rates of ADHD were significantly elevated in first-degree relatives of children and adolescents with comorbid ADHD and OCD (15.3% - 18.9%) compared to healthy controls (4.6%). Prevalence rates of OCD were also significantly elevated among relatives of children and adolescents with comorbid ADHD and OCD (13% - 14.8%) compared to healthy controls (0.5%). These findings are consistent with the argument that ADHD and OCD are heritable conditions, with comorbid ADHD and OCD representing a unique familial subtype (Geller et al., 2007a, 2007b). Considerable indirect support for the notion that comorbid ADHD and OCD are genetically linked can be found in the literature using TD as a conceptual link between these two disorders. Family studies have demonstrated that TD and OCD as well as TD and ADHD are often comorbid and co-segregate within families (Faraone et al., 2001; Hanna et al., 2005; Pauls et al., 1995; Rosario-Campos et al., 2005; Sheppard et al., 1999).

Twin Studies

No twin studies have investigated the genetic relationship of children and adolescents with comorbid ADHD and OCD compared to unaffected siblings. However, independent twin studies implicate genetic factors as important in the expression of three
key childhood disorders, ADHD, OCD and Tic disorders (Andrews et al., 1990; Gjone et al., 1996; Hyde et al., 1992; Torgersen, 1983).

**Molecular Genetic Studies**

Given the frequent comorbidity that has been observed between ADHD and OCD, there may be common susceptible genes for comorbid ADHD and OCD which may result in several overlapping neurologically mediated behaviours (Geller et al., 2007a, 2007b). Therefore, the familial association is consistent with the background of a putative genetic association between comorbid ADHD and OCD. Molecular genetic studies have yet to investigate key common genes associated with comorbid ADHD and OCD in children and adolescents. Two recent studies suggested that abnormalities or the deletion of small pieces from Chromosome 22 in which catechol-O-methyltransferase (COMT) resides, is a major candidate gene for genetic susceptibility of ADHD and OCD in Velocardiofacial Syndrome (VCFS), and the possible cause in the inactivation of dopamine, serotonin, and noradrenaline neurotransmitters (Gothelf et al., 2007; Michaelovsky et al., 2008). Greatly altered COMT activity may be a risk factor for the development of ADHD and OCD. Future longitudinal studies focusing on additional COMT sites and other candidate genes from the deleted region may elucidate molecular pathways leading to comorbid ADHD and OCD.
Environmental Risk Factors

Pregnancy and Birth Complications

Evidence from several studies have implicated prenatal or perinatal complications as risk factors in the development of ADHD in various studies (Breslau et al., 1996; Milberger et al., 1997; Sykes et al., 1997; Szatmari et al., 1993), with less evidence that these factors contribute to the development of OCD. In a recent study, pregnancy and birth related factors were not identified as significant risk factors in children and adolescents with comorbid ADHD and OCD compared to children with ADHD and healthy controls (Arnold et al., 2005). The absence of elevated pregnancy and birth related risk factors in children with comorbid ADHD and OCD, is not consistent with previous findings of children with ADHD (Breslau et al., 1996; Milberger et al., 1997; Sykes et al., 1997; Szatmari et al., 1993).

Psychosocial Risk Factors

Adverse Life Events

Only one study to date has examined the role of adverse psychosocial risk factors in children and adolescents with comorbid ADHD and OCD (Arnold et al., 2005). Psychosocial risk factors were not identified as significant variables in children and adolescents with comorbid ADHD and OCD, or ADHD compared to healthy control children (Arnold et al., 2005). The absence of adverse psychosocial risk factors in children with comorbid ADHD and OCD, is not consistent with previous findings of elevated levels of adverse psychosocial events in children with ADHD (Johnson et al., 2001; Johnston & Mash, 2001; Pfiffner et al., 2001), or OCD (Cromer, Schmidt, & Murphy, 2007; de Silva & Marks, 1999; Heim & Nemeroff, 2001; Lochner et al., 2002).
Family Factors

The significance of adaptive and family functioning factors were recently examined in children and adolescents with comorbid ADHD and OCD compared to children with ADHD, OCD and healthy controls (Sukhodolsky et al., 2005). Elevated family dysfunction in children and adolescents with comorbid ADHD and OCD was uniquely associated with measures of family dysfunction in ADHD rather than with OCD. This was evidenced by higher scores on conflict scales and lower scores on cohesion scales compared to children and adolescents with OCD or healthy controls. The researchers noted that this was in contrast to previous research (Cooper, 1996; Swedo et al., 1989a) in which families of children with OCD exhibited significant family dysfunction. However, results from recent findings do not provide evidence that psychosocial adversity in families play a direct causal role in OCD (Hirshfeld-Becker et al., 2004).

Section Summary

Both ADHD and OCD share certain pathophysiological and aetiological features, although children and adolescents with comorbid ADHD and OCD may be aetiologically distinct from children with either ADHD or OCD. Theoretical and conceptual models describe linkages among hypothesised biological, genetic, and environmental risk factors in the development of comorbid ADHD and OCD. Biological models ascertained through neuropsychological, structural and functional neuroimaging, neurochemical, and neuropharmacological studies implicate abnormalities in key areas in the prefrontal cortex, particularly, the orbitofrontal cortex and basal ganglia regions in children and
adolescents with comorbid ADHD and OCD. These abnormalities are thought to result in EF deficits. There have been no twin or adoption studies of children and adolescents with comorbid ADHD and OCD. Family studies, however, support the notion that comorbid ADHD and OCD are heritable, while molecular genetic studies implicate key candidate genes that may lead to abnormalities in dopamine, serotonin, and noradrenaline systems. Environmental and psychosocial risk factors do not appear to be strong aetiological factors, although they are thought to exacerbate symptoms of comorbid ADHD and OCD.

**Treatment**

While the nature of the relationship between ADHD and OCD remains unclear, the treatment of children with both these disorders has presented health professions with clinical and therapeutic dilemmas (Rapport, 2001). The treatment response and outcomes of children and adolescents with comorbid ADHD and OCD may differ from those with either ADHD or OCD (Geller et al., 2003a; Jensen et al., 1997; Pliszka, 1998).

**Pharmacological Interventions**

Research has shown that stimulant medication can effectively treat ADHD, but is ineffective in the treatment of OCD and may exacerbate obsessions or compulsions in some cases (Buzan, Shore, O'Brien, & Schneck, 2000; Geller et al., 2003c; Jensen et al., 1997; Kouris, 1998; Pliszka, 1998). Serotonin reuptake inhibitors effectively treat OCD, but are ineffective for ADHD and may worsen ADHD symptoms by causing behavioural activation in some children, and increasing treatment withdrawal (Geller et al., 2003c; Masi et al., 2006). The use of tricyclic anti-depressants as a class of medication in
children and adolescent has generally proven to effectively treat both ADHD and OCD (Daly & Wilens, 1998; Geller, 1999). However, prospective and systematic research studies of treatment of children and adolescents with comorbid ADHD and OCD are needed since standard pharmacological treatments do not address the impact of comorbidity on core symptoms of each disorder.

**Psychosocial Interventions**

Pharmacological therapy is not the only treatment for comorbid ADHD and OCD in children and adolescents. Since psychosocial treatments such as Cognitive Behaviour Therapy (CBT) require reasonable levels of attention, concentration and cooperation to treat OCD, the core features of ADHD may adversely impact the participation of children and adolescents with comorbid ADHD and OCD in psychosocial treatment protocols and decrease their effectiveness (Geller et al., 2004). Therefore, such cases require a different treatment plan than children and adolescents with either ADHD or OCD that addresses each set of symptoms (Geller et al. 2003a). Long-term treatment studies are needed to investigate the impact of comorbid ADHD and OCD on CBT treatment.

**Combined Interventions**

To current knowledge, no studies have documented a combined pharmacological and psychosocial treatment plan for children and adolescents with comorbid ADHD and OCD. Given the relatively high prevalence rates of comorbid ADHD and OCD among children and adolescents, the long-term treatment outcomes for combined pharmacological and psychosocial treatment interventions compared to individual treatment interventions needs to be addressed.
**Section Summary**

From the limited evidence available, stimulant medication is effective in treating ADHD, but not OCD, while selective serotonin reuptake inhibitors are effective in treating OCD, but result in negative effects in children with ADHD. Tricyclic antidepressants have proven to be an effective pharmacological treatment intervention in children and adolescents with ADHD and/or OCD. Psychosocial interventions such as CBT may effectively treat OCD, but the core symptoms of ADHD may adversely impact the treatment of children with comorbid ADHD and OCD. Not one study has examined the combined effectiveness of pharmacological and psychosocial interventions in the treatment of children and adolescents with comorbid ADHD and OCD. However, the literature does suggest that children and adolescents with comorbid ADHD and OCD require a specialised treatment plan that addresses the core symptoms of each disorder.
Chapter Summary

The elevated prevalence rates of comorbid ADHD and OCD far exceeds that expected by chance alone with prevalence rates of ADHD ranging from 10% - 50% in OCD populations, and prevalence of OCD ranging between 8% - 11% in ADHD populations. Evidence from children and adolescents with comorbid ADHD and OCD indicate that the core symptoms of each disorder independently contribute to academic, intellectual, and social impairments even though the disorders are phenomenologically different. Comorbid ADHD and OCD appears to be more prevalent in males than females, and is associated with increased prevalence of additional comorbid disorders like disruptive behaviour, anxiety, depressive and tic disorders. Both ADHD and OCD share key common aetiological biological, genetic, and environmental risk factors that have led to a greater understanding of the mediation of comorbid ADHD and OCD.

Biological models implicate key structural and functional abnormalities in the prefrontal cortex, particularly, the orbitofrontal, dorsolateral and anterior cingulate cortex that are thought to subserve deficits in EF in children and adolescents with comorbid ADHD and OCD. In addition, abnormalities in dopamine and serotonin neurotransmitter systems levels are often implicated in the development of ADHD and OCD. Evidence supports the argument that children and adolescents with ADHD have left hemisphere hypofunction, while children with OCD have left hemisphere hyperfunction. Thus, children with comorbid ADHD and OCD may alternate between both states of brain functioning. Genetic risk factors likely play a major role in the aetiology of both ADHD and OCD, based on evidence from family studies that indicate the disorders are familially linked, and molecular genetic studies indicate the disorders may share common candidate
genes, particularly the DRD 4 gene. However, there is little evidence to support an environmental aetiological model for the cause of comorbid ADHD and OCD, although psychosocial environmental factors may play a significant role in the exacerbation of both ADHD and OCD symptomatology. Tricyclic anti-depressants have proven to be the only effective pharmacological treatment intervention for children with comorbid ADHD and OCD. There is little available evidence for the effectiveness of psychosocial treatment intervention in children with comorbid ADHD. Treatment plans for children and adolescents with comorbid ADHD and OCD need to address the core symptoms of each disorder that independently contribute to both morbidity and functional impairment.
CHAPTER 4
EXECUTIVE FUNCTION

Introduction

The neuropsychological profile of both Attention Deficit Hyperactivity Disorder (ADHD) and Obsessive Compulsive Disorder (OCD) appears to be one of primary executive dysfunction (Pennington & Ozonoff, 1996). Neuropsychological constructs provide an effective way to measure attention and memory components of Executive Function (EF) in children and adolescents with ADHD or OCD. Neuropsychological studies also provide evidence for neurobiological models of these disorders by mapping behaviour to brain regions identified by neuroimaging studies. Despite the important clinical and research implications posed by the comorbidity of ADHD and OCD, not one published neuropsychological study has compared children and adolescents with ADHD and/or OCD on key measures of EF. The purpose of this chapter is to provide a neuropsychological comparison of EF constructs of attention (attentional set shifting, selective attention, sustained attention, processing speed, and response inhibition) and memory (visuospatial working memory and visuospatial short-term memory) in children and adolescents with ADHD or OCD.

Definition of Executive Function

Executive function (EF) has been used as an umbrella term to describe functions that mediate a set of cognitive abilities that control and regulate other abilities and behaviours that are necessary for purposeful, goal directed behaviour (Pennington & Ozonoff, 1996). Extensive research has investigated the role of EFs in children and
adolescents with ADHD (for meta-analysis see Willeutt et al., 2005). The literature on EF in children and adolescents with OCD is limited (see Andres et al., 2007; Beers et al., 1999; Shin et al., 2008) with most research studies focusing on the role of EF in adults with OCD (see Kuelz et al., 2004). Not one study has explored the similarities or differences in children and adolescents with comorbid ADHD and OCD relative to children with either ADHD or OCD. Recent studies have explored the possibility that childhood disorders such as ADHD and OCD can be partially understood in terms of frontostriatal dysfunction in the prefrontal cortex and its subcortical connections that result in EF deficits (Bradshaw & Sheppard, 2000; Carlsson, 2000, 2001). Among the key aspects of EF that will be explored in the present study are attention (attentional set shifting, selective attention, sustained attention, and processing speed), response inhibition, visuospatial working memory, and visuospatial short-term memory (Barkley, 2006; Grodzinsky, 1999; Hughes et al., 2002; Pennington & Ozonoff, 1996).

**Brain-Behaviour Relationships of Neuropsychological Constructs**

Despite the cognitive symptoms of inattention observed in children and adolescents with ADHD or OCD, there have been few studies examining the associated neuropsychological constructs of visuospatial attention, visuospatial short-term memory, or visuospatial working memory. Neuropsychological studies using constructs with known brain-behaviour relationships may be used to provide evidence of the underlying neural dysfunction implicated in ADHD and OCD in children. The constructs of attention, short-term memory and working memory, including their brain-behaviour relationships, will now be reviewed.
Attention

Attention is a multifaceted construct encompassing several related functions, including: orienting to sensory events; detecting and/or selecting sensory signals for conscious processing; and maintaining a vigilant or alert state (Fernandez-Duque & Posner, 2001). These three components of the attentional system function are relatively independent, but related functional neural networks in children and adolescents (Rueda et al., 2004). The construct of attention can be divided into at least four linked modules that include sustained and selective attention, attention set shifting, and speed of information processing, which make up the ‘attentional system’ (Davis, Bruce, & Gunnar, 2002). Current neuropsychological understandings of attention models emphasise linkage of attention to memory that can interfere with the mnemonic encoding and retrieval processes (Barnett, Maruff, & Vance, 2005). There is converging evidence that these attention processes are subserved by a distributed array of neural networks (anterior cingulate cortex, posterior parietal and dorsolateral prefrontal cortex regions) located predominately in the right hemisphere (Knudsen, 2007). Attention has both verbal and non-verbal visuospatial domains. The following review focuses on visuospatial attention.

Neuropsychological Studies of Visuospatial Attention

A number of neuropsychological studies have attempted to define and enhance understanding of impairments in attention that are commonly reported in children and adolescents with ADHD or OCD. The following review focuses on EF constructs of attention, including attentional set shifting, selective attention, sustained attention, and information processing speed in children and adolescents with ADHD or OCD.
Attentional Set Shifting

Attentional set shifting refers to the ability to flexibly switch attention to a more appropriate response, or the processes that enables a shift from one response to another (Robbins et al., 2000). This ability to switch between tasks or strategies is measured by complex tasks such as the Wisconsin Card Sorting Test (WCST; Berg, 1948), the Object Alternation Test (OAT; Freedman, 1990), Delayed Alternation Test (DAT; Freedman & Oscar-Berman, 1986), and the CANTAB (Cambridge Automated Neuropsychological Assessment Battery) Intra-Dimensional/Extra-Dimensional (ID/ED; Fray, Robbins, & Sahakian, 1996b) set-shifting task. Deficits in attentional set shifting are associated with frontal cortex abnormalities in regions of the orbitofrontal prefrontal cortex, dorsolateral prefrontal cortex, ventrolateral prefrontal cortex and the anterior prefrontal cortex (Robbins et al., 2000). Neuroimaging studies have demonstrated that attentional set shifting deficits are associated with abnormal activation within neural networks that comprise of the lateral dorsolateral and ventrolateral prefrontal cortex in the right hemisphere and the premotor cortex, anterior cingulate, and the insula and cerebellum (Owen et al., 1991; Robbins et al., 2000; Rogers et al., 1999). Consistent with this profile, patients with frontal cortex damage have been found to have difficulty switching between tasks (Aron et al., 2004; Owen et al., 1992; Rogers et al., 1998).

ADHD and Attentional Set Shifting

There has been considerable recent debate as to whether attentional set shifting is deficient in children and adolescents with ADHD. This is because set shifting is considered to be a comparatively late developing ability while DSM criteria specify that
the condition needs to be apparent early in the child’s life (before age 7 years) (Barkley, 1997). A number of studies using the traditional WCST have consistently reported that children with ADHD exhibit set shifting deficits as evidenced by the completion of fewer categories and that they make significantly more perseverative errors compared to healthy control children (Grodzinsky & Barkley, 1999; Lawrence et al., 2004; Pineda, Ardila, & Rosseli, 1999; Seidman et al., 1997; Sergeant, Geurts, & Oosterlaan, 2002; see Willcutt et al., 2005). A handful of studies that utilised the CANTAB ID/ED attentional set shifting paradigm have identified attentional set shifting deficits in children and adolescents with ADHD (Goldberg et al., 2005; Kempton et al., 1999; Mehta et al., 2004; Rhodes et al., 2005; 2006; Vance, Maruff, & Barnett, 2003).

OCD and Attentional Set Shifting

The only known study to explore attentional set shifting deficits in children and adolescents with OCD identified that children made significantly more errors and completed fewer stages on the WCST compared to the healthy control group (Shin et al., 2008), supporting a hypothesised frontostriatal dysfunction. Evidence from adult studies of attentional set shifting ability in OCD has demonstrated inconsistent results (for review see Kuelz et al., 2004). Early studies identified attentional set shifting deficits in adults with OCD (Aronowitz et al., 1994; Boone, 1991; Christensen, 1992; Head, Bolton, & Hymas, 1989). Recent evidence also suggests that OCD adult patients have more difficulties in set shifting than healthy controls on the WCST (Basso, Bornstein, Carona, & Morton, 2001; Moritz et al., 2002; Okasha et al., 2000; Veale et al., 1996).
Neuropsychological studies have also reported marked set shifting deficits in OCD adult patients on the OAT (Abbruzzese et al., 1995a; Abbruzzese et al., 1997; Aycicegi et al., 2003; Cavedini et al., 1998) and the DAT tasks (Moritz, 2001b). The OAT and the DAT set shifting tasks are more sensitive to orbitofrontal dysfunction (Zald et al., 2002). Numerous recent studies have reported no difference in performance on the WCST, OAT, and DAT between OCD adult patients compared to healthy controls (Deckersbach et al., 2000; Kim et al., 2002; Moritz et al., 2001a; Moritz et al., 2002; Schmidtke et al., 1998; Zohar et al., 1999).

Evidence from studies that have utilised the CANTAB ID/ED attentional set shifting task is also inconsistent. Three studies have identified deficits in OCD adult patients on the ID/ED task as evidenced by the continuous cumulative increase in the number who failed at each stage of the task (Fenger et al., 2005; Veale et al., 1996; Watkins et al., 2005). In contrast, three studies did not identify impaired attentional set shifting in adults with OCD (Nielen & Den Boer, 2003; Purcell et al., 1998a; 1998b). It has been hypothesised that attentional set shifting impairments in OCD are caused by the presence of comorbid depressive symptoms, as patients suffering from depressive disorders usually perform poorly on set shifting tasks (Basso et al., 2001; Moritz et al., 2001a). Studies that carefully controlled for depressive symptoms did not observe attentional set shifting deficits in adults with OCD (Cavedini et al., 1998; Moritz et al., 2001a; Purcell et al., 1998b).
**Section Summary**

Evidence of attentional set shifting deficits in children and adolescents with ADHD has been fairly consistent. Neuropsychological studies of attentional set shifting ability in children and adolescents with OCD are limited. Only one recent study that explored attentional set shifting abilities in children and adolescents with OCD identified set shifting deficits. Attentional set shifting ability in adults with OCD also remains highly debated with some studies identifying set shifting deficits, and others not. Evidence for attentional set shifting deficits in adults with OCD may perhaps be partly caused by confounding comorbid depressive disorder symptomatology. It is also noteworthy that common set shifting tasks have different sensitivity levels and activate different regions of the prefrontal cortex. For example, the WCST and ID/ED primarily activate the dorsolateral prefrontal cortex, while OAT or DAT tasks are primarily sensitive to the orbitofrontal prefrontal cortex. The present study is designed to measure attentional set shifting using the ID/ED paradigm, and has controlled for the presence of severe major depressive disorder in children and adolescents with ADHD, OCD, and comorbid ADHD and OCD.

**Selective Attention**

Selective attention refers to the ability to focus on a specific target so that information can be responded to appropriately (Plude, Enns, & Brodeur, 1994). Often children suffering from deficits in selective attention are unable to ‘filter’ information and begin to feel bombarded by environmental stimulation. Selective attention is commonly tested using tasks such as the Stroop task (see MacLeod, 1991) in which the target stimuli are embedded in an array of conflicting and inappropriate response stimuli. Matching to
Sample (MTS) tasks are relatively ‘pure’ tests of selective attention (Fray, Robbins, & Sahakian, 1996b) as they remove speed and memory components. Tasks of visuospatial selective attention appear to activate frontoparietal neural networks including the anterior cingulate cortex and lateral prefrontal cortex regions (Kastner & Ungerleider, 2000). Researchers use the term *executive attention* to stress the nature of long-term and short-term memory activation in selective attention (Kane & Engle, 2002).

**ADHD and Selective Attention**

The results of selective attention studies in children and adolescents with ADHD have been inconsistent. Early studies reported selective attention deficits in children and adolescents with ADHD compared to healthy control children (Carter et al., 1995; Higginbotham & Bartling, 1993; Satterfield et al., 1990). One recent study also identified selective attention deficits in children with ADHD (Tsal, Shalev, & Mevorach, 2005). These findings are in contrast to numerous more recent studies that have failed to identify deficits in selective attention in children and adolescents with ADHD compared to healthy control children (Booth et al., 2005; Brodeur & Pond, 2001; DeShazo et al., 2001; Huang-Pollock & Nigg, 2003; Huang-Pollock, Nigg, & Carr, 2005; Mason, Humphreys, & Kent, 2003). These findings support the notion that deficits in sustained attention and response inhibition deficits are more prominent characteristics compared to selective attention deficits in children with ADHD (Huang-Pollock et al., 2005).
**OCD and Selective Attention**

A deficit in selective attention may be responsible for the inability of adults with OCD to selectively ignore competing external sensory and internal intrusive cognitive thoughts. It is difficult to make any conclusions about potential selective attention deficits due to the lack of research among children and adolescents with OCD (Clayton, Richards, & Edwards, 1999; Cohen, Lachenmeyer, & Springer, 2003). However, evidence of selective attention deficits in adults with OCD has produced inconsistent results. While most studies have not identified selective attention deficits (Aronowitz et al., 1994; Mataix-Cols et al., 2002a; Moritz et al., 2002; Nielen & Den Boer, 2003; Schmidtke et al., 1998), some studies have been able to distinguish adults with OCD from healthy control participants as evidenced by relatively poor performance on selective attention measures (Clayton, Richards, & Edwards, 1999; Cohen, Lachenmeyer, & Springer, 2003). The findings lend support to the argument that children and adolescents with OCD may also exhibit deficits in selective attention. However, evidence of selective attention deficits may be due to excessive caution or slow responding that is perhaps associated with greater psychopathology or medication use (Clayton et al., 1999).

**Section Summary**

Selective attention refers to the ability to focus on a specific target so that information can be responded to appropriately. Evidence of selection attention deficits in children and adolescents with ADHD are inconsistent. More recent evidence indicates that children and adolescents with ADHD present with response inhibition deficits that
manifest as deficits in selective attention. Evidence of a deficit in selective attention in children and adolescents with OCD is not available. The evidence for a deficit in selective attention in adults with OCD is inconsistent and weak. Matching to Sample (MTS) tasks like the one used in the present study are relatively ‘pure’ tests of selective attention as they remove speed and memory components.

**Sustained Attention**

Sustained attention refers to the capacity to maintain focus and alertness over time and is often conceptualised as ‘vigilance’ (Barkley, 1997). Children with ADHD often experience particular difficulty with sustained attention ability, resulting in what is often called a ‘short attention span’ (Barkley, Grodzinsky, & DuPaul, 1992). Neuroimaging studies have found that sustained attention is associated with activation in the right prefrontal cortex, parietal and medial striatal regions (see Sarter, Givens, & Bruno, 2001). Studies of non-human primates have found that reciprocal neural pathways connect the parietal and frontal lobes (Sarter et al., 2001). Sustained attention is most commonly measured on computerised tasks referred to as Continuous Performance Tests (CPT) including the Conners CPT (Conners, 1995), the Test of Variables of Attention (TOVA; Greenberg & Waldman, 1993), and the Vigil CPT (Psychological Corporation, 1996). However, psychomotor speed plays a significant role in performance of these tasks, with participants required to respond quickly.
**ADHD and Sustained Attention**

Assessment of sustained attention deficits has generally yielded consistent results in children and adolescents with ADHD. Children with ADHD often have difficulties persisting on tasks over long periods of time, particularly in tedious and mundane tasks. Investigations have frequently demonstrated that children and adolescents with ADHD exhibit sustained attention deficits in CPT tasks (as measured by more errors, slowed performance, more impulsivity) that demand sustained attention and vigilance (Barkley, 1997; DeShazo et al., 2001; Stins et al., 2005). A recent meta-analysis (Huang-Pollock & Nigg, 2003) reported that no consistent results of deficits in sustained attention emerged across early studies. One recent study that compared performance between children and adolescents, and adults with ADHD also failed to find sustained attentional deficits (Tucha et al., 2008). A systematic investigation is required in order to determine whether visuospatial sustained attention deficits exist.

**OCD and Sustained Attention**

Studies have failed to investigate the sustained attention construct in children and adolescents with OCD, making it difficult to ascertain whether or deficits would manifest in children and adolescents with OCD. The relatively few studies that have assessed sustained attention using CPT have not identified abnormalities in adults OCD (Mataix-Cols et al., 1997; Milliery, Bouvard, Aupetit, & Cottraux, 2000; Zielenski et al., 1991). Investigation of sustained attention using verbal performance on the Digit Span forward task have also identified that adults with OCD are unaffected (Cohen et al., 1996; Milliery et al., 2000; Moritz et al., 2002; Okasha et al., 2000)
Section Summary

Neuropsychological studies of sustained attention in children and adolescents with ADHD have produced divergent results, although there is some support for impairments in this attention construct. No known studies have examined sustained attention abilities in children and adolescents with OCD. The findings from a limited number of studies have failed to identify sustained attention deficits in adults with OCD. Interpreting the above findings from sustained attentional studies may be problematic given that attention is a difficult construct to isolate and measure. Many of the available neuropsychological tasks involve psychomotor speed with participants required to respond quickly. In contrast, Matching to Sample (MTS) tasks allow the relatively ‘pure’ assessment of sustained attention, by removing speed and memory components.

Information Processing Speed

Information processing speed is a term used to describe the rate at which information from the environment is registered and then output via motor activities takes place (Shanahan et al., 2006). Response times are typically measured on the same computerised tasks used to measure sustained attention and appear to index the stability and reliability of the attentional system. With the increasing recognition of the importance of these components of attention, a number of omnibus tests provide standardised scores for children on these attributes. Two such measures are the Test of Everyday Attention in Children (TEAch; Manly, Robertson, Nimmo-Smith, Turner, Watson, & Robertson, 2001), and the Trail Making Test (TMT) Parts A and B (Corrigan & Hinkeldey, 1987).
**ADHD and Information Processing Speed**

Deficits in information processing speed have been associated with symptoms of impulsivity and related problems in time perception and/or timing (Keilp, Sackeim, & Mann, 2005). Information processing speed deficits have been found previously in children with ADHD on tasks of time estimation, time duration, and motor timing, implicating a deficit in temporal processing abilities, which has been interpreted as either secondary or primary to core EF deficits using a variety of timed task designs (Barkley et al., 2001a; Lawrence et al., 2004; Shanahan et al., 2006; Smith et al., 2002; Toplak et al., 2003). Neuroimaging findings of prefrontal cortex abnormalities have sparked renewed interest in the constructs of information processing, timing, motor control, and response inhibition in children and adolescents with ADHD (Aron & Poldrack, 2005; Barkley, 1997; Castellanos & Tannock, 2002c). Findings from these studies suggest that children and adolescents with ADHD perform poorly on timed tasks which load heavily on impulsiveness and attentional processes and suggest that children may have a perceptual deficit of time discrimination. A temporal perception deficit in ADHD may impact upon other functions such as perceptual language skills and motor timing (Smith et al., 2002). Information processing speed is closely linked to the construct of response inhibition that is discussed in the next section.

**OCD and Information Processing Speed**

Reduced information processing speeds in OCD has been attributed to intrusive thoughts or meticulousness. There is little evidence to suggest differences between OCD adult patients and healthy controls on measures from reaction time tasks (for review see,
Kuelz et al., 2004). A few studies have identified slower processing speed deficits in OCD adult patients (Basso, 2001; Moritz et al., 2001a; Moritz et al., 2002; Schmidtke et al., 1998). However, some of these studies failed to account for the fact that adult OCD patients were medicated with selective serotonin reuptake inhibitors (SSRIs) or benzodiazepines (Basso, 2001; Moritz et al., 2001a; Moritz et al., 2002). It is possible that evidence of processing speed deficits may be the result of side-effects of medication use. This argument is substantiated by findings from several studies that reported information processing speeds were unimpaired on the TMT Part A in non-medicated adults with OCD (Aronowitz et al., 1994; Cohen et al., 1996; Jurado et al., 2001).

**Section Summary**

Neuropsychological studies have identified information processing deficits in children and adolescents with ADHD as evidenced by slow processing and longer reaction times in comparison to healthy control children. In contrast, investigations of information processing speed ability in children and adolescents with OCD are non-existent. However, OCD adult patients do not appear impaired on measures of information processing speed. More information can be gained on information processing speed through the examination of the closely linked construct of response inhibition, which is described next.

**Response Inhibition**

Response inhibition is considered by many to be one component under the umbrella term of EF. Response inhibition is conceptualised as a multidimensional
construct that refers to the ability to engage in appropriate responses, and to withhold (inhibit) or cease inappropriate responses (Mostofsky & Simmonds, 2008). Performance-based measures sensitive to deficiencies in response inhibition demand that children wait and watch for events to take place. Responses that occur too quickly or too often signal deficits in response inhibition (Fischer et al., 2005). Errors made in response inhibition tasks are attributed to EF deficits mediated by dysfunction of the prefrontal cortex (especially orbitofrontal cortex) and subcortical circuits that are critical to response inhibition (see Barkley, 1997; Mostofsky & Simmonds, 2008). Clinical manifestations of deficits in response inhibition include motor hyperactivity, evidenced by inability to remain seated, fidgetiness and talkativeness, impulsive object touching, persistent propensity to interrupt, impatience waiting or taking turns, and resistance to delayed gratification (Barkley et al., 2001a). This conceptualisation of response inhibition covers a broad spectrum of behaviours frequently seen in children and adolescents with ADHD (Barkley, 1997; Booth et al., 2005; Fischer et al., 2005; Nigg, 1999; Schulz et al., 2004) and OCD (Moritz & Von Muhlenen, 2005).

**ADHD and Response Inhibition**

The emphasis on response inhibition deficits in models of ADHD has progressed in tandem with empirical research exploring their interrelation (Barkley, 1997; Fischer et al., 2005; Schulz et al., 2004). Common neuropsychological measures used to assess response inhibition in children and adolescents with ADHD include the Continuous Performance Test (CPT), Delay of Gratification Task (DGT), Go/No-go paradigm, Stop-Signal paradigm, and the Stroop test (Barkley, 1997; Frazier et al., 2004; Oosterlaan, Logan, & Sergeant, 1998; Willcutt et al., 2005). Most neuropsychological studies to date
have demonstrated robust findings of response inhibition deficits in children and adolescents with ADHD compared to healthy control children, as evidenced by increased errors on these neuropsychological measures (for reviews see, Aron & Poldrack, 2005; Band & Scheres, 2005; Barkley, 1997; Booth et al., 2005; Doyle et al., 2000; Grodzinsky & Barkley, 1999; Homack & Riccio, 2004; Nigg, 2001; Oosterlaan, Scheres, & Sergeant, 2005; Pennington & Ozonoff, 1996; Schachar et al., 2000; Scheres et al., 2004; Schulz et al., 2004; Willcutt et al., 2005). The number, as well as diversity, of studies reporting significant results attests to the robust nature of the concurrent relation between deficient response inhibition in children and adolescents with ADHD.

Deficits in response inhibition found in children and adolescents with ADHD implicate key prefrontal cortex abnormalities in the pathophysiology of ADHD (Schulz et al., 2004). Research has also found that deficits in response inhibition are not explained by differences in IQ, comorbid disorders (Nigg, 2001), or learning deficits (Klorman et al., 1999). Several authors have proposed that response inhibition deficits are the possible underlying processes that impact or manifest as deficits in EF in children and adolescents with ADHD (Barkley, 1997; Nigg, 2001; Oosterlaan et al., 2005; Scheres et al., 2004). As the main proponent of this view, Barkley’s (1997) unified theory of ADHD posited that response inhibition is the primary deficit in ADHD that leads to secondary deficits. The EFs in the model are considered separate neuropsychological systems secondary to the response inhibition system. Deficient response inhibition is specifically linked to secondary problems in working memory, internalisation of speech, self-regulation of emotion-motivation-arousal, and reconstitution (behavioural analysis and synthesis), all of which are part of Barkley’s conceptualisation of EF (Barkley, 1997).
OCD and Response Inhibition

Neuropsychological models of OCD point to a fairly consistent pattern of deficit in response inhibition. However, little is known about response inhibition functioning with respect to children and adolescents with OCD (Schultz, Evans, & Wolff, 1999). Commonly used computerised neuropsychological tasks such as the Go/No-Go and stop-signal reaction time (SSRT) paradigms assess motor response inhibition, while the Stroop paradigm can assess cognitive inhibition. Evidence for response inhibition deficits has come from recent studies using in children (Schultz et al., 1999; Woolley et al., 2008) and adults with OCD (Aycicegi et al., 2003; Bannon et al., 2002; 2006; Bohne et al., 2008; Chamberlain et al., 2007b; Coles et al., 2006; Herrmann, 2003; Penades et al., 2007; Roth et al., 2007). Findings of response inhibition deficits in adults have also come from studies using oculomotor tasks that require the suppression of eye movements (Rosenberg et al. 1997a; 1997b). The incorporation of neuroimaging and neuropsychological techniques in recent studies of OCD have elicited that response inhibition deficits are characterised by reduced activation in the frontostriatal circuit (that include neural pathways that connect the orbitofrontal cortex, anterior cingulate cortex, dorsolateral cortex frontal lobe regions with the basal ganglia) that are necessary for response motor and cognitive response inhibition in children (Woolley et al., 2008) and adults with OCD (Menzies et al., 2008; Roth et al., 2007).

The question of whether OCD symptoms reflect an inability to inhibit irrelevant obsessive thoughts that would normally not enter consciousness have been addressed using the negative priming (NP) paradigm (Tipper, 1985). Early studies found significant reduction of NP that was suggestive of impaired response inhibition in adults with OCD.
(Enright, Beech, & Claridge, 1995; Enright & Beech, 1990, 1993), although these results have not been replicated (MacDonald, Antony, MacLeod, & Swinson, 1999). The study of inhibition of return (IOR) was first demonstrated by Posner and Cohen (1984) using a spatial cue paradigm (see Lupianez, Klein, & Bartolomeo, 2006). They identified that adults with OCD took longer reaction times to redirect attention to a previously attended location than to an unattended location. The deficits of IOR in OCD has turned out to be fairly robust, and it has been replicated across different modalities and paradigms (Lupianez et al., 2006; Moritz & Von Muhlenen, 2005).

**Section Summary**

Deficits in response inhibition have been consistently identified in children and adolescents with ADHD and OCD. The combination of neuroimaging and neuropsychological techniques have identified that deficits in response inhibition are associated with reduced structural and functional abnormalities in the prefrontal cortex (including the orbitofrontal cortex, anterior cingulate cortex, dorsolateral cortex) and basal ganglia regions. These regions are essential for effective motor and cognitive response inhibition in children and adolescents with ADHD or OCD.

**Memory**

Classifications of memory are based on the duration of memory retention with three distinct types of memory often identified: short-term memory, sensory memory and long term memory. For the purpose of this thesis, discussion will focus on short-term memory in children and adolescents with ADHD or OCD, defined as the capacity to
temporarily encode, store, maintain and retrieve information to assist in planning goal-oriented behaviour (Rogers et al., 1998). Memory has traditionally been divided into a verbal component (‘phonological loop’) that is responsible for encoding and retrieving short-term verbal material and a nonverbal visuospatial component (‘visuospatial sketchpad’) that is responsible for the encoding and retrieval of visuospatial short-term material (Baddeley & Hitch, 1994; Baddeley, Gathercole, & Papagno, 1998). These modality specific components are then coordinated by the central executive system, or working memory, that directs attentional focus and is responsible for coordinating and planning information from the two subsidiary systems to integrate the information within one subsidiary system to achieve goal directed behaviour (Baddeley & Hitch, 1994). According to this model, the three components of memory are distinct systems with independent neural networks. The following review focuses on visuospatial short-term memory and visuospatial working memory abilities in children and adolescents with ADHD or OCD.

Neuropsychological Studies of Visuospatial Memory

Neuropsychological studies have attempted to define and enhance understanding of visuospatial memory impairments that are commonly reported in children and adolescents with ADHD or OCD. The following review focuses on attention constructs of EF that include visuospatial short-term memory and visuospatial working memory in children and adolescents with ADHD or OCD.
Visuospatial Short-Term Memory

Visuospatial short-term memory (VSTM) includes tasks of recognition memory. Recognition memory is the ability to recognise stimuli that have been viewed previously. Like the attentional system, the VSTM recognition process is hypothesised to involve key selective encoding, retention and retrieval components (Paule et al., 1998). Thus, VSTM recognition impairment may be due to problems with the attentional aspect of information encoding and/or problems with the mnemonic aspect of information retention and retrieval (Barnett et al., 2005). The design of the delayed matched-to-sample (DMTS) task enables the separation of memory processes. Performance on the matched-to-sample (MTS) condition is believed to reflect attention and encoding processes, as the target stimulus and the four exemplars are both visible (Robbins et al., 1994). The MTS condition provides an ideal control to determine the extent to which problems in discriminating stimuli contribute to later deficits in the recognition or recall of target stimuli. The DMTS conditions assess impairments in memory retrieval. The combination of these tasks in a VSTM encoding and retrieval paradigm enables the valid and reliable separation of deficits in encoding from deficits in retrieval, providing a measure of the extent to which encoding deficits contribute to observed mnemonic deficits (Fray, Robbins, & Sahakian, 1996b).

There is a large body of evidence from the animal literature showing the importance of the medial-temporal lobe in the processing of VSTM (Baker et al., 1995; Fray & Robbins, 1996a). Studies with non-human primates have shown that lesions in the temporal cortical regions lead to impaired DMTS performance (Murray, 1996), a measure of visuospatial memory. Based on non-human primate research, Mishkin (1982) proposed a functional neural network model for the recognition-memory system. It was
hypothesised that, when a novel stimulus is viewed, a series of temporal cortical pathways arising from the visual cortex are activated which, in turn, project to the amygdala and hippocampus and then to the thalamus. This activation pathway is referred to as the cortical-limbo-thalamo-cortical circuit.

Research with humans yielded findings consistent with this recognition memory system hypothesise that temporal excisions produce VSTM deficits (Owen et al., 1995). Adult patients with damage to the medial temporal lobes due to excisions of the medial temporal lobe or amygdalo-hippocampal structures have not displayed deficits in the simultaneous MTS condition of the DMTS task (Owen et al., 1995). Adult patients with lesions of the temporal lobe and neural degeneration in Alzheimer-Type Dementia also demonstrate impairments on all delay conditions, while performances on the MTS condition of the DMTS task were unimpaired (Lawrence et al., 2000; Sahakian et al., 1988). In contrast, poor performance on the CANTAB MTS and DMTS task conditions has been observed in adults patients with disorders of the basal ganglia and frontostriatal neural networks, including Parkinson’s disease (Elliott et al., 1998), Huntington’s disease (Lawrence et al., 2000), and Schizophrenia (Vance et al., 2007). These findings suggest that dysfunction of medial temporal lobe structures primarily leads to deficits in the mnemonic retrieval aspects of VSTM, while frontostriatal dysfunction is mainly associated with poor encoding, leading to impaired MTS and DMTS performance.

**ADHD and Visuospatial Short-Term Memory**

Neuropsychological studies have consistency identified VSTM recognition deficits in children and adolescents with ADHD as evidenced by poor performance on the
delay conditions of the DMTS with associated MTS performance deficits (Barnett et al., 2005; Kempton et al., 1999; Rhodes et al., 2005). Recent neuropsychological studies have used pharmacological methylphenidate stimulant medication to demonstrate VSTM deficits in children and adolescents with ADHD that resulted in subtle performance improvements following the administration of stimulant medication (Coghill et al., 2007; Rhodes et al., 2004; Rhodes et al., 2006; Vance et al., 2003). These findings provide support for a robust biological framework that implicates frontostriatal dysfunction in children and adolescents with ADHD.

**OCD and Visuospatial Short-Term Memory**

The paucity of neuropsychological investigations in children and adolescents with OCD limits the discussion to VSTM abilities in adult populations with OCD. Recent studies have identified VSTM deficits on the CANTAB pattern recognition task (Chamberlain et al., 2007a; Watkins et al., 2005). A number of studies, however, have failed to identify VSTM recognition deficits on tasks like the DMTS or pattern recognition tasks from the CANTAB in adults with OCD compared to healthy controls (Nielen & Den Boer, 2003; Purcell et al., 1998a; 1998b). The findings of these two studies suggest that there is dissociation between memory for VSTM and VSWM in OCD. For instance, pattern recognition and DMTS tasks allow the applications of verbal stimuli according to shape and colour, while spatial working memory tasks are more reliant on the development of organisational strategies. Research suggests that visual memory deficits may be mediated by organisational deficits in OCD (Savage et al., 1999; 2000). The notion that adult with OCD are not impaired on tasks that allow verbal mediation is supported by several studies (Nielen & Den Boer, 2003; Zielenski et al.,
1991). In contrast, adult patients with OCD have difficulty when they must keep an internal and non-verbal representation of stimuli in their memory in order to guide behaviour (see Purcell et al., 1998b).

**Section Summary**

VSTM recognition impairment may be due to problems with the attentional aspect of information encoding and/or problems with the mnemonic aspect of information retention and retrieval. Results from studies into VSTM function of children and adolescents with ADHD have been unequivocal. Studies consistently identify VSTM deficits in children and adolescents with ADHD. In contrast, the limited literature does not indicate adults with OCD display VSTM impairment. It has been proposed that adult OCD patients are not impaired on tasks like the DMTS that allows verbal mediation, but display impairments on tasks that are more reliant on the development of organisational strategies. Findings of VSTM deficits in children and adolescents with ADHD, but not in adults with OCD, may provide additional evidence for the nosological distinction of ADHD and OCD as separate disorders.

**Visuospatial Working Memory**

Visuospatial working memory (VSWM) refers to the ability to identify visual objects such as shape or colour that is stored in visual memory, and spatial information that involves the spatial relationship of objects (the configuration and location of objects) that is stored in spatial memory (Baddeley, 1986; Baddeley & Hitch, 1994; Taylor, 2004). VSWM is thought to consist of two components. The first component of working memory, the ‘buffer site’, involves encoding of material into a memory ‘span’. Memory
span is the ability to store and reproduce a sequence of spatial stimuli in working
memory. The second component, the ‘executive system’, maintains and manipulates
information (Baddeley, 1986; Taylor, 2004).

The recent development of the computerised CANTAB (see Fray, Robbins, &
Sahakian, 1996b; Luciana & Nelson, 2002; Luciana et al., 2005) includes tasks such as
the spatial span and spatial working memory (SWM) tasks that have been designed to
assess the visuospatial component of working memory. Deficits on these VSWM tasks
have been associated with abnormalities in the frontostriatal networks (particularly the
right regions of the dorsolateral prefrontal cortex, ventrolateral prefrontal cortex, and
anterior prefrontal cortex) in child, adolescent and adult populations (Luciana & Nelson,
2002; Luciana et al., 2005; Owen et al., 1990; 1996; Pantelis et al., 1997; Robbins et al.,
1998; Sahakian et al., 1988).

**ADHD and Spatial Span**

Short-term VSWM capacity in children and adolescents with ADHD is generally
impaired (Barnett et al., 2001; Rhodes et al., 2005). Short-term VSWM capacity in these
studies was assessed using a computer administered Spatial Span task from the
Cambridge Neuropsychological Testing Automated Battery (CANTAB), based on the
Corsi Block Test. Participants had to try to remember and reproduce the order of
observed visual stimuli. Performance between those with ADHD and controls differed
significantly. Similarly, short-term VSWM in adults with ADHD was also reported to be
impaired in a single study of adults with ADHD using the Spatial Span task compared
with spatial span performance following treatment with methylphenidate stimulant
medication (Turner, 2005).
OCD and Spatial Span

There have been no reported previous studies to current knowledge that have explored spatial span abilities in children and adolescents with OCD. A few studies of adults with OCD, however, have found spatial span deficits (Barnett, 1999; Purcell et al., 1998a; 1998b) indicating a reduction in their ability to hold information in their spatial memory. However, the CANTAB battery is sensitive to the effects of normal ageing (Robbins et al., 1994). It has been shown that by the mid-60s, skills of EF return to almost child-level performance (De Luca et al., 2003). While the relationship between ageing and OCD with regards to cognitive function is unknown, it is apparent that short-term VSWM capacity impairments are apparent in adults with OCD.

ADHD and Spatial Working Memory

VSWM is a core construct of EF that plays a key role in children and adolescents with ADHD (Barkley, 1997). Neuropsychological studies strongly support the existence of VSWM deficits in children and adolescents with ADHD (for meta-analyses reviews see Martinussen et al., 2005; Willcutt et al., 2005). Previous controlled studies have reported deficits on CANTAB measures of SWM and SRM in children and adolescents (Barnett et al., 2001; Kempton et al., 1999; Rhodes et al., 2004; Rhodes et al., 2005), as well as in adults with ADHD (Clark et al., 2007; McLean, 2004).

Recent controlled neuropsychological and pharmacological studies have also identified deficits on CANTAB tasks of VSWM as evidenced by subtle performance improvements following methylphenidate medication administration in children and adolescents with ADHD (Bedard et al., 2004; Coghill, Rhodes, & Matthews, 2007;
Mehta et al., 2004; Rhodes et al., 2006; Vance et al., 2003). Neuropsychological findings are consistent with neuroimaging profiles suggesting that VSWM deficits are associated with prefrontal cortex abnormalities in children and adolescents with ADHD (Castellanos & Swanson, 2002b). VSWM deficits in ADHD appear to be relatively specific to EF rather than reflecting generalised cognitive impairment. This point is supported by findings that ADHD children with above-average IQ also exhibit performance deficits on measures sensitive to prefrontal cortex activation, but not on measures of temporal lobe or non EF tasks (Antshel et al., 2008).

**OCD and Spatial Working Memory**

There are relatively few studies that have explored the relationship between working memory and OCD in childhood or adolescence, in either the verbal or visuospatial domain (see Greisberg & McKay, 2003). Given the onset of OCD is often in childhood, and the possible relationship with VSWM deficits, studies of this nature are required. The findings from the limited number of studies that have examined VSWM ability in children and adolescents with OCD have been inconsistent. One recent study by Andres et al. (2007) identified that children and adolescents with OCD performed significantly worse on VSWM tasks relative to healthy control children. Impairment was not related to age, symptom severity, or pharmacological treatment (Andres et al., 2007). In contrast, the earlier study by Beers et al. (1999) failed to identify deficits on various measures of VSWM. This finding was recently supported by results from Shin et al., (2008) that also failed to identify VSWM deficits in children and adolescents with OCD.
Evidence for VSWM deficits in adults has also produced divergent results (for a meta-analysis review see Kuelz et al., 2004). Neuropsychological studies have also provided evidence of VSWM impairments in adults with OCD using the spatial working memory, spatial recognition, and/or pattern recognition tasks from the CANTAB (Chamberlain et al., 2007a; Nielen & Den Boer, 2003; Purcell et al., 1998a; 1998b). Numerous neuropsychological investigations also indicate that adults with OCD show dysfunction on a number of different VSWM tasks (Bohne et al., 2005; Boldrini et al., 2005; Cohen et al., 2003; Deckersbach et al., 2000; Moritz et al., 2003; Savage et al., 1999; 2000). Convergent findings from neuropsychological and neuroimaging studies have conceptualised VSWM deficits as a reflection of left and right hemisphere dysfunction of the frontostriatal circuit (particularly the dorsolateral and orbitofrontal prefrontal cortex regions that connect with the basal ganglia) (Friedlander & Desrocher, 2006; Lacerda et al., 2003; Nielen & Den Boer, 2003; Shin et al., 2004).

Two studies, however, failed to identify VSWM deficit on the PRM or SRM CANTAB tasks in their adult OCD sample (Barnett et al., 1999; Watkins et al., 2005). Previous investigations have also failed to identify VSWM deficits in adults with OCD on a number of different VSWM neuropsychological tasks (Bannon et al., 2006; Kim et al., 2002; Kim et al., 1999; van der Wee et al., 2003). However, many researchers have argued that observable deficits in adults with OCD are due to failures in the employment of appropriate organisational strategies during encoding that lead to retrieval deficits (Deckersbach et al., 2000; Kim et al., 2002; for review see Kuelz et al., 2004; Penandes et al., 2005; Purcell et al., 1998a; 1998b; Watkins, 2005).
Section Summary

Neuropsychological studies of VSTM ability in children and adolescents with ADHD are consistent, whilst studies of VSTM ability in children and adolescents with OCD are limited and inconsistent. Similarly, findings from OCD adult studies of VSTM ability have produced divergent results. For the most part, there is some consensus that adults with OCD may present with VSTM deficits, albeit subtle. Research indicates that VSTM deficits may be due to failures in the employment of organisational strategies. Converging evidence from neuropsychology and neuroimaging studies suggest that deficits in VSTM are associated with abnormalities in key frontostrial regions (including the orbitofrontal prefrontal cortex and dorsolateral prefrontal cortex regions that connect with the basal ganglia). The present study will use the CANTAB spatial working memory and spatial span measures to examine VSTM in children and adolescents with ADHD, OCD and comorbid ADHD and OCD compared to healthy control children.
Chapter Summary

EF constructs of attention and memory are key neuropsychological correlates of both ADHD and OCD. As such, this review has examined the neuropsychological status of attention and memory function in children and adolescents with ADHD or OCD. Given the paucity of studies of this nature in children and adolescents with OCD, it has also examined studies of attention and memory function in adults with OCD. The cognitive functions of attention and memory may be explored in both the verbal and the visuospatial domains. The focus of this thesis is only on attention and memory tasks in the visuospatial domain. Neuropsychological visuospatial tasks predominantly employ abstract, complex test figures. More recent visuospatial tasks, including CANTAB subtests, have been developed based on extensive animal research which are more specific in their activation of cognitive skills, and have proven brain-behaviour relationships as evidenced by the activation key prefrontal cortex regions in functional MRI neuroimaging research.

The cognitive functioning of visuospatial attention observed in children and adolescents with ADHD has been demonstrated to vary considerably from that of OCD, reiterating the inference that these two disorders have different phenomenological features. Neuropsychological studies of visuospatial attention have produced consistent results of attentional set shifting, information processing speed, and response inhibition deficits in children and adolescents with ADHD. However, neuropsychological studies of selective attention and sustained attention have produced inconsistent results in this area. Many of the cognitive attention processes and the underlying neuropathology have not been explored in neuropsychological studies in child and adolescent populations with
OCD. The few studies that have explored performance on visuospatial attention measures in children, adolescents, or adults with OCD have failed to consistently demonstrate impairment on visuospatial attention measures. The number of visuospatial attention studies in child and adolescent populations with OCD are limited and confounded by non-specific assessment tasks. Neuropsychological studies have failed to consistently identify deficits in children and adolescents, or adults with OCD, on measures of sustained attention, selective attention, and information processing speed constructs. Some studies suggest that adults with OCD exhibit deficits on attentional set shifting measures. However, it has been hypothesised that attentional set shifting impairments in OCD may be caused by the presence of comorbid depressive symptoms. Neuropsychological studies of OCD point to a consistent pattern of response inhibition deficit in children, adolescents, and adults with OCD.

VSTM recognition tasks effectively separate attention and mnemonic components. Results have consistently identified VSTM deficits in children and adolescents with ADHD. In contrast, there are no known studies of VSTM in children and adolescents with OCD. The limited literature of VSTM function in adults with OCD has not identified VSTM deficits in memory recognition or recall. There has been support for the argument that adults with OCD are not impaired on VSTM tasks which allow verbal mediation such as the DMTS task. Evidence of VSWM deficits in children and adolescents with ADHD has been consistent. However, neuropsychological studies of VSWM ability in children and adolescents with OCD are limited and inconsistent. Similarly, findings in regards to VSWM ability in OCD adult populations have also produced divergent results. There is some evidence VSWM deficits in adults with OCD
may be due to failures in the employment of organisational strategies. Medication status may have also confounded results in a proportion of these studies.

Relatively few neuropsychological studies of OCD have explored visuospatial attention or memory constructs in the child and adolescent literature. This has meant that similarities or differences between children and adolescents with either ADHD or OCD on EF constructs of attention and memory have not been examined. In addition, neuropsychological studies have not explored the neuropsychological profile of EF constructs of attention and memory in children and adolescents with comorbid ADHD and OCD relative to those with ADHD or OCD alone. Given the different courses of the disorders and the possibly differing aetiological picture of ADHD and OCD, it is important to examine these two groups separately and to compare performance on visuospatial neuropsychological tasks of interest in children and adolescents with comorbid ADHD and OCD. Such studies will provide further evidence of the nature of the differences between the two disorders.
CHAPTER 5
RATIONAL FOR CURRENT STUDY

Attention Deficit Hyperactivity Disorder (ADHD) and Obsessive Compulsive Disorder (OCD) are common childhood disorders. However, the comorbid relationship between ADHD and OCD has been relatively neglected in the literature. The adverse influence of ADHD and/or OCD on academic, social and family functioning among children and adolescents have been well documented, with greater functional impairment amongs those with comorbid ADHD and OCD. However, the effets of comorbid ADHD and OCD in specific areas of adaptive, family and emotional functioning have not been thoroughly examined. Furthermore, previous literature has never explored or compared the neuropsychological profiles of children and adolescents with ADHD and/or OCD. The lack of research into executive function (EF) deficits in children and adolescents with OCD has also made it difficult to establish how much of a role OCD plays in those with comorbid ADHD and OCD.

Given the lack of research into children and adolescents with comorbid ADHD and OCD, this exploratory study aimed to explore and understand the demographic, clinical and neuropsychological profiles of children and adolescents aged between 7 to 16 years of age with DSM-IV diagnosed ADHD and/or OCD. The design of the present study enabled some insight into key demographic and clinical characteristics associated with ADHD and/or OCD in children and adolescents. Additionally, parent-reported internalising and externalising symptoms and child-reported anxiety and depressive symptoms were also compared between all four groups. As previously highlighted, the pathophysiology of ADHD and/or OCD implicate abnormalities in frontostriatal linked systems with associated
EF deficits. The design of the present study enabled explorations into visuospatial attention and memory function constructs between children and adolescents with ADHD and/or OCD and healthy control participants. These aims were important for three reasons: (1) previous investigations have not explored the neuropsychological profiles of children and adolescents with ADHD and/or OCD, and (2) neuropsychological function in children and adolescents with OCD has been relatively unexplored in comparison to research undertaken on ADHD, and (3) the results may enable insight into possible dysfunctional neural networks that subserve aspects of cognitive function across diagnostic ADHD and/or OCD groups and developmental stage. The aims of this thesis were three-fold.

Aims and Hypotheses

Aims 1: Exploration of Demographic and Clinical Characteristics

The first aim was to explore on a descriptive level the key broader demographic and clinical characteristics of children and adolescents aged 7 to 16 years old with ADHD and/or OCD compared to a healthy control group. Key factors across the four groups including severity of ADHD and OCD symptoms, academic and intellectual functioning, family functioning, parental psychopathology, and social adversity status were compared.

Hypotheses

1(a) Symptom Severity

Based on the literature presented in the previous introductory chapters, it was hypothesised that children and adolescents with ADHD and/or OCD would have significantly greater levels of attention problems on the Child Behaviour Checklist (CBCL) and hyperactive/impulsive symptoms on the Conners Global Index (CGI) compared to the healthy control group. It was also hypothesised that the comorbid
ADHD and comorbid ADHD and OCD groups would have significantly greater levels of
attention and hyperactive-impulsive symptoms compared to the OCD group, and that the
comorbid ADHD and OCD group would have significantly greater levels compared to
the ADHD group. It was hypothesised that obsessive-compulsive symptom ratings on
the Child-Yale Brown Obsessive Compulsive Scale (CY-BOCS) would not significantly
differ between the OCD and comorbid ADHD and OCD groups.

1(b) Academic Functioning

Children and adolescents with ADHD and/or OCD were expected to perform
significantly worse across academic spelling, reading and arithmetic tasks compared to
healthy controls on the Wide Range Achievement Test (WRAT-3). Academic functioning
was not expected to differ between children and adolescents with ADHD and/or OCD.

1(c) Intellectual Functioning

Full Scale Intelligence Quotient (IQ), Performance IQ, and Verbal IQ measures
from the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV) was
hypothesised to be significantly lower in the ADHD, OCD and comorbid ADHD and
OCD groups compared to the healthy control group. Scores on these IQ measures were
not expected to differ between children and adolescents in the ADHD and/or OCD.

1(d) Family Functioning

Impaired family functioning based on the Family Assessment Device (FAD) was
hypothesised to be elevated among children and adolescents with ADHD and/OCD
relative to the healthy control group, and that impaired family functioning would be more
evident in the comorbid ADHD and OCD group compared to the ADHD or OCD groups.
1(e) Parental Psychopathology

Levels of parental psychopathology based on parent-report ratings on the Hopkins Symptom Checklist (HSCL) were hypothesised to be higher in the ADHD and/or OCD groups compared to the healthy control group, and that levels of parental psychopathology would be higher in the comorbid ADHD and OCD compared to the ADHD group or OCD group.

1(f) Social Adversity Status

Social adversity status based on summary information (family income level, mother’s educational level, single parent status, number of siblings, and parental relationship) obtained from the Parental Account of Childhood Symptoms (PACS) semi-structured interview was hypothesised to be higher in the presence of children and adolescents with ADHD and/or OCD compared to the healthy control group. Social adversity status was also hypothesised to higher among children and adolescents with comorbid ADHD and OCD in comparison to the ADHD or OCD groups.

Aims 2: Exploration of Clinical Parent and Child Symptom Ratings

The second aim was to use a clinical approach to assist in understanding the nature of parent-reported adaptive functioning and child-reported anxiety and depressive symptomatology in children and adolescents diagnosed with ADHD and/or OCD, and a healthy control group. Parental ratings of internalising, externalising, and total symptoms, measures of adaptive functioning, from the Child Behaviour Checklist (CBCL) were compared between the four groups. The present study also examined child self-reported ratings of anxiety symptoms assessed by the Revised Children's Manifest Anxiety Scale
(RCMAS) and self-reported depressive symptoms assessed by the Children's Depression Inventory (CDI) among children and adolescents in the ADHD, OCD, comorbid ADHD and OCD, and healthy control groups.

**Hypotheses**

2(a) **Parent Report of Adaptive Functioning**

It was hypothesised that parent-report internalising, externalising, and total symptom ratings from the Child Behaviour Checklist (CBCL) would be elevated in children and adolescents with ADHD and/or OCD compared to healthy control children, and that children and adolescents with comorbid ADHD and OCD group would have elevated internalising, externalising, and total symptoms ratings compared to children or adolescents with ADHD or OCD.

2(b) **Anxiety Symptoms**

Child-reported anxiety symptoms on the Revised Children’s Manifest Anxiety Scale (RCMAS) would be higher in children and adolescents with ADHD, OCD, or comorbid ADHD and OCD compared to healthy control children, and that children and adolescents with comorbid ADHD and OCD would have increased levels of self-reported anxiety symptoms compared to the ADHD or OCD groups.

2(b) **Depressive Symptoms**

Child-reported depressive symptom scores on the Children’s Depression Inventory (CDI) was hypothesised to be higher among children and adolescents in the ADHD and/or OCD groups compared to the healthy control group, and that children and
adolescents with comorbid ADHD and OCD would have elevated levels of depressive symptoms compared to children and adolescents with ADHD or OCD.

**Aims 3: Exploration of Neuropsychological Profiles of Executive Function**

The third aim was to compare clinically referred groups of children and adolescents aged 7 to 16 with ADHD, OCD, comorbid ADHD and OCD, and a healthy control group with respect to visuospatial attention, visuospatial short-term recognition memory (VSTM), and visuospatial working memory (VSWM). The Cambridge Neuropsychological Test Automated Battery (CANTAB; Cambridge Cognition Ltd, 1999) facilitates the assessment of attention, working memory, and short-term memory in the visuospatial domain. The battery of interrelated tasks enables the independent and systematic investigation of these abilities in children and adolescents with ADHD and/or OCD across a wide age range. This is important given the protracted developmental progress of many EF skills. While some cognitive abilities develop early, EFs do not reach their peak until early adulthood (De Luca et al., 2003; Luciana & Nelson, 2002; Luciana et al., 2005). Each test in this battery can be performed by children as young as 4 years, yet adults may still find many of these tasks challenging.

**Hypotheses**

3(a) Visuospatial Attention

The CANTAB Intra-Dimensional/Extra-Dimensional (ID/ED) set shifting task provides a measure of attentional set shifting, sustained and selective attention. It was hypothesised that children and adolescent with ADHD and/or OCD would exhibit attentional set shifting, selective, and sustained attention deficits (as measured by the
numbers of trials, errors and stages completed) compared to the healthy control group. The comorbid ADHD and OCD group was hypothesised to perform significantly worse on these measures relative to children with ADHD or OCD.

3(b) Visuospatial Short-Term Memory

The CANTAB includes a Delayed Matching to Sample (DMTS) task that incorporates a Matching-to-Sample (MTS) condition that was used to assess whether any observed Visuospatial Short-Term Memory (VSTM) deficit was due to an attentional and/or mnemonic impairment. It was hypothesised that VSTM encoding and retrieval ability would be more impaired in children and adolescents with ADHD and/or OCD relative to the healthy control group, and that children with comorbid ADHD and OCD would exhibit increased VSTM deficits compared to those with ADHD or OCD.

3(c) Visuospatial Working Memory

The CANTAB Spatial Working Memory (SWM) task assesses overall Visuospatial Working Memory (VSWM) ability in terms of accuracy and response time. It also provides a measure of the strategy component of VSWM. The CANTAB Spatial Span task provides a measure of VSWM capacity. Taken together, these tasks allow an assessment of whether poor performance on a task of VSWM may be due to deficits in the spatial span and/or strategy components. It was hypothesised that children and adolescents with ADHD and/or OCD would exhibit VSWM deficits compared to healthy control children, and that VSWM deficits would be significantly worse in the comorbid ADHD and OCD group relative to those in the ADHD or OCD groups.
CHAPTER 6

METHOD

Participants

General Exclusion Criteria

Exclusion criteria for each child or adolescent included Full Scale Intelligence Quotient (FSIQ) scores below 70 on the Wechsler Intelligence Scale for Children, WISC-IV (Wechsler, 2003), and spelling, reading or arithmetic learning disorder determined by a score below 70 on the Wide Range Achievement Test-3 (WRAT-3) (Wilkinson, 1993). Colour blindness, hearing impairment, developmental coordination disorder, endocrine disorder, and substance abuse were also exclusionary criteria. Children and adolescents diagnosed with comorbid major depressive disorder, neurological disorders, pervasive developmental disorders, and tic and Tourette’s disorders were also excluded from this study because these conditions have been shown to have an independent association with behavioural measures of frontostriatal dysfunction. This ensured that no comorbid conditions with shared frontostriatal risk factors were likely to confound the neuropsychological profile of clinical and healthy control participants. Descriptive information for each group is detailed below.

Total Sample

A total of 130 children and adolescents aged between 7 and 16 years old ($M = 11.93, SD = 2.40$) were categorised into four groups fulfilling DSM-IV criteria for: Attention Deficit Hyperactivity Disorder (ADHD), Obsessive Compulsive Disorder (OCD), comorbid ADHD and OCD, and healthy control participants. Twenty-four additional
children and adolescents were evaluated for the study, but did not meet DSM-IV criteria for ADHD \((n = 4)\), or OCD \((n = 5)\). Children and adolescents were also excluded for showing signs of, or fulfilling DSM-IV diagnostic criteria for Autism Spectrum Disorder \((n = 3)\), Tic Disorder \((n = 2)\), Conduct Disorder \((n = 1)\), Major Depressive Disorder \((n = 2)\), or for having a FSIQ less than 70 \((n = 1)\). Healthy control participants were also excluded because of clinically significant symptoms reported by the parent and/or child during the Anxiety Disorder Interview Schedules – Child/Parent edition (ADIS-C/P) \((n = 6)\). Parents of healthy control children were notified of any concerns, and a follow-up meeting with a registered psychiatrist and/or referral to a registered clinical psychologist was offered.

**Inclusion Criteria**

**ADHD Group**

Thirty-five children and adolescents diagnosed with clinical ADHD (30 males, 5 females) between 7 and 16 years old \((M = 11.93\text{ years}, SD = 2.31\text{ years})\) participated in the study. The diagnosis of ADHD was defined through (1) separate structured clinician-administered interview, the Anxiety Disorders Interview Schedule for DSM-IV (Child and Parent Versions) (ADIS-C/P; Silverman & Albano, 1996), administered to the child’s parent(s) and/or child, and (2) parent report of subscale scores of core ADHD symptom domains greater than 1.5 standard deviations above the mean on the Conners Global Index (CGI; Conners, 1997). Exclusion criteria for the ADHD group included a comorbid diagnosis of OCD. Parents were requested to withhold stimulant medication from children with ADHD for at least 24 hours prior to testing. At least 3 out of 35 \((8.57\%)\) children with ADHD were reported to be on stimulant medications (methylphenidate or dexamphetamine) at the time of the assessment.
**OCD Group**

Twenty-Nine children and adolescents fulfilling DSM-IV criteria for OCD (15 males, 15 females) between 7 and 16 years ($M = 12.66$ years, $SD = 2.68$ years) participated in this study. The diagnosis of OCD was defined through (1) separate ADIS-C/P (Silverman & Albano, 1996) structured clinician-administered interviews with the child’s parent(s) and/or child, and (2) parent and/or child report of obsessive and compulsive symptoms total scores above 15 on the Child Yale-Brown Obsessive Compulsive Scale (CY-BOCS; Seahill et al., 1997), was rated by the interviewing clinician. Exclusion criteria for the OCD group included a comorbid diagnosis of ADHD. The presence of other anxiety disorders was not an exclusion criteria as they have been shown to have no effect on the neuropsychological profile of visuospatial attention and memory functions (Vance et al., 2006). Of the OCD group, 8 out of 29 (28%) participants were receiving stable doses of serotonin reuptake inhibitors (SRI) or selective serotonin reuptake inhibitors (SSRIs) at the time of testing.

**Comorbid ADHD and OCD Group**

Thirty-four children and adolescents diagnosed with comorbid clinical ADHD and OCD (26 males, 8 females) between 7 and 16 years ($M = 11.56$ years, $SD = 2.28$ years) participated in this study. The diagnosis of comorbid ADHD and OCD was defined through (1) separate ADIS-C/P (Silverman & Albano, 1996) structured clinician-administered interview with the child’s parent(s), and/or child, and (2) parent report of subscale scores of core ADHD symptom domains greater than 1.5 standard deviations on the CGI (Conners, 1997); and (3) parent and/or child report of obsessive and compulsive
symptoms that were scored above 15 on the CY-BOCS (Scahill et al., 1997). Parents were requested to withhold stimulant medication from children with comorbid ADHD for at least 24 hours prior to testing. At least 9 out of 34 (26%) children with comorbid ADHD and OCD were receiving medication to treat ADHD and/or OCD symptoms at the time of testing.

Healthy Control Group

Thirty-two healthy children and adolescents (22 males, 10 females) between 7 and 16 years ($M = 11.58$ years, $SD = 2.31$ years) formed the healthy control group in this study. Healthy control participants were age-matched to ADHD, OCD and comorbid ADHD and OCD participants. These children met the relevant inclusion and exclusion criteria of the clinical groups, and were free of past or present paediatric, psychiatric or neurological disorders. None of the healthy control children were reported to have been taking any type of medication.

Measures

The measures administered for the study are categorised below into diagnostic measures (DSM-IV criteria for ADHD and/or OCD), demographic and clinical measures (academic functioning, intellectual functioning, social adversity status, family functioning, and parental psychopathology; parent-reported child behaviour checklist, and children’s self-reported depressive and anxiety symptom scales), and neuropsychological measures (visuospatial attentional set shifting, spatial working memory, spatial span, and delayed matching to sample tasks).
Diagnostic Measures

Anxiety Disorders Interview for DSM-IV (Child & Parent Versions)

The ADIS-C/P (Silverman & Albano, 1996) is a semi-structured diagnostic interview schedule with child and parent versions. It is based on DSM-IV criteria and yields a categorical presence or absence of childhood disorders, including ADHD and OCD based on DSM-IV criteria. In both the parent and child versions, symptoms and associated impairment in social, academic, and family domains are rated separately. The A-DISC was selected for use in this study as it is designed to assess psychiatric disorders in child and adolescent populations, rather than adolescent and adult populations. The reliability of the ADIS-C/P ranges from .63 to .80 for the child interview, and .65 to .88 for the parent interview (Silverman, Saavedra, & Pina, 2001). The clinical utility and validity of the ADIS-C/P have been supported by research findings.

Symptom Severity

Hyperactive-Impulsive Symptoms

Conners Global Index (CGI)

The abbreviated CGI (Conners, 1997) is a 10-item questionnaire that outlines the core symptom domains of ADHD in children and adolescents aged between 3 to 17 years old. It comprises two empirically derived factors, the restless-impulsive and emotional liability indexes. The ratings are completed by the parent(s) and teachers and yield a continuous variable of ADHD symptoms. Each item is scored on a 4-point scale (0 = Not at all true, 1 = Just a little bit true, 2 = Pretty much true, 3 = Very much true) based on the degree to which items characterise the child. The CGI has good validity and reliability and has been used extensively in community and clinical populations (Conners, 1997).
Obsessive-Compulsive Symptoms

*Children’s Yale-Brown Obsessive-Compulsive Scale (CY-BOCS)*

The CY-BOCS (Scahill et al., 1997) is a clinician-administered, 10-item semi-structured measure designed to rate the severity and type of common obsessive and compulsive symptoms in children and adolescents aged 6 to 17 years. The CY-BOCS interview often involves the parent and/or child depending on the age and level of anxiety experienced by the child. Ratings for the amount of time consumed, degree of life interference, internal distress, resistance and control of symptoms are recorded for obsessions and compulsions. The clinician rated scale consists of 10 items, each rated on a scale from 0 (no symptoms) to 4 (extreme symptoms). A total score (maximum score = 40) is derived from summing the 10 scale item (obsession and compulsions subtotals). Researchers have provide robust evidence to support the reliability, validity and stability of the CY-BOCS for assessing OCD symptoms in children and adolescents (McKay et al., 2003; Storch et al., 2006). A cut-off score of >15 determined the diagnosis of OCD.

Demographic and Clinical Measures

Academic Functioning

*Wide Range Achievement Test-Third Edition (WRAT-3)*

The WRAT-3 (Wilkinson, 1993) is an academic achievement test that assesses reading, arithmetic and spelling in children, adolescents, and adults aged from 5 – 75 years old. Each form takes 15 to 30 minutes to complete depending on the skill level and behavioural style of the individual tested. In the spelling subtest, the participant is asked to write words as they are dictated. The Arithmetic subtest has 40 arithmetic problems
that involve counting, reading number symbols, and written computations. The participants is instructed to complete as many arithmetic problems as they can within 15 minutes. The reading subtest includes the pronunciation of words out of context. Raw scores for each task were converted into standard scores with a mean of 100 and standard deviation of 15 for comparisons in this study. Internal consistency for the WRAT-3 is moderate to high ranging from .69-.95. Concurrent validity is also fair to high as correlations between the WRAT-3 and other achievement tests range from .41-.87 (Flanagan, McGrew, Abramowitz, & Untiedt, 1997; Wilkinson, 1993).

**Intellectual Functioning**

*Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV)*

The WISC-IV (Wechsler, 2003) is an individually administered standardised instrument for assessing general intellectual functioning in children and adolescents aged from 6 – 16 years old. Four composite scores are derived from 10 core subtests to represent intellectual functioning in specific cognitive domains, Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI), and Processing Speed Index (PSI). The WISC-IV also provides a Full Scale IQ (FSIQ) composite score that represents overall intellectual ability. In this study all the core subtests were administered, and three composite scores were reported: the VCI (referred to as “verbal IQ”), the PRI (referred to as “Performance IQ”), and the FSIQ.
Family Functioning

Family Assessment Device (FAD)

The FAD (Epstein, Baldwin, & Bishop, 1983) is a 60 item parent-report measure of family functioning. It identifies six areas of family functioning: problem solving, communication, roles, affective responsiveness, affective involvement and behaviour control. The parent rates his/her agreement with how well an item describes their family by marking one of four response categories; strongly agree, agree, disagree, or strongly disagree. The General Functioning Scale assesses the overall functioning of the family. The FAD has moderate to high levels of internal consistency, good test-retest reliability, preliminary predictive validity, construct and criterion validity, and low correlations with social desirability (Miller, Epstein, Bishop, & Keitner, 1985).

Parental Psychopathology

Hopkins Symptom Checklist (HSCL)

The HSCL (Derogatis, Lipman, Rickels et al., 1974) is a 58-item inventory that measures the severity of somatic and psychological symptoms as self reported by the parent. The HSCL is comprised of five underlying symptom dimensions (somatization, obsessive-compulsive behaviour, interpersonal sensitivity, anxiety and depression). Each item is rated by the respondent on a four-point scale (1 = not at all, 2 = a little, 3 = quite a lot, 4 = extremely distressed). Higher scores are associated with elevated levels of parental psychopathology. The present study used the global symptom score calculated by the sum of the scores for each item. Reliability tests show high internal consistency ranging from .84-.87, test-retest reliability ranging from .75 to .84, and good criterion and construct validity (Derogatis et al., 1974).
Social Adversity

**Parental Account of Childhood Symptoms (PACS)**

The PACS (Taylor, Schacher, Thorley, & Wieselberg, 1986) is a semi-structured clinical interview developed as an instrument for the measurement of children's behaviour problems as experienced at home. The PACS is administered by a trained clinician. Parents are asked for detailed descriptions of what their child has done in specified situations over the previous week and over the preceding 12-month period. It also yields demographic and developmental information (for example, motor and/or language milestones). A social adversity scale (ranging from 0 – 5) is developed based on a summary of family income level, mother’s educational level, single parent status, number of siblings, and parental relationship. It is reported to have good reliability and adequate validity and has been used extensively in published research studies (Taylor et al., 1986; Vance et al., 2002).

**Parent-Reported Internalising and Externalising Problems**

**Child Behaviour Checklist (CBCL)**

The CBCL (Achenbach, 1991) is a measure of emotional and behavioural problems in children and adolescents aged 6-18 years old. A parent and/or guardian completes the CBCL in relation to their child. The checklist contains 113 items about specific behavioural and emotional problems. Each item is scored on a 3-point scale (0 = not true, 1 = somewhat or sometimes true, 2 = very true of often true) based on the child’s behaviour over the last six months. The CBCL scoring profile T scores on two broad dimensions, internalising and externalising scores, which are merged to provide a Total Problem score. The T-scores for each of these subscales, and the attention
problems subscale were used in this study. The CBCL has demonstrated good internal consistency and test-retest reliability. It also has good concurrent validity as it correlates well with related measures, and has strong discriminant validity (Achenbach, 1991).

**Anxiety Symptoms**

*Revised Children’s Manifest Anxiety Scale (RCMAS)*

The RCMAS (Reynolds & Richmond, 1997) is a 37-item questionnaire designed to measure the level and nature of general anxiety symptoms in children and adolescents aged 6 to 19 years old. Four subscales have been derived from the instrument, including: (a) Physiological Anxiety, (b) Worry/Oversensitivity, and (c) Social Concerns/Concentration. In addition, nine items derive a Lie scale that is used to determine if the child was making a valid attempt to respond. The total anxiety score was based upon 28 items determined by the number of "yes" responses to the anxiety items. Raw scores were converted to standardized $T$ scores ranging from 0 to 100. There are no clinical cut-off scores, so $T$ scores greater than 60 were considered to have “greater significance” (Reynolds & Richmond, 1997, p.9). The RCMAS was selected because it is widely used as a measure of anxiety in child and adolescents populations. The RCMAS has also demonstrated good reliability and validity (Reynolds & Richmond, 1997).

**Depressive Symptoms**

*Children’s Depression Inventory (CDI)*

The CDI (Kovacs, 1992) is a 27-item self-report measure of the presence and severity of depressive symptoms in children and adolescents aged 7 to 17 years old. Each item is accompanied by three statements scored in severity from 0 to 2 ($0 = \text{absence}$, $1 = \text{mild}$, $2 = \text{severe}$).
mild symptom, 2 = definitive symptom). This yields scores ranging from 0 to 54, with higher scores reflecting increasing severity of depressive symptoms. Raw scores were converted to standardized $T$ scores. A $T$ score greater than 65 is generally regarded as clinically significant (Kovacs, 1992). The CDI was selected because it is widely used as a measure of depression in child and adolescent populations and for its demonstrated good internal consistency and validity (Nelson & Politano, 1990). The CDI also has good test-retest reliability and construct validity demonstrated by strong correlations with other measures of depression and related constructs such as anxiety and self-esteem (Craighead, Smucker, Craighead, & Ilardi, 1998; Kovacs, 1992).

**Neuropsychological Measures of Executive Function**

*Cambridge Automated Neuropsychological Testing Battery (CANTAB)*

The neuropsychological tasks of executive function (EF) administered in the present study were part of the CANTAB (Cambridge Cognition Ltd, 1999). The CANTAB measures neuropsychological constructs in the visuospatial domain. Four neuropsychological tasks were selected from the CANTAB, one task from the attention battery, one task from visuospatial short-term recognition memory, and two tasks from the visuospatial working memory battery. The instructions given for each neuropsychological task are included in Appendix E. A brief description of the key measures for each of the tasks is presented in Table 1, followed by a description of each task. Tests from CANTAB have also been extensively described elsewhere (Robbins et al., 1998) and their administration was according to standard protocols.
Table 1

Summary of Neuropsychological Tasks and Key Dependent Measures

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>References</th>
<th>Key Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attention Battery</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ID/ED</td>
<td>Discrimination learning, testing the ability to selectively attend to and set-shift between shape, colour or number stimulus dimensions</td>
<td>Rogers et al. (1999); Owen et al. (1991)</td>
<td>Stage Completion; Total Trials/Errors; Total IDS + IDR Trials/Errors; Total EDS + EDR Trials/Errors; Response Latency (ms)</td>
</tr>
<tr>
<td><strong>Visual Memory Battery</strong></td>
<td></td>
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<tr>
<td>DMTS</td>
<td>A four-choice test of simultaneous and delayed matching to sample of abstract patterns, which share colour or pattern with the distractors</td>
<td>Owen et al. (1995); Robbins et al. (1994)</td>
<td>Response Accuracy (%); Total Errors; Error Types; Response Latency (ms)</td>
</tr>
<tr>
<td><strong>Working Memory Battery</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial Span</td>
<td>A test of spatial memory span to recall the order in which a series of boxes were highlighted</td>
<td>Owen et al. (1990)</td>
<td>Span Length</td>
</tr>
<tr>
<td>SWM</td>
<td>A test of spatial working memory and strategy performance to find individually hidden ‘blue tokens’ without returning to a box where one has previously been found</td>
<td>Owen et al. (1990)</td>
<td>Strategy Score; Total BSEs; Response Latency (ms)</td>
</tr>
</tbody>
</table>

*Note.* BSE = Between-Search-Errors; DMTS = Delayed Matching to Sample; IDS = Intra-Dimensional Shift; IDR = Intra-Dimensional Reversal; EDS = Extra-Dimensional Shift; EDR = Extra-Dimensional Reversal; SSP = Spatial Span; SWM = Spatial Working Memory.
Attentional Set Shifting Task

The Intra-Dimensional/Extra-Dimensional (ID/ED) attentional set-shifting task (Downes et al., 1989) task was derived from the Wisconsin Card Sorting Test. The paradigm involves the participant learning a series of discriminations in which only one of two stimuli is correct and relevant. The stimuli are alternative forced choice shapes of simple geometric forms of the same colour. The participant is instructed to choose one of two patterns shown on the screen and is assisted by automated auditory-visual feedback provided by the computer (see Figure 1). Touching a shape results in feedback of either a tick or a cross to enable the participant to learn the correct pattern. The task is terminated if a participant has not reached the criterion of learning the current rule and correctly responding to 6 consecutive responses within 50 trials at each stage.

Figure 1. An example of the ID/ED attentional set shifting task.
The ID/ED task consists of nine stages as follows: (1) Simple discrimination (SD); (2) Reversal of response (SDR); (3) Compound patterns (CP); (4) Compound discrimination (CD); (5) Reversal of response (CDR); (6) Intra-Dimensional Shift to novel exemplars of patterns (IDS); (7) Intra-Dimensional Reversal of response (IDR); (8) Extra-Dimensional Shift to another perceptual dimension of patterns (EDS); and (9) Extra-Dimensional Reversal of relevant perceptual dimension (EDR). The ID/ED attentional set-shifting measures the ability to sustain attention from one aspect of a stimulus dimension (IDS stage) and shift attention to a previously irrelevant stimulus dimension (EDS stage). The ability to shift attentional set was measured by the percentage of participants that successfully completed each stage of the task, the number of trials taken to reach the criterion for each stage, and the mean response latency of correct responses for each stage.

**Delayed Matching to Sample Task (DMTS)**

The DMTS task is a visuospatial short-term memory task. It assesses the ability to recall visual features of a complex abstract target pattern consisting of a rectangle of four quadrants of differing colours and shapes. The target stimulus is presented on the touch-sensitive screen in a red box for four seconds. Participants are to observe and remember and select the target pattern from a choice of four abstract patterns. Four types of conditions are presented to participants in random order; a simultaneous condition and three time delay conditions. In the simultaneous, or matching to sample (MTS) condition, the target pattern remains on screen while the four alternative choice patterns are presented in white boxes located under the target pattern (see Figure 2). Participants are required to touch the choice pattern that is identical to the target pattern.
In the three DMTS conditions, the target pattern is removed from the screen, followed by the presentation of the four-choice patterns after a 0, 4, or 12 second delay (see Figure 3). Each condition has 10 trials, resulting in 40 trials in total. In each trial, correct and incorrect responses were signalled by differing auditory tones and visual feedback in the form of green ticks or red crosses. If participants made an incorrect response, they were required to continue to choose until the target pattern had been correctly chosen. Performance was defined by the percentage of correct responses (accuracy), types of errors (colour error, shape error, or distractor error), and response latencies (the difference in time between the appearance of the four-choice pattern and the first response on the touch screen recorded automatically by the software) on each of the four conditions.
Spatial Span Task (SSP)

The SSP task assesses the ability to encode and retrieve a sequence of visuospatial stimuli and provides a measure of visuospatial short-term memory (VSTM) capacity. It is a computerised version of the Corsi Block Tapping Test (Milner, 1971). The task assesses the ability of the participant to remember a sequence of squares that change colour in a random order, one square at a time. Participants are required to observe the sequence of squares changing colour, and then to replicate the sequence by touching boxes on the computer screen in the same order originally presented by the computer (see Figure 4).
Participants must replicate the correct sequence to progress to the next level of difficulty, which involves an increase in the number of squares in the sequence that change colour. A change in sequence and colour was used from sequence to sequence to minimise interference. After an incorrect sequence, the trial remains at the same level of difficulty for two more attempts. The SSP score is based on the number of squares in a sequence that the participants correctly replicated at least once. The sequence of squares presented begins at two and increases to a maximum of nine squares (Owen et al., 1992). The maximum possible SSP score is nine.

Figure 4. An example of the spatial span task.
Spatial Working Memory Task (SWM)

The SWM task is a self-ordered searching test that measures visuospatial working memory (VSWM) for spatial stimuli and requires participants to use mnemonic information to work towards a goal. It is based on the Radial Arm Maze developed in animal research (Olton & Wolf, 1981; Petrides & Milner, 1982). The participant is required to search through an array of boxes display in order to locate a ‘blue token’ hidden inside the boxes displayed on the screen. A box is ‘opened’ by touching it on the screen. On any given search, there is only one blue token hidden within one box, and participants must search through the boxes until a blue token is found. The blue token is then placed in the ‘black column’ to the side of screen (see Figure 5). Once a token has been located within a box then that particular box will not contain another blue token (it is ‘empty’). Each trial ends when the participant has found a token in every one of the boxes in the display.

Participants are initially presented with two practice trials with two boxes (containing two blue tokens). There are then four test trials at each level of difficulty; three, four, six, and eight boxes. The colour and position of the boxes used are changed from trial to trial to discourage the use of stereotyped search strategies. The accuracy of SWM performance was derived from the total number of between-search errors (BSE’s) or ‘forgetting’ (when the participants returns to an ‘empty’ box in which a token had already been found and removed during an earlier search sequence) and within-search errors (returning to a box already opened and shown to be empty earlier in the same search sequence).
The SWM task also involves a strategy component. This component reflects the ability to plan and organise a sequence of responses (Collins, Roberts, Dias, Everitt, & Robbins, 1998). A strategy score (maximum score of 56) is estimated during the task, based on performance on the 6 and 8 box levels. It is calculated from the number of times a search was initiated from the same box during a trial. Lower scores represent consistent use of this strategy, whereas high scores represent an inefficient and random search strategy (Owen et al., 1990; Owen et al., 1996). Response latency is also obtained for each trial. This records the time difference between the presentation of the boxes on the screen and completion of the trial when all the blue tokens have been found. It is recorded automatically by the software, and provides a timing accuracy of 1 centisecond.
**Procedure**

Research ethics approval for the study was obtained from the Royal Children’s Hospital, Swinburne University Ethics Committees and the Catholic Education Department (see Appendix A). Children and adolescents within the clinical groups were selected into the study based on meeting DSM-IV (American Psychiatric Association, 2000) diagnostic criteria for ADHD and/or OCD. Participants in the clinical groups were recruited through referrals from community mental health agencies, general practitioners, and child mental health specialists. Participants were identified in separate specialised clinics for disruptive behaviour and anxiety disorder clinics within the Royal Children’s Hospital Mental Health Service (RCHMHS). Control participants were recruited from local primary and secondary schools that responded to letters of invitation sent to principals of local primary and secondary schools and school newsletters outlining the nature and aims of the project. Prior to participating, each child and their parent/guardian were provided with information about the procedure and aims of the study. Informed consent was obtained from parent(s)/guardian(s), and consent was obtained from the child (if over the age of 12) (see Appendix B). Participants were informed that participation was voluntary and they could discontinue at any time.

A provisional psychologist undertook the assessment of each child or adolescent with the assistance of a multidisciplinary team of professionals, doctorate-level psychology students, and supervision by a registered psychiatrist at the RCHMHS. Testing occurred over two separate sessions requiring a total testing time of approximately 3-4 hours. In the first session, parents independently completed the CBCL (Achenbach & Edelbrock, 1983) and the CGI (Conners, 1997) about their child as a part
of the initial assessment battery. Parents also completed measures designed to assess demographic variables such as parental psychopathology (HSCL; Derogatis et al., 1974); and family functioning (FAD; Epstein, Baldwin, & Bishop, 1983). Parents were also administered a highly structured diagnostic interview by the research investigator(s) (ADIS-C/P; Silverman & Albano, 1996), and the background and developmental interview of the parent’s account of childhood symptoms to ascertain their child’s medical and developmental history, and social adversity status (PACS; Taylor et al., 1986). The CY-BOCS (Scahill et al., 1997) was also administered to determine the presence or absence of OCD symptomatology.

While the participants’ parents completed the listed measures and interviews, children were administered the self-report questionnaires and interviews. A member of the research team administered the semi-structured ADIS-C interview with the child and the CY-BOCS. Children were also asked to complete the CDI (Kovacs, 1992), and the RCMAS (Reynolds & Richmond, 1978) to screen for child self-reported depressive and anxiety symptom severity. The present study relied upon information obtained from both the parent and child as the starting point for most diagnostic comparisons. The categorical and dimensional diagnostic information collected from the parent/guardian(s) and child in the structured interviews and rating scales were employed to exclude children who did not meet the diagnostic criteria to participate in the research study, and to classify children into clinical groups.

In the second session, each child completed the four CANTAB computerised neuropsychological tasks. The tasks were presented in a random order on an IBM high-resolution colour monitor via a portable computer with a touch sensitive screen and a
response key used for response latency. Participants were seated 50 cm from the monitor and were instructed to respond to each task by touching the screen. The testing session lasted 30 to 40 minutes, with the duration of each task approximately 10 minutes. The tasks were administered according to standard protocols with the principal research investigator present to explain and supervise the tests at all times (see Appendix E for CANTAB instructions). A trained provisional psychologist under the supervision of a trained clinical psychologist administered the WISC-IV (Wechsler, 2003) to provide verbal, performance and full-scale IQ scores as a measure of intelligence. Administration and scoring of the WISC-IV took place according to standard protocols, and was supervised by a qualified psychologist. In addition, the WRAT-III (Jastak & Wilkinson, 1984) was administered to provide a measure of spelling, reading and arithmetic abilities. The information collated from these two sessions was then entered onto the database in a numerical format. Statistical analysis was conducted and is described in the next chapter.
CHAPTER 7
RESULTS

Statistical Analyses

Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS) program (Windows, SPSS version 15). For all initial analyses, an alpha level of .05 was chosen for the detection of significant differences as part of the hypothesis generating rather than confirming nature of the study. Post-hoc analyses were conducted using Tukey HSD. Bonferroni corrections were applied to the analyses to ensure that moderate effect sizes were detected and to guard against the possibility of Type I error.

Preliminary Analyses

Group Descriptive Characteristics

Preliminary analyses were initially conducted to examine age, gender, education, and medication status among children and adolescents in the ADHD, OCD, comorbid ADHD and OCD, and healthy control groups. The variables of age and education were compared between groups using one-way analysis of variance (ANOVA), with Type I error rate adjusted where there were multiple components to the measure. Chi square tests were used to explore group differences on gender and medication status. Means and standard deviations for age and education, as well as ratio comparisons for gender and medication status of each group are given in Table 2.
Table 2

*Descriptive Information for Clinical and Healthy Control Groups*

<table>
<thead>
<tr>
<th>Measure</th>
<th>ADHD (n = 35)</th>
<th>OCD (n = 29)</th>
<th>ADHD + OCD (n = 34)</th>
<th>Control (n = 32)</th>
<th>Test</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>F</strong></td>
</tr>
<tr>
<td>Age (years, months)</td>
<td>11.93a (2.31)</td>
<td>12.66a (2.68)</td>
<td>11.56a (2.28)</td>
<td>11.58a (2.31)</td>
<td>1.45</td>
<td>ns</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>X²</strong></td>
</tr>
<tr>
<td>Male</td>
<td>30 (86%)</td>
<td>15 (52%)</td>
<td>26 (76%)</td>
<td>22 (69%)</td>
<td>10.68</td>
<td>****</td>
</tr>
<tr>
<td>Female</td>
<td>5 (14%)</td>
<td>14 (48%)</td>
<td>8 (24%)</td>
<td>10 (31%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medication Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>X²</strong></td>
</tr>
<tr>
<td>Medicated</td>
<td>3 (9%)</td>
<td>8 (28%)</td>
<td>9 (27%)</td>
<td>0 (0%)</td>
<td>13.29</td>
<td>****</td>
</tr>
<tr>
<td>Not-Medicated</td>
<td>32 (91%)</td>
<td>22 (72%)</td>
<td>25 (73%)</td>
<td>0 (0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder and Obsessive-Compulsive Disorder Group. χ² = Chi-Square analysis comparing all four groups; F = One-way ANOVA analysis. **Denotes significance at p < .01. Scores in any row with the same superscript are not significantly different, p > .05 (Tukey HSD Post-hoc test)
Age

A one-way ANOVA did not reveal significant differences between the groups on age, $F(3, 127) = 1.45, p = .23$.

Gender

Pearson chi square tests demonstrated that the clinical groups significantly differed on gender, $\chi^2(3) = 10.68, p = .01$. Group comparisons revealed significant gender differences between the OCD group and the ADHD group, $\chi^2(1) = 9.67, p < .01$, and between the OCD group and the comorbid ADHD and OCD group, $\chi^2(1) = 4.85, p = .03$. No significant gender differences were noted between the healthy control group and the OCD, ADHD, and Comorbid ADHD and OCD groups. There were also no significant gender difference between the ADHD group and Comorbid ADHD and OCD group. Table 2 displays the percentage of males and females within each group.

Medication Status

Pearson chi square tests demonstrated that the clinical groups significantly differed on medication status, $\chi^2(3) = 13.29, p < .01$. Table 2 displays the group frequencies of medicated and non-medicated participants. Significant group differences were also noted on medication status between the ADHD group and the OCD group, $\chi^2(1) = 3.76, p = .05$, and between the ADHD group, and the comorbid ADHD and OCD group, $\chi^2(1) = 3.85, p = .05$. These significant differences revealed that more participants in the OCD group, and the comorbid group were taking medication when participating in the study than the ADHD group. No significant group differences were noted between the OCD and the comorbid ADHD and OCD groups.
Diagnostic Characteristics

Differences in mean scores of key diagnostic symptom severity scales (inattention, hyperactive-impulsive, and obsessive-compulsive symptoms) were compared between groups using one-way ANOVAs, with Bonferroni correction. A summary of the means and standard deviation of these diagnostic symptom severity measures in the clinical and control groups are reported in Table 3.

Attention Problems

*Child Behaviour Checklist (CBCL) Attention Problems Subscale*

There was a significant difference in the parent-report of their child’s inattentive symptoms (CBCL-attention subscale) between the four study groups, $F(3, 127) = 39.78$, $p < .01$. Post hoc analysis reported in Table 3 indicates that the ADHD group and comorbid ADHD and OCD group were significantly more inattentive than both the OCD group and the healthy control group. The OCD group was also significantly more elevated on this subscale than the healthy control group. Both the ADHD and comorbid ADHD and OCD groups were in the clinical range, while the OCD group was in the borderline-clinical range.
Table 3

Group Comparison of Means and Standard Deviations of Key Diagnostic Measures of Symptom Severity

<table>
<thead>
<tr>
<th>Measures</th>
<th>ADHD (n = 35)</th>
<th>OCD (n = 29)</th>
<th>ADHD + OCD (n = 34)</th>
<th>Control (n = 32)</th>
<th>Group Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F (3, 127) p</td>
</tr>
<tr>
<td>Diagnostic Characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBCL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention Problems</td>
<td>71.57 c (10.54)</td>
<td>64.07 b (9.16)</td>
<td>75.03 c (13.04)</td>
<td>50.94 a (1.99)</td>
<td>39.78 **</td>
</tr>
<tr>
<td>CGI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyperactive-Impulsive</td>
<td>20.63 c (6.50)</td>
<td>13.77 b (6.69)</td>
<td>21.41 c (5.66)</td>
<td>2.34 a (2.89)</td>
<td>80.22 **</td>
</tr>
<tr>
<td>CY-BOCS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obsessions Subtotal</td>
<td>0.00 a (0.00)</td>
<td>14.03 c (3.60)</td>
<td>11.88 b (3.34)</td>
<td>0.00 a (0.00)</td>
<td>2.48 **</td>
</tr>
<tr>
<td>Compulsions Subtotal</td>
<td>0.00 a (0.00)</td>
<td>14.20 c (3.71)</td>
<td>11.88 b (3.93)</td>
<td>0.00 a (0.00)</td>
<td>2.42 **</td>
</tr>
<tr>
<td>Total Score</td>
<td>0.00 a (0.00)</td>
<td>28.23 c (7.07)</td>
<td>23.76 b (6.82)</td>
<td>0.00 a (0.00)</td>
<td>2.57 **</td>
</tr>
</tbody>
</table>

Note. ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder and Obsessive-Compulsive Disorder Group. CBCL = Child Behaviour Checklist; CGI = Conners Global Index; CY-BOCS = Children’s Yale-Brown Obsessive Compulsive Scale. ** Denotes significance at $p < .01$. Scores in any row with different superscripts are significantly different, $p < .05$ (Tukey HSD Post-hoc test)
Hyperactive-Impulsive Symptoms

Conners Global Index (CGI)

As shown in Table 3, a one-way ANOVA revealed there was a significant difference in the parent report of hyperactive-impulsive symptoms on the CGI between the clinical and control groups, $F(3, 127) = 80.22, p < .01$. Post-hoc analyses using Tukey’s HSD indicated that the mean CGI score for the comorbid ADHD and OCD group, and ADHD group were significantly higher in comparison to the OCD group. The mean CGI score was significantly lower in the control group in comparison to the ADHD and/or OCD groups. Both the ADHD group and comorbid ADHD and OCD group did not differ on CGI mean scores, and both met criteria for ADHD in the clinical range as demonstrated by a score of 15 or greater on the CGI (Conners, 1997).

Obsessive-Compulsive Symptoms

Children’s Yale-Brown Obsessive Compulsive Scale (CY-BOCS)

A one-way ANOVA revealed that the groups differed significantly in the severity of obsessive symptoms, $F(3,127) = 247.85, p < .01$, compulsive symptoms, $F(3,127) = 232.90, p < .01$, and total obsessive-compulsive symptoms, $F(3,127) = 268.12, p < .01$, as measured by the CY-BOCS. As shown in Table 3, a post-hoc analysis using Tukey’s HSD revealed clinician-rated obsessive, compulsive, and total symptom scores on the CY-BOCS were significantly higher in the OCD group in comparison to the comorbid ADHD and OCD group. Furthermore, both the OCD group and the comorbid ADHD and OCD group had significantly higher obsessive, compulsive, and total symptom severity scores compared to the ADHD group and control group. The ADHD and control
group did not significantly differ from each other on ratings of the CY-BOCS. Both the OCD group and comorbid ADHD and OCD group met criteria for OCD in the clinical range as demonstrated by a CY-BOCS total score of 15 or greater (McKay et al., 2003; Storch et al., 2006).

**Demographic Characteristics**

In accordance with Aim 1 of this study, key demographic characteristics (academic and intellectual functioning, family functioning, parental psychopathology and social adversity status) were compared between groups using one-way ANOVAs, with Bonferroni correction. The means and standard deviations of the academic and intellectual functioning measures for each group are shown in Table 4, whilst family functioning, parental psychopathology and social adversity status measures are shown in Table 5.

**Academic Functioning**

*Wide Range Achievement Test – Third Edition (WRAT-3)*

A one-way ANOVA showed significant differences between the groups on the WRAT-3 subtests of spelling, $F(3, 127) = 20.22, p < .01$, reading, $F(3, 127) = 15.28, p < .01$, and arithmetic, $F(3, 127) = 23.31, p < .01$. It can be seen in Table 4 that the Tukey HSD post-hoc test showed that the healthy control group had significantly higher scores on the spelling, reading, and arithmetic subtests compared to children and adolescents with ADHD and/or OCD. In addition, children and adolescents in the OCD group had a significantly higher score on the spelling subtest compared to those in the ADHD group.
### Table 4

**Group Comparison of Means and Standard Deviations of Academic and Intellectual Functioning**

<table>
<thead>
<tr>
<th>Measure</th>
<th>ADHD (n = 35)</th>
<th>OCD (n = 29)</th>
<th>ADHD + OCD (n = 34)</th>
<th>Control (n = 32)</th>
<th>Group Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F (3, 127) p</td>
</tr>
<tr>
<td><strong>Academic Functioning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRAT-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spelling</td>
<td>88.86&lt;sup&gt;c&lt;/sup&gt; (11.60)</td>
<td>98.97&lt;sup&gt;b&lt;/sup&gt; (16.49)</td>
<td>92.94&lt;sup&gt;bc&lt;/sup&gt; (14.72)</td>
<td>115.63&lt;sup&gt;a&lt;/sup&gt; (17.08)</td>
<td>20.22 **</td>
</tr>
<tr>
<td>Reading</td>
<td>92.89&lt;sup&gt;b&lt;/sup&gt; (14.67)</td>
<td>96.53&lt;sup&gt;b&lt;/sup&gt; (15.31)</td>
<td>95.35&lt;sup&gt;b&lt;/sup&gt; (15.72)</td>
<td>117.03&lt;sup&gt;a&lt;/sup&gt; (19.14)</td>
<td>15.28 **</td>
</tr>
<tr>
<td>Arithmetic</td>
<td>84.00&lt;sup&gt;b&lt;/sup&gt; (13.86)</td>
<td>84.77&lt;sup&gt;b&lt;/sup&gt; (16.08)</td>
<td>84.68&lt;sup&gt;b&lt;/sup&gt; (15.01)</td>
<td>110.06&lt;sup&gt;a&lt;/sup&gt; (15.37)</td>
<td>23.31 **</td>
</tr>
<tr>
<td><strong>Intellectual Functioning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WISC-IV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VCI</td>
<td>89.71&lt;sup&gt;b&lt;/sup&gt; (12.75)</td>
<td>94.62&lt;sup&gt;b&lt;/sup&gt; (15.16)</td>
<td>93.35&lt;sup&gt;b&lt;/sup&gt; (13.80)</td>
<td>111.41&lt;sup&gt;a&lt;/sup&gt; (17.58)</td>
<td>13.75 **</td>
</tr>
<tr>
<td>PRI</td>
<td>95.97&lt;sup&gt;b&lt;/sup&gt; (12.58)</td>
<td>102.79&lt;sup&gt;b&lt;/sup&gt; (14.41)</td>
<td>95.12&lt;sup&gt;b&lt;/sup&gt; (13.85)</td>
<td>111.94&lt;sup&gt;a&lt;/sup&gt; (13.85)</td>
<td>10.69 **</td>
</tr>
<tr>
<td>FSIQ</td>
<td>90.11&lt;sup&gt;b&lt;/sup&gt; (11.21)</td>
<td>95.93&lt;sup&gt;b&lt;/sup&gt; (13.57)</td>
<td>90.06&lt;sup&gt;b&lt;/sup&gt; (12.50)</td>
<td>112.72&lt;sup&gt;a&lt;/sup&gt; (13.63)</td>
<td>23.20 **</td>
</tr>
</tbody>
</table>

**Note.** ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder and Obsessive-Compulsive Disorder Group; WRAT-3 = Wide Range Achievement Test-Third Edition; WISC-IV = Wechsler Intelligence Scale for Children-Fourth Edition; VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index ('Performance IQ'); FSIQ = Full Scale Intelligence Quotient. ** Denotes significance at $p < .01$. Scores in any row with different superscripts are significantly different, $p < .05$ (Tukey HSD Post-hoc test)
Intellectual Functioning

*Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV)*

A one-way ANOVA showed significant differences between the groups on the Full Scale IQ, $F(3, 127) = 23.20, p < .01$, Verbal Comprehension Index, $F(3, 127) = 13.75, p < .01$, and the Perceptual Reasoning Index, $F(3, 127) = 10.69, p < .01$. Tukey HSD post-hoc analysis that is reported in Table 4 revealed that the control group performed significantly higher than the ADHD and/or OCD groups on all the indices of the WISC-IV measure of intellectual functioning.

Family Functioning

*Family Assessment Device (FAD)*

The level of family function significantly differed between the clinical groups and control group, $F(3, 127) = 3.84, p = .01$. Post hoc comparisons shown in Table 5 indicate that the level of family dysfunction in the ADHD and/or OCD groups was significantly worse compared to the control group. The level of family dysfunction in the ADHD and/OCD groups was in the clinical range, but did not differ significantly from each other.

Parental Psychopathology

*Hopkins Symptom Checklist (HSCL)*

A significant difference in parental psychopathology was noted between the three clinical groups and healthy control group, $F(3, 127) = 4.32, p = .01$. As shown in Table 5, post hoc comparisons indicated that the level of parental psychopathology in parents of children and adolescents with ADHD and/or OCD was significantly higher than parents of children in the healthy control group. The levels of parental psychopathology in parents of children in the ADHD and/or OCD groups were in the clinical range.
Table 5  
*Group Comparison of Means and Standard Deviations of Clinical Measures between the Clinical and Control Groups*

<table>
<thead>
<tr>
<th>Functional Domains and Measures</th>
<th>ADHD ($n = 35$)</th>
<th>OCD ($n = 29$)</th>
<th>ADHD + OCD ($n = 34$)</th>
<th>Control ($n = 32$)</th>
<th>Group Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
<td>$F$ (3, 127)</td>
</tr>
<tr>
<td><strong>Family Functioning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FAD</td>
<td>$2.05^b$ (0.41)</td>
<td>$2.09^b$ (0.43)</td>
<td>$2.10^b$ (0.75)</td>
<td>$1.67^a$ (0.40)</td>
<td>3.84</td>
</tr>
<tr>
<td><strong>Parental Psychopathology</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCSL</td>
<td>$95.80^b$ (27.34)</td>
<td>$100.13^b$ (25.86)</td>
<td>$97.03^b$ (29.87)</td>
<td>$76.71^a$ (15.50)</td>
<td>4.32</td>
</tr>
<tr>
<td><strong>Social Adversity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PACS</td>
<td>$9.06^b$ (2.53)</td>
<td>$7.70^a$ (1.49)</td>
<td>$8.29^{ab}$ (2.07)</td>
<td>$7.56^a$ (1.31)</td>
<td>4.12</td>
</tr>
</tbody>
</table>

*Note.* ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder and Obsessive-Compulsive Disorder Group. FAD = Family Assessment Device; HSCL = Hopkins Symptom Checklist; PACS = Parental Account of Childhood Symptoms. ** Denotes significance at $p < .01$. Scores in any row with different superscripts are significantly different, $p < .05$ (Tukey HSD Post-hoc test)
Social Adversity Status

**Parental Account of Childhood Symptoms (PACS)**

Analysis of the level of social adversity among the clinical groups and control group revealed there was a significant difference, $F(3, 127) = 4.12, p < .01$. Table 5 shows the Tukey HSD post-hoc test revealed the ADHD group had a significantly higher social adversity scale score than both the OCD group and control group. The comorbid ADHD and OCD group did not significantly differ from the ADHD group, OCD group or the healthy control group in terms of social adversity status.

Clinical Characteristics

In line with Aim 2 of this study, differences in mean scores on key measures of adaptive functioning (parent reported ratings of internalising, externalising and total symptom scores of their child) and emotional functioning (child-reported ratings of anxiety and depressive symptoms) were compared between groups using one-way ANOVAs, with Bonferroni correction.

**Adaptive Functioning**

*Child Behaviour Checklist (CBCL)*

The means and standard deviations of the parent-report ratings of internalising, externalising, and total problems from the CBCL are shown in Table 6. Without exception, Table 6 shows the ADHD and/or OCD groups differed significantly from the healthy control group on the internalising, externalising and total problem subscales, at the $p < .01$ level. Therefore, further analysis was limited to the ADHD and/or OCD clinical groups. Based on recommendations of the CBCL manual (Achenbach, 1991), the
current study used a $T$-score of 63 to estimate the proportion of participants in each of the clinical groups with scores on the CBCL scales that placed them in the clinical range. Tukey HSD post-hoc analysis revealed that the comorbid ADHD and OCD group had mean $T$-scores that were equal to the ADHD group, or significantly greater than the OCD group on the internalising, externalising and total scales of the CBCL. Both the comorbid ADHD and OCD, and the OCD group had significantly higher $T$-scores on the Internalising scale, $F(3, 127) = 46.98, p < .01$, compared with the ADHD group. However, the comorbid ADHD and OCD group did not differ significantly from the OCD group on the internalising scale $T$-score.

![Figure 6. A group comparison of internalising, externalising, and total symptom problem scales on the CBCL.](image-url)
Both the comorbid ADHD and OCD group and ADHD group had significantly higher $T$-scores on the CBCL externalising scale, $F(3, 127) = 70.05, p < .01$, compared with the OCD group, although no significant differences were detected between the ADHD group and the comorbid ADHD and OCD group. Furthermore, the comorbid ADHD and OCD group had a significantly higher $T$-score on the Total Problem scale, $F(3, 127) = 120.08, p < .01$, compared to the OCD group. However, no significant difference was noted between the ADHD group and OCD group on the Total Problem scale. To illustrate the mean differences between the groups, Figure 6 shows that the ADHD and/or OCD groups were in the clinical range on the internalising, externalising, and total problem scales compared to the control group.

**Emotional Functioning**

**Anxiety Symptoms**

*Revised Children’s Manifest Anxiety Scale (RCMAS)*

An investigation into child self-report anxiety symptoms (RCMAS) between the clinical groups and healthy control group revealed significant differences, $F(3, 127) = 12.33, p < .01$. Post hoc comparisons using Tukey’s HSD post-hoc test indicated that the mean RCMAS anxiety $T$-scores reported in Table 6 shows the ADHD and/or OCD groups had significantly higher mean RCMAS $T$-scores relative to the healthy control group. There were no significant differences between children and adolescents in the ADHD and/or OCD clinical groups, and none of the groups had clinically elevated mean anxiety scores on the RCMAS.
Table 6

*Group Comparison of Means and Standard Deviations of the Child Behaviour Checklist Subscales*

<table>
<thead>
<tr>
<th>Measures</th>
<th>ADHD (n = 35)</th>
<th>OCD (n = 29)</th>
<th>ADHD + OCD (n = 34)</th>
<th>Control (n = 32)</th>
<th>Group Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F (3, 127)</td>
</tr>
<tr>
<td><strong>Adaptive Functioning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBCL Scales</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internalising Problems</td>
<td>65.31&lt;sup&gt;b&lt;/sup&gt; (10.79)</td>
<td>72.03&lt;sup&gt;c&lt;/sup&gt; (8.37)</td>
<td>70.03&lt;sup&gt;bc&lt;/sup&gt; (9.50)</td>
<td>45.06&lt;sup&gt;a&lt;/sup&gt; (11.63)</td>
<td>46.98 **</td>
</tr>
<tr>
<td>Externalising Problems</td>
<td>75.23&lt;sup&gt;c&lt;/sup&gt; (8.60)</td>
<td>63.70&lt;sup&gt;b&lt;/sup&gt; (11.18)</td>
<td>73.59&lt;sup&gt;c&lt;/sup&gt; (8.28)</td>
<td>40.72&lt;sup&gt;a&lt;/sup&gt; (14.63)</td>
<td>70.05 **</td>
</tr>
<tr>
<td>Total Problems</td>
<td>72.66&lt;sup&gt;bc&lt;/sup&gt; (7.10)</td>
<td>69.03&lt;sup&gt;b&lt;/sup&gt; (7.18)</td>
<td>74.62&lt;sup&gt;c&lt;/sup&gt; (6.99)</td>
<td>43.91&lt;sup&gt;a&lt;/sup&gt; (8.41)</td>
<td>120.08 **</td>
</tr>
<tr>
<td><strong>Emotional Functioning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anxiety Symptoms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCMAS</td>
<td>48.97&lt;sup&gt;b&lt;/sup&gt; (8.67)</td>
<td>53.83&lt;sup&gt;b&lt;/sup&gt; (11.60)</td>
<td>51.00&lt;sup&gt;b&lt;/sup&gt; (11.09)</td>
<td>39.00&lt;sup&gt;a&lt;/sup&gt; (9.91)</td>
<td>12.33 **</td>
</tr>
<tr>
<td><strong>Depressive Symptoms</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDI</td>
<td>54.43&lt;sup&gt;b&lt;/sup&gt; (11.91)</td>
<td>56.10&lt;sup&gt;b&lt;/sup&gt; (14.38)</td>
<td>53.47&lt;sup&gt;b&lt;/sup&gt; (12.23)</td>
<td>41.88&lt;sup&gt;a&lt;/sup&gt; (5.79)</td>
<td>10.16 **</td>
</tr>
</tbody>
</table>

*Note.* ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder and Obsessive-Compulsive Disorder Group. CBCL = Child Behaviour Checklist; CDI = Childhood Depression Inventory; RCMAS = Revised Children’s Manifest Anxiety Scale. ** denotes significance at *p* < .01. Scores in any row with different superscripts are significantly different, *p* < .05 (Tukey HSD Post-hoc test)
Depressive Symptoms

*Culthood Depression Inventory (CDI)*

As shown in Table 6, a one-way ANOVA revealed a significant difference in the child-report of depressive symptoms (CDI) between the three clinical groups and control group, $F(3, 127) = 10.16, p < .01$. Post hoc comparisons using Tukeys HSD post-hoc test indicated that the mean CDI $T$-score for the ADHD and/or OCD groups was significantly higher than in the healthy control group. Children and adolescents with ADHD and/or OCD did not differ on the self-report measure of depressive symptomatology, and did not score in the clinical range on the CDI.

Neuropsychological Executive Function Characteristics

Descriptive Statistics

In accordance with Aim 3, the present study sought to determine whether significant differences existed on neuropsychological executive function (EF) constructs of visuospatial attention and memory in children and adolescents with ADHD, OCD, comorbid ADHD and OCD, or healthy controls. The Cambridge Neuropsychological Test Automated Battery (CANTAB) is sensitive to performance IQ and age differences in cognitive and neuropsychological ability (Barnett et al., 2005; Luciana, 2003; Luciana & Nelson, 2002). In order to establish robustness of possible EF differences, statistical analyses took into account differences in performance IQ (reported previously) between the groups by covarying for performance IQ for all the dependent EF measures of the CANTAB tasks.
Visuospatial Attention

Attentional Set Shifting

Total Stage Completion (Pass/Fail)

Performance on the Intra-Dimensional/Extra-Dimension (ID/ED) attentional set shifting task was examined by comparing the percentage of participants who succeeded in reaching criterion at each stage of the task. For purposes of analysis, participants were scored as to whether they successfully passed or failed each stage of the task. As shown in Table 7, group comparisons revealed that more participants in the healthy control group successfully completed the ID/ED task than both the ADHD group, $\chi^2(2) = 14.36, p < .01$, and OCD group, $\chi^2(2) = 6.47, p = .04$. However, the number of participants that completed all nine stages of the ID/ED task did not significantly differ between those in the comorbid ADHD and OCD group and the healthy control group, $\chi^2(2) = 5.15, p = .08$, the OCD group, $\chi^2(2) = 1.54, p = .46$, or the ADHD group, $\chi^2(3) = 7.28, p < .06$. There was also no significant difference on stage completion between the ADHD group and the OCD group, $\chi^2(3) = 2.61, p = .46$. Figure 7 displays the cumulative percentage of participants reaching the criterion at each of the nine stages of the ID/ED task.

Non-Cumulative Stage Completion (Pass/Fail)

Group performance at each stage of the task was also analysed non-cumulatively, (Purcell et al., 1997). Table 7 displays the percentage of participants who passed key stages of the ID/ED task. The percentage of participants that passed the Intra-dimensional shift (IDS) and the Intra-dimensional Reversal (IDR) stages did not differ between groups, although there were significant group differences on the Extra-
dimensional shift (EDS) stage, $\chi^2(3) = 13.14, p < .01$, and the Extra-dimensional reversal shift (EDR) stage, $\chi^2(3) = 14.28, p < .01$. Further analysis revealed that more ADHD participants, $\chi^2(1) = 10.87, p < .01$, and OCD participants $\chi^2(1) = 3.58, p = .05$, failed at the EDS stage than healthy control participants, while more ADHD participants failed at the EDS than the comorbid ADHD and OCD group, $\chi^2(1) = 6.85, p = .01$. The number of participants who failed at the EDS did not differ between the OCD group and both the ADHD group, $\chi^2(1) = 2.02, p = .16$, and the comorbid ADHD and OCD group, $\chi^2(1) = 1.32, p = .25$, or between the control group and the comorbid ADHD and OCD group, $\chi^2(1) = 0.65, p = .42$.

Further analysis into the EDR stage revealed that more ADHD participants, $\chi^2(1) = 13.86, p < .01$, and OCD participants $\chi^2(1) = 5.77, p = .02$, failed at the EDR stage than control participants, while more ADHD participants failed at the EDR than the comorbid ADHD and OCD group, $\chi^2(1) = 4.22, p = .04$. The number of participants who failed at the EDR did not differ between the OCD group and both the ADHD group, $\chi^2(1) = 1.80, p = .18$, and the comorbid ADHD and OCD group, $\chi^2(1) = 0.43, p = .51$, or between control group did not differ from the comorbid ADHD and OCD, $\chi^2(1) = 3.34, p = .07$. 
Figure 7. The non-cumulative percentage of participants reaching criterion at each stage of the ID/ED attentional set shifting task.
Table 7

Group Comparison of the Percentage of Participants that Completed the ID/ED Stages of the Attentional Set Shifting Task

<table>
<thead>
<tr>
<th>Measure(s)</th>
<th>ADHD (n = 35)</th>
<th>OCD (n = 29)</th>
<th>ADHD + OCD (n = 34)</th>
<th>Control (n = 32)</th>
<th>Group Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Attentional Set Shifting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage Completion (% Pass)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IDS Stage</td>
<td>100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.91 ns</td>
</tr>
<tr>
<td>IDR Stage</td>
<td>97.14&lt;sup&gt;a&lt;/sup&gt;</td>
<td>100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.76 ns</td>
</tr>
<tr>
<td>EDS Stage</td>
<td>45.71&lt;sup&gt;c&lt;/sup&gt;</td>
<td>63.33&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>76.47&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>84.38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.14 **</td>
</tr>
<tr>
<td>EDR Stage</td>
<td>40.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>58.62&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>64.71&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>84.38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.28 **</td>
</tr>
<tr>
<td>Total Stage Completion</td>
<td>40.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>58.62&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>64.7&lt;sup&gt;1ab&lt;/sup&gt;</td>
<td>84.38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.82 **</td>
</tr>
</tbody>
</table>

*Note.* ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder Group and Obsessive-Compulsive Disorder Group. IDS = Intra-Dimensional Shift; IDR = Intra-Dimensional Reversal; EDS = Extra-Dimensional Shift; EDR = Extra-Dimensional Reversal; F-value for the repeated measures ANCOVA; ** denotes significance at *p* < .01; ns denotes non-significance. Scores in any row with different superscripts are significantly different, *p* <.05 (Tukey HSD Post-hoc test)
Total Trials
The mean number of cumulative trials required to complete each stage of the task were analysed using an ANCOVA analysis with performance IQ as a covariate. It can be seen in Table 8 that the total number of trials across all stages of the ID/ED task revealed significant group differences, $F(3,127) = 4.07, p = .01$, partial $\eta^2 = .09$, after covarying for performance IQ, $F(1,127) = 1.71, p = .19$, partial $\eta^2 = .01$. Post-hoc analysis revealed that the ADHD group had significantly more total number of trials cumulatively across all stages, and required more trials to reach criterion at the EDS stage and the EDR stage than the healthy control group. Neither the OCD group or comorbid ADHD and OCD group were significantly different in the number of mean trials from each other, or from the control group or the ADHD group. Figure 8 presented below shows the non-cumulative mean number of trials required to attain the criterion at each stage of the task.

Non-Cumulative Stage Trials
The mean number of non-cumulative trials required to reach the criterion at each stage of the task were analysed using an ANCOVA analysis with performance IQ as a covariate. The number of trials required at the IDS and IDR stages did not differ between groups, although there were significant group differences at the EDS stage, $F(3,127) = 2.73, p = .05$, partial $\eta^2 = .06$, and the EDR stage of the task, $F(3,127) = 3.60, p = .02$, partial $\eta^2 = .08$, after controlling for performance IQ, which had no significant independent association. Post-hoc comparisons presented in Table 8 revealed that the ADHD group had significantly more trials compared to the healthy control group on the EDS and EDR stages. However, the OCD group and comorbid ADHD and OCD group did not significantly differ from each other, or from the ADHD group, or the control group on the number of trials taken to complete the EDS and EDR stages.
Figure 8. The non-cumulative mean number of trials at each stage of the ID/ED attentional set shifting task.
Table 8

Group Comparison of Mean and Standard Deviation Trial Scores on the Attentional Set Shifting Task

<table>
<thead>
<tr>
<th>Measure(s)</th>
<th>ADHD (n = 35)</th>
<th>OCD (n = 29)</th>
<th>ADHD + OCD (n = 34)</th>
<th>Control (n = 32)</th>
<th>Group Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F (3, 127)</td>
</tr>
<tr>
<td><strong>Attentional Set Shifting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IDS Stage</td>
<td>8.11&lt;sup&gt;a&lt;/sup&gt; (4.38)</td>
<td>7.67&lt;sup&gt;a&lt;/sup&gt; (2.25)</td>
<td>8.03&lt;sup&gt;a&lt;/sup&gt; (2.91)</td>
<td>6.91&lt;sup&gt;a&lt;/sup&gt; (1.09)</td>
<td>0.99</td>
</tr>
<tr>
<td>IDR Stage</td>
<td>10.86&lt;sup&gt;a&lt;/sup&gt; (8.43)</td>
<td>8.70&lt;sup&gt;a&lt;/sup&gt; (3.64)</td>
<td>10.71&lt;sup&gt;a&lt;/sup&gt; (5.37)</td>
<td>8.53&lt;sup&gt;a&lt;/sup&gt; (3.33)</td>
<td>1.96</td>
</tr>
<tr>
<td>EDS Stage</td>
<td>35.60&lt;sup&gt;b&lt;/sup&gt; (17.38)</td>
<td>29.23&lt;sup&gt;ab&lt;/sup&gt; (18.29)</td>
<td>26.35&lt;sup&gt;ab&lt;/sup&gt; (17.42)</td>
<td>21.72&lt;sup&gt;a&lt;/sup&gt; (15.65)</td>
<td>2.73</td>
</tr>
<tr>
<td>EDR Stage</td>
<td>34.43&lt;sup&gt;b&lt;/sup&gt; (19.99)</td>
<td>27.07&lt;sup&gt;ab&lt;/sup&gt; (20.55)</td>
<td>24.82&lt;sup&gt;ab&lt;/sup&gt; (19.58)</td>
<td>16.50&lt;sup&gt;a&lt;/sup&gt; (16.42)</td>
<td>3.60</td>
</tr>
<tr>
<td>Total Trials</td>
<td>134.34&lt;sup&gt;b&lt;/sup&gt; (44.96)</td>
<td>115.27&lt;sup&gt;ab&lt;/sup&gt; (38.97)</td>
<td>117.71&lt;sup&gt;ab&lt;/sup&gt; (40.42)</td>
<td>93.13&lt;sup&gt;a&lt;/sup&gt; (30.09)</td>
<td>4.08</td>
</tr>
</tbody>
</table>

Note. ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder Group and Obsessive-Compulsive Disorder Group. IDS = Intra-Dimensional Shift; IDR = Intra-Dimensional Reversal; EDS = Extra-Dimensional Shift; EDR = Extra-Dimensional Reversal. F-value for the repeated measures ANCOVA; * denotes significance at p < .05; ** denotes significance at p < .01; ns denotes non-significance. Scores in any row with different superscripts are significantly different, p < .05 (Tukey HSD Post-hoc test)
Total Errors

The total number of errors across all stages of the ID/ED task revealed significant group differences, $F(3,127) = 5.89, p < .01$, partial $\eta^2 = .12$. Post-hoc analysis revealed that the ADHD group made significantly more errors cumulatively across all stages compared with the healthy control group. Neither the OCD group or comorbid ADHD and OCD group were significantly different in the number of mean errors from each other, or the healthy control or ADHD groups. Figure 9 shows the non-cumulative mean number of errors made at each stage of the task.

Non-Cumulative Stage Errors

The mean number of non-cumulative errors made before reaching the criterion at each stage of the task were also analysed using an ANCOVA analysis. The number of errors made at the IDS and IDR stages did not differ between groups, although there were significant group differences at the EDS stage, $F(3,127) = 3.39, p = .02$, partial $\eta^2 = .08$, and the EDR stage of the task, $F(3,127) = 4.10, p = .01$, partial $\eta^2 = .10$, after controlling for performance IQ, which had a non-significant independent association with trials on both the EDS and EDR stages. Table 9 displays the mean and standard deviation of the total errors made by each group. Post-hoc analysis revealed that the ADHD group had made significantly more errors than the healthy control group on the EDS and EDR stages. However, the OCD group and comorbid ADHD and OCD group did not significantly differ from each other, or from the ADHD group, or the healthy control group on the number of errors made in the EDS and EDR stages.
Figure 9. The non-cumulative mean number of errors at each stage of the ID/ED attentional set shifting task.
Table 9

*Group Comparison of Mean and Standard Deviation Errors on the Attentional Set Shifting Task*

<table>
<thead>
<tr>
<th>Measure(s)</th>
<th>ADHD (n = 35)</th>
<th>OCD (n = 29)</th>
<th>ADHD + OCD (n = 34)</th>
<th>Control (n = 32)</th>
<th>Group Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F (3,127)</td>
</tr>
<tr>
<td><strong>Attentional Set Shifting Errors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IDS Stage</td>
<td>0.91&lt;sup&gt;a&lt;/sup&gt; (1.44)</td>
<td>0.93&lt;sup&gt;a&lt;/sup&gt; (0.91)</td>
<td>1.03&lt;sup&gt;a&lt;/sup&gt; (1.22)</td>
<td>0.75&lt;sup&gt;a&lt;/sup&gt; (0.76)</td>
<td>0.19 &lt;sup&gt;ns&lt;/sup&gt;</td>
</tr>
<tr>
<td>IDR Stage</td>
<td>2.63&lt;sup&gt;a&lt;/sup&gt; (3.99)</td>
<td>1.67&lt;sup&gt;a&lt;/sup&gt; (1.37)</td>
<td>2.32&lt;sup&gt;a&lt;/sup&gt; (1.85)</td>
<td>1.59&lt;sup&gt;a&lt;/sup&gt; (2.45)</td>
<td>1.75 &lt;sup&gt;ns&lt;/sup&gt;</td>
</tr>
<tr>
<td>EDS Stage</td>
<td>17.86&lt;sup&gt;b&lt;/sup&gt; (11.66)</td>
<td>14.43&lt;sup&gt;ab&lt;/sup&gt; (11.63)</td>
<td>11.53&lt;sup&gt;ab&lt;/sup&gt; (10.14)</td>
<td>9.06&lt;sup&gt;a&lt;/sup&gt; (8.55)</td>
<td>3.39 *</td>
</tr>
<tr>
<td>EDR Stage</td>
<td>29.60&lt;sup&gt;b&lt;/sup&gt; (23.26)</td>
<td>22.87&lt;sup&gt;ab&lt;/sup&gt; (23.46)</td>
<td>16.68&lt;sup&gt;ab&lt;/sup&gt; (20.65)</td>
<td>10.06&lt;sup&gt;a&lt;/sup&gt; (18.10)</td>
<td>4.10 **</td>
</tr>
<tr>
<td>Total Errors</td>
<td>59.11&lt;sup&gt;b&lt;/sup&gt; (37.53)</td>
<td>46.43&lt;sup&gt;ab&lt;/sup&gt; (33.92)</td>
<td>39.82&lt;sup&gt;ab&lt;/sup&gt; (30.39)</td>
<td>26.69&lt;sup&gt;a&lt;/sup&gt; (25.20)</td>
<td>4.54 **</td>
</tr>
</tbody>
</table>

*Note.* ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder Group and Obsessive-Compulsive Disorder Group. IDS = Intra-Dimensional Shift; IDR = Intra-Dimensional Reversal; EDS = Extra-Dimensional Shift; EDR = Extra-Dimensional Reversal. *F*-value for the repeated measures ANCOVA; * denotes significance at p < .05; ** denotes significance at p < .01; ns denotes non-significance. Scores in any row with different superscripts are significantly different, p < .05 (Tukey HSD Post-hoc test)
Total Response Latency

Total response latency (logarithm-transformed) was analysed using a one-way ANCOVA. There was no significant group difference on the cumulative total response latency, $F(3, 127) = 0.66, p = .58$, after covarying for performance IQ, $F(1, 127) = 0.81$, $p = .37$, which had no significant independent association with total response latency.

Non-Cumulative Response Latency

One-way ANCOVA analyses revealed that response latency did not significantly differ between groups, and stages, with no interaction (largest $F(3, 127) = 2.49, p = .07$).

Visuospatial Short-Term Memory (VSTM)

Delayed-Matching to Sample

Total Response Accuracy

When averaged across all four conditions, post-hoc analysis revealed that the mean total response accuracy as reported in Table 10 was significantly higher in the healthy control group compared to both the ADHD group, and comorbid ADHD and OCD group. Furthermore, the total response accuracy was significantly higher in the OCD group compared to the ADHD group. No significant differences on total response accuracy were found between the healthy control and OCD groups, nor between the OCD and comorbid ADHD and OCD groups, or between the ADHD and comorbid ADHD and OCD groups. Large effect sizes were observed between the healthy control group and both the ADHD group (Cohen’s $d = 1.13$), and the comorbid ADHD and OCD group (Cohen’s $d = 0.91$). Moderate effect sizes were also found between the ADHD group and OCD group (Cohen’s $d = 0.56$).
Table 10

*Group Comparison of Means and Standard Deviations of Response Accuracy on the DMTS Task*

<table>
<thead>
<tr>
<th>Measure</th>
<th>ADHD (n = 35)</th>
<th>OCD (n = 29)</th>
<th>ADHD + OCD (n = 34)</th>
<th>Control (n = 32)</th>
<th>Group Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F (3, 127) p</td>
</tr>
<tr>
<td>Delayed Matching to Sample</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response Accuracy (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simultaneous Delay</td>
<td>88.00 b (16.42)</td>
<td>93.10 ab (14.42)</td>
<td>92.94 ab (8.72)</td>
<td>96.56 a (7.87)</td>
<td>2.20 ns</td>
</tr>
<tr>
<td>0 Second Delay</td>
<td>63.71 b (19.87)</td>
<td>73.79 ab (21.11)</td>
<td>67.65 b (20.90)</td>
<td>82.81 a (12.50)</td>
<td>2.96 *</td>
</tr>
<tr>
<td>4 Second Delay</td>
<td>64.57 b (20.77)</td>
<td>78.28 a (17.34)</td>
<td>72.35 ab (20.46)</td>
<td>83.44 a (13.10)</td>
<td>4.11 **</td>
</tr>
<tr>
<td>12 Second Delay</td>
<td>54.57 b (22.93)</td>
<td>62.07 ab (22.58)</td>
<td>56.18 ab (22.57)</td>
<td>69.69 a (20.71)</td>
<td>1.33 ns</td>
</tr>
<tr>
<td>Total Response Accuracy</td>
<td>67.71 c (16.76)</td>
<td>76.81 ab (15.95)</td>
<td>72.28 bc (13.94)</td>
<td>83.13 a (9.20)</td>
<td>3.82 **</td>
</tr>
</tbody>
</table>

Note. ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder Group and Obsessive-Compulsive Disorder Group. *F*-value for the repeated measures ANCOVA; * denotes significance at $p < .05$; ** denotes significance at $p < .01$; *ns* denotes non-significance. Scores in any row with different superscripts are significantly different, $p < .05$ (Tukey HSD Post-hoc test)
Response Accuracy in the Encoding and Memory Retrieval Components

Differences between groups in the mean number of correct responses on the Delayed Matching to Sample (DMTS) task were analysed using 4 (group) x 4 (condition) repeated measures ANCOVA to assess accuracy of memory retrieval over increasing delay. The analysis indicated a significant effect of condition, Wilks’ $\lambda = .83$, $F(3,123) = 8.29$, $p < .01$, partial $\eta^2 = .17$, and group $F(3,125) = 3.82$, $p = .01$, partial $\eta^2 = .08$, on the number of correct responses, after covarying for performance IQ, $F(1,125) = 4.11$, $p < .05$, partial $\eta^2 = .03$, which had a significant independent association with response accuracy. There was no significant interaction between condition and diagnostic group, Wilks’ $\lambda = .95$, $F(9,299) = .75$, $p = .66$, partial $\eta^2 = .02$, after covarying for performance IQ, while no significant independent associations were found between condition and performance IQ. Wilks’ $\lambda = .94$, $F(3,123) = 2.41$, $p = .07$, partial $\eta^2 = .06$. The mean number of correct responses presented above in Table 10 shows the ADHD group was significantly less accurate than the healthy control group across the simultaneous and delayed conditions. The comorbid ADHD and OCD group was significantly less accurate than the control group in the 0 second delay condition, while the ADHD group was significantly less accurate than the OCD group in the 4 second delay condition.

Response Accuracy in the Memory Retrieval Component

To determine the extent to which differences between groups in the accuracy of encoding information affected the accuracy of their recall ability after a delay, a 4 (group) x 3 (delay conditions) ANCOVA was performed with the three DMTS conditions entered as levels of the independent variable and accuracy on the MTS condition treated as a covariate. This analysis indicated that the covariates for MTS, $F(3, 125) = 47.96$, $p < .01$,
and performance IQ, $F(1,125) = 6.25, p = .14$, partial $\eta^2 = .05$, were significant with the effect of group non-significant when the effect of the covariate was removed, $F(3,124) = 1.89, p = .14$, partial $\eta^2 = .04$. Further, there was no significant effect of condition, Wilks’ $\lambda = .97, F(2,123) = 1.91, p = .15$, partial $\eta^2 = .03$, or group $F(3,124) = 1.89, p = .14$, partial $\eta^2 = .04$, on the number of correct responses. The interaction between group and condition was non-significant, Wilks’ $\lambda = .98, F(6,248) = .42, p = .87$, partial $\eta^2 = .01$. There were also no significant independent associations between condition and the MTS condition, Wilks’ $\lambda = .97, F(2,123) = 2.04, p = .14$, or performance IQ, partial $\eta^2 = .03$, Wilks’ $\lambda = .99, F(2,123) = .43, p = .65$, partial $\eta^2 = .01$. Figure 10 below shows the mean percentage of response accuracy for each group in the simultaneous and the three delay conditions of the DMTS task.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure10.png}
\caption{The mean response accuracy of each group on each condition of the DMTS task.}
\end{figure}
Errors

Total Number of Errors x Condition

The total number of each error type in each of the four conditions (simultaneous and delay) was submitted to a 3 (total error type) x 4 (condition) repeated measures ANCOVA, covarying for performance IQ. Repeated measures ANCOVA showed that there was a significant difference in the total number of errors made at each delay condition, Wilk’s $\lambda = .83$, $F(3,123) = 8.38$, $p < .01$, partial $\eta^2 = .17$. However, no significant interaction was found between condition and performance IQ, Wilk’s $\lambda = .94$, $F(2,124) = 2.45$, $p = .07$, partial $\eta^2 = .06$, or between condition and group, Wilk’s $\lambda = .94$, $F(9,299) = 0.80$, $p = .62$, partial $\eta^2 = .02$. There was, however, a significant main effect of group, $F(3,125) = 3.16$, $p = .03$, partial $\eta^2 = .07$, although the between group effect was not significant after covarying for performance IQ, $F(3,125) = 3.35$, $p = .07$, partial $\eta^2 = .03$. Figure 11 displays the mean totals of each type of error at each condition of the DMTS. As the group differences in the mean number of errors presented in Table 11, averaged across all error types, is the inverse of the finding of differences between groups for accuracy of performance, this effect was not explored further.
Differences between groups in the types of errors made on the DMTS task, including distractor, wrong shape and wrong colour errors, were analysed using a 4 (group) x 3 (error type) repeated measures ANCOVA. For analysis of error type, the ANCOVA indicated a significant main effect of group, $F(3,125) = 3.17, p = .03$, after covarying for performance IQ, $F(1,125) = 3.43, p = .07$. The ANCOVA also indicated a significant main effect for condition, Wilk’s $\lambda = .76, F(2,124) = 19.56, p < .01$, partial $\eta^2 = .24$, and for condition and performance IQ, Wilk’s $\lambda = .87, F(3,125) = 3.17, p = .03$, partial $\eta^2 = .13$. However, no significant interaction was found between condition and group, Wilk’s $\lambda = .94, F(6,248) = 3.17, p = .25$, partial $\eta^2 = .03$. Figure 12 presented below shows that all the
groups made significantly more errors of the ‘shape’ type than of both the ‘colour’ and the ‘distractor’ types. Post-hoc analyses using Tukey HSD that are reported in Table 11 indicated that the ADHD group and the comorbid ADHD and OCD group made significantly more ‘colour’ type errors than the control group, while the OCD group did not significantly differ from other groups on the number of ‘colour’ error types. Additionally, the ADHD group made significantly more ‘distractor’ type errors than the control group. However, neither the OCD group or comorbid ADHD and OCD group differed from the ADHD group or the control group on mean ‘distractor’ error type.

![Figure 12](image.png)

*Figure 12.* The mean number of each type of error made by each group on the DMTS task.
Table 11

*Group Comparison on Mean and Standard Deviation of Total Errors and Error Types on the DMTS Task*

<table>
<thead>
<tr>
<th>Measure</th>
<th>ADHD (n = 35)</th>
<th>OCD (n = 29)</th>
<th>ADHD + OCD (n = 34)</th>
<th>Control (n = 32)</th>
<th>Group Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F (3, 127)</td>
</tr>
<tr>
<td><strong>Delayed Matching to Sample</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Errors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simultaneous Delay</td>
<td>1.06 a (1.51)</td>
<td>0.67 a (1.42)</td>
<td>0.71 a (0.87)</td>
<td>0.34 a (0.79)</td>
<td>1.66 ns</td>
</tr>
<tr>
<td>0 Second Delay</td>
<td>3.49 b (1.99)</td>
<td>2.60 ab (2.08)</td>
<td>3.24 b (2.09)</td>
<td>1.72 a (1.25)</td>
<td>2.54 ns</td>
</tr>
<tr>
<td>4 Second Delay</td>
<td>3.40 b (2.10)</td>
<td>2.13 a (1.74)</td>
<td>2.74 ab (1.99)</td>
<td>1.66 a (1.31)</td>
<td>3.52 *</td>
</tr>
<tr>
<td>12 Second Delay</td>
<td>4.40 a (2.29)</td>
<td>3.70 a (2.28)</td>
<td>4.38 a (2.26)</td>
<td>3.03 a (2.07)</td>
<td>1.17 ns</td>
</tr>
<tr>
<td>Total Errors</td>
<td>12.34 b (6.67)</td>
<td>9.10 ab (6.34)</td>
<td>11.09 b (5.58)</td>
<td>6.72 a (3.72)</td>
<td>3.17 *</td>
</tr>
<tr>
<td><strong>Error Type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shape Errors</td>
<td>5.91 a (3.37)</td>
<td>4.33 a (3.30)</td>
<td>5.44 a (3.28)</td>
<td>4.56 a (3.21)</td>
<td>0.57 ns</td>
</tr>
<tr>
<td>Colour Errors</td>
<td>4.03 b (2.99)</td>
<td>3.17 ab (2.77)</td>
<td>3.94 b (2.79)</td>
<td>1.66 a (1.93)</td>
<td>3.51 *</td>
</tr>
<tr>
<td>Distractor Errors</td>
<td>2.40 b (2.45)</td>
<td>1.60 ab (2.27)</td>
<td>1.71 ab (1.85)</td>
<td>0.50 a (0.92)</td>
<td>5.44 **</td>
</tr>
</tbody>
</table>

Note. ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder Group and Obsessive-Compulsive Disorder Group. F-value for the repeated measures ANCOVA; * denotes significance at p < .05; ** denotes significance at p < .01; ns denotes non-significance. Scores in any row with different superscripts are significantly different, p < .05 (Tukey HSD Post-hoc test).
Response Latency

Response Latency in the Memory Retrieval and Encoding Components

Differences in the response latency (msec) on the DMTS task, across groups, were analysed using a 4 (group) x 4 (condition) repeated measures ANCOVA, with performance IQ as a covariate (see Table 12 below). There was no significant effect of condition, Wilks’ $\lambda = .98$, $F(3,123) = 0.75$, $p < .53$, partial $\eta^2 = .02$, or group, $F(3,125) = 1.20$, $p = .31$, partial $\eta^2 = .03$, on speed of responses, nor after co-varying for performance IQ, $F(1,125) = 0.15$, $p = .70$, partial $\eta^2 = .00$. There was also no significant interaction between condition and group, Wilks’ $\lambda = .90$, $F(9,299) = 1.52$, $p = .14$, partial $\eta^2 = .04$, after co-varying for performance IQ, or between condition and performance IQ, Wilks’ $\lambda = .98$, $F(3,123) = 0.73$, $p = .53$, partial $\eta^2 = .02$. Figure 13 shows that the mean response latency for each group in each condition did not significantly differ, except in the simultaneous condition where the ADHD group responded significantly slower than the control group.

![Figure 13](image)

**Figure 13.** The mean response latency of each group on each condition of the DMTS task.
**Response Latency in the Encoding Component**

A repeated measures ANCOVA using a 4 (group) x 3 (delay condition) design was used to assess latency of response over increasing delay, as well as to determine the impact of latency of encoding information after increasing delays. The three DMTS conditions entered as levels of the repeated factor and the MTS condition treated as a covariate. This analysis indicated that there were no significant effects of condition, Wilks’ $\lambda = .98$, $F(2,123) = 1.56, p = .21$, partial $\eta^2 = .03$, or diagnostic group, $F(3,124) = 1.71, p = .17$, partial $\eta^2 = .04$, on speed of response, after co-varying for performance IQ, $F(1,124) = 0.96, p = .33$, partial $\eta^2 = .01$, which did not have a significant independent association with response latency. However, there was a significant group effect after covarying for the MTS condition, $F(1,124) = 1.27, p < .01$, partial $\eta^2 = .20$. No significant interaction was found between condition and group, Wilks’ $\lambda = .96$, $F(6,246) = 0.71, p = .64$, partial $\eta^2 = .02$, and there was no significant independent association between condition and the MTS condition, Wilks’ $\lambda = .98$, $F(2,123) = 1.56, p = .21$, partial $\eta^2 = .03$, or performance IQ, Wilks’ $\lambda = .99$, $F(2,123) = 0.51, p = .60$, partial $\eta^2 = .01$. 
### Table 12

**Group Comparison of Means and Standard Deviations of Response Latency on the DMTS**

<table>
<thead>
<tr>
<th>Measure</th>
<th>ADHD (n = 35)</th>
<th>OCD (n = 29)</th>
<th>ADHD + OCD (n = 34)</th>
<th>Control (n = 32)</th>
<th>Group Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F (3, 127)</td>
</tr>
<tr>
<td><strong>Delayed Matching to Sample</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response Latency (msec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simultaneous Delay</td>
<td>3.63&lt;sup&gt;b&lt;/sup&gt; (0.13)</td>
<td>3.57&lt;sup&gt;ab&lt;/sup&gt; (0.15)</td>
<td>3.59&lt;sup&gt;ab&lt;/sup&gt; (0.12)</td>
<td>3.51&lt;sup&gt;a&lt;/sup&gt; (0.13)</td>
<td>3.08 **</td>
</tr>
<tr>
<td>0 Second Delay</td>
<td>3.49&lt;sup&gt;a&lt;/sup&gt; (0.16)</td>
<td>3.49&lt;sup&gt;a&lt;/sup&gt; (0.14)</td>
<td>3.52&lt;sup&gt;a&lt;/sup&gt; (0.15)</td>
<td>3.52&lt;sup&gt;a&lt;/sup&gt; (0.12)</td>
<td>0.31 ns</td>
</tr>
<tr>
<td>4 Second Delay</td>
<td>3.60&lt;sup&gt;a&lt;/sup&gt; (0.16)</td>
<td>3.53&lt;sup&gt;a&lt;/sup&gt; (0.17)</td>
<td>3.60&lt;sup&gt;a&lt;/sup&gt; (0.19)</td>
<td>3.56&lt;sup&gt;a&lt;/sup&gt; (0.13)</td>
<td>1.47 ns</td>
</tr>
<tr>
<td>12 Second Delay</td>
<td>3.60&lt;sup&gt;a&lt;/sup&gt; (0.19)</td>
<td>3.57&lt;sup&gt;a&lt;/sup&gt; (0.18)</td>
<td>3.65&lt;sup&gt;a&lt;/sup&gt; (0.16)</td>
<td>3.62&lt;sup&gt;a&lt;/sup&gt; (0.17)</td>
<td>1.20 ns</td>
</tr>
<tr>
<td>Total Latency</td>
<td>14.31&lt;sup&gt;a&lt;/sup&gt; (0.44)</td>
<td>14.17&lt;sup&gt;a&lt;/sup&gt; (0.51)</td>
<td>14.36&lt;sup&gt;a&lt;/sup&gt; (0.44)</td>
<td>14.22&lt;sup&gt;a&lt;/sup&gt; (0.48)</td>
<td>1.20 ns</td>
</tr>
</tbody>
</table>

**Note.** ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder Group and Obsessive-Compulsive Disorder Group. *F*-value for the repeated measures ANCOVA; ** denotes significance at *p* < .01; *ns* denotes non-significance. Scores in any row with different superscripts are significantly different, *p* < .05 (Tukey HSD Post-hoc test)
Visuospatial Working Memory (VSWM)

**Spatial Span**

Performance on spatial span was compared using a one-way ANCOVA to analyse the difference between the mean spatial span of each group, covarying for performance IQ. There was a significant difference between the clinical groups in spatial span performance, \( F(3,126) = 3.11, p = .05, \text{partial } \eta^2 = .69, \) after co-varying for performance IQ, \( F(1, 129) = 7.39, p = .01, \text{partial } \eta^2 = .06, \) which had a significant independent association with spatial span performance. Table 13 shows that the Tukey HSD post hoc analysis revealed that children and adolescents in the ADHD and/or OCD groups had significantly shorter mean spatial span scores than children in the healthy control group. The mean spatial span score did not significantly differ between children and adolescents in the ADHD and/or OCD groups.

**Spatial Working Memory**

**Strategy Score**

A univariate ANCOVA was used to analyse the difference between the mean strategy score for each group, covarying for performance IQ, on the Spatial Working Memory (SWM) task. There was a significant difference between the four groups in search strategy scores used during the SWM task, \( F(3, 127) = 3.86, p = .01, \text{partial } \eta^2 = .09, \) after co-varying performance IQ, \( F(1,129) = 11.63, p > .01, \text{partial } \eta^2 = .09, \) which had a significant independent association with search strategy performance. Tukey HSD post-hoc comparisons reported in Table 13 indicate that the mean strategy scores was significantly higher in the ADHD group and the comorbid ADHD and OCD group, indicating a less efficient search strategy, than for the OCD group and the healthy control
group. The ADHD group did not significantly differ from the comorbid ADHD and OCD group, nor did the OCD group significantly differ from the control group. Large effect sizes were found between the control group and ADHD group (Cohen’s $d = 1.06$), as well as, between the control group and comorbid ADHD and OCD group (Cohen’s $d = 0.95$). Moderate effect sizes were also found between the ADHD group and OCD group (Cohen’s $d = 0.79$), and between the OCD group and the comorbid ADHD and OCD group (Cohen’s $d = 0.70$).

**Between Search-Errors (BSEs)**

**Total BSEs**

A one-way ANCOVA was used to analyse the difference between the mean total BSE’s for each diagnostic group, covarying for performance IQ. There was a significant difference between the clinical groups in total BSE’s, $F(3,127) = 3.82$, $p = .04$, partial $\eta^2 = .08$, after co-varying for performance IQ, $F(1, 129) = 5.34$, $p = .02$, partial $\eta^2 = .04$, which had a significant independent association with BSE’s on the SWM task. As shown in Table 13 post-hoc analyses revealed that the ADHD group and the comorbid ADHD and OCD group made significantly more total BSEs than both the OCD and healthy control group. The comorbid ADHD and OCD group did not differ significantly from the ADHD group, nor did the OCD group differ significantly from the control group. Large effect sizes were found between the control group and both the ADHD group (Cohen’s $d = 1.15$) and the comorbid ADHD and OCD group (Cohen’s $d = 1.09$). Moderate effect sizes were also found between the control group and OCD group (Cohen’s $d = 0.55$), the ADHD group and OCD group (Cohen’s $d = 0.43$), and the OCD group and comorbid ADHD and OCD group (Cohen’s $d = 0.44$).
Table 13
Group Comparison of Mean and Standard Deviation Spatial Span and Spatial Working Memory Tasks

<table>
<thead>
<tr>
<th>Measure</th>
<th>ADHD (n = 35)</th>
<th>OCD (n = 29)</th>
<th>ADHD + OCD (n = 34)</th>
<th>Control (n = 32)</th>
<th>Group Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F (3, 127)</td>
</tr>
<tr>
<td>Spatial Span</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Span Score</td>
<td>5.17 b</td>
<td>5.66 b</td>
<td>5.00 b</td>
<td>6.50 a</td>
<td>3.12 **</td>
</tr>
<tr>
<td>Spatial Working Memory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strategy</td>
<td>37.11 b</td>
<td>33.93 a</td>
<td>36.74 b</td>
<td>33.47 a</td>
<td>3.86 **</td>
</tr>
<tr>
<td>Between-Search Errors (BSE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 3</td>
<td>0.34 a</td>
<td>0.24 a</td>
<td>0.29 a</td>
<td>0.13 a</td>
<td>0.47 ns</td>
</tr>
<tr>
<td>Level 4</td>
<td>2.03 a</td>
<td>1.48 a</td>
<td>2.35 a</td>
<td>0.72 a</td>
<td>2.34 ns</td>
</tr>
<tr>
<td>Level 6</td>
<td>14.00 b</td>
<td>10.83 ab</td>
<td>14.59 b</td>
<td>7.22 a</td>
<td>3.80 **</td>
</tr>
<tr>
<td>Level 8</td>
<td>29.89 b</td>
<td>25.62 ab</td>
<td>29.65 b</td>
<td>19.81 a</td>
<td>2.62 *</td>
</tr>
<tr>
<td>Total BSE’s</td>
<td>45.91 b</td>
<td>37.93 ab</td>
<td>46.59 b</td>
<td>27.75 a</td>
<td>3.82 **</td>
</tr>
</tbody>
</table>

Note. ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder Group and Obsessive-Compulsive Disorder Group; BSE = Between Search Errors. F-value for the repeated measures ANCOVA. * denotes significance at p < .05. ** denotes significance at p < .01, ns denotes non-significance. Scores in any row with different superscripts are significantly different, p < .05 (Tukey HSD Post-hoc test)
**BSEs across Task Difficulty Levels**

Differences in accuracy of performance (BSE’s) across the diagnostic groups were explored using a 4 (group) x 4 (difficulty level) repeated measures ANCOVA. Table 13 shows the mean BSE’s for each group at each difficulty level on the SWM task. There remained a significant main effect of condition (difficulty level), Wilks’ $\lambda = .76$, $F(3,123) = 12.74, p > .01$, partial $\eta^2 = .02$, and diagnostic group $F(3,127) = 3.87, p = .01$, partial $\eta^2 = .09$, on the number of BSE’s, after co-varying for performance IQ, $F(3,127) = 5.34, p = .02$, partial $\eta^2 = .04$, which had a significant independent association with the number of BSE’s. There was no significant interaction effect between condition and diagnostic group, Wilks’ $\lambda = .91$, $F(9,299) = 1.34, p > .22$, after co-varying for performance IQ. No significant independent associations were also found between condition and performance IQ, Wilks’ $\lambda = .95$, $F(3,123) = 2.14, p = .10$. Figure 14 shows that the difference between the number of BSE’s for each group increased with increasing level of task difficulty.
**Figure 14.** The mean number of between-search errors (BSEs) on the SWM task.

### Response Latency

**Total Response Latency**

A one-way ANCOVA was used to analyse the difference between the mean total response latency for each diagnostic group, covarying for performance IQ. Table 14 indicates that there was no significant group difference on response latency, $F(3,127) = 2.47, p = .07$, partial $\eta^2 = .06$, after co-varying for performance IQ, $F(1, 129) = .83, p = .36$, partial $\eta^2 = .01$, in which neither had a significant independent association with response latency on the SWM task. Figure 15 illustrates that the difference in response latency between groups did not differ with increasing level of difficulty.
Figure 15. The mean response latency of each group at each level of difficulty on the SWM task.

Response Latency across Levels of Task Difficulty

Response latencies (logarithm-transformed) on the SWM task across each group were analysed using a 4 (group) x 4 (difficulty level) repeated measures ANCOVA (see Table 14). After co-varying for performance IQ, there was no significant effect of condition, Wilks’ $\lambda = .58$, $F(3,127) = 29.32$, $p < .01$. There was also no significant independent association found between response latency and group, $F(1, 129) = 2.47$, $p = .07$, partial $\eta^2 = .06$, even after covarying for performance IQ, $F(1,129) = 0.83$, $p = .36$, partial $\eta^2 = .01$. There was also no significant interaction between latency and diagnostic group, Wilks’ $\lambda = .91$, $F(9,299) = 1.33$, $p = .22$, after co-varying for performance IQ, or between latency and performance IQ, Wilks’ $\lambda = .97$, $F(3,127) = 0.28$, $p = .03$. 
Table 14

*Group Comparison of Mean and Standard Deviation on the Response Latency Measure of the Spatial Working Memory Task*

<table>
<thead>
<tr>
<th>Measure</th>
<th>ADHD (n = 35)</th>
<th>OCD (n = 29)</th>
<th>ADHD + OCD (n = 34)</th>
<th>Control (n = 32)</th>
<th>Group Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F (3, 127)</td>
</tr>
<tr>
<td><strong>Spatial Working Memory</strong></td>
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<tr>
<td>Response Latency</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latency Level 3</td>
<td>4.89 a (0.13)</td>
<td>4.98 a (0.26)</td>
<td>4.89 a (0.11)</td>
<td>4.90 a (0.15)</td>
<td>2.01</td>
</tr>
<tr>
<td>Latency Level 4</td>
<td>4.89 a (0.08)</td>
<td>4.93 a (0.09)</td>
<td>4.88 a (0.20)</td>
<td>4.87 a (0.08)</td>
<td>1.32</td>
</tr>
<tr>
<td>Latency Level 6</td>
<td>5.17 a (0.09)</td>
<td>5.17 a (0.10)</td>
<td>5.20 a (0.14)</td>
<td>5.11 a (0.10)</td>
<td>1.92</td>
</tr>
<tr>
<td>Latency Level 8</td>
<td>5.37 a (0.09)</td>
<td>5.39 a (0.08)</td>
<td>5.40 a (0.09)</td>
<td>5.33 a (0.10)</td>
<td>2.11</td>
</tr>
<tr>
<td>Total Latency</td>
<td>20.32 a (0.30)</td>
<td>20.47 a (0.40)</td>
<td>20.37 a (0.39)</td>
<td>20.21 a (0.32)</td>
<td>2.77</td>
</tr>
</tbody>
</table>

*Note.* ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder Group and Obsessive-Compulsive Disorder Group. *F*-value for the repeated measures ANCOVA. *ns* denotes non-significance. Scores in any row with the same superscript are not significantly different, *p > .05* (Tukey HSD Post-hoc test).
The Relationship between Visuospatial Working Memory Tasks

Spatial Working Memory, Strategy and Spatial Span Correlations

The relationships between SWM (BSE’s and strategy) and spatial span components of VSWM in each diagnostic group were assessed with Pearson product-moment correlation coefficients (see Table 15). Preliminary analyses were carried out to ensure no violation of the assumption of normality, linearity, and homoscedasticity. For children and adolescents in the ADHD group ($r = .69, p < .01$), OCD group ($r = .81, p < .01$), comorbid ADHD and OCD group ($r = .34, p < .05$), and the control group ($r = .60, p < .01$) there were significant positive correlations between Total BSEs and Strategy Score. For children and adolescents in the ADHD group ($r = -.43, p = .01$), OCD group ($r = -.50, p < .01$), comorbid ADHD and OCD group ($r = -.38, p = .03$), and control group ($r = -.47, p < .01$) there were significant negative correlations between Total BSEs and Spatial Span. A significant negative correlation was also observed between spatial span and strategy score for children and adolescents in the ADHD group ($r = -.53, p < .01$), comorbid ADHD and OCD group ($r = -.36, p = .04$), and healthy control group ($r = -.44, p = .01$), although this association was not observed in the OCD group.
Table 15

_Bivariate Correlations between Group Means on Total Between-Search Errors, Strategy Score, and Spatial Span_

<table>
<thead>
<tr>
<th></th>
<th>Total BSE’s</th>
<th>Strategy Score</th>
<th>Spatial Span</th>
</tr>
</thead>
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<tr>
<td></td>
<td>ADHD</td>
<td>OCD</td>
<td>ADHD &amp; OCD</td>
</tr>
<tr>
<td>Total BSE’s</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Strategy Score</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Spatial Span</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note.* ADHD = Attention-Deficit Hyperactivity Disorder Group; OCD = Obsessive-Compulsive Disorder Group; ADHD + OCD = Comorbid Attention-Deficit Hyperactivity Disorder Group and Obsessive-Compulsive Disorder Group; BSE = Between Search Errors. * denotes significance at $p < .05$; ** denotes significance at $p < .01$. 
CHAPTER 8
DISCUSSION

Diagnostic and Demographic Characteristics

The first major objective of the current study was to compare the clinical ADHD and/or OCD groups and the healthy control group with respect to their diagnostic (symptom severity of ADHD and/or OCD symptoms) and demographic characteristics (academic and intellectual functioning, family functioning, parental psychopathology, and psychosocial adversity status). Results described in the preceding chapter suggest that there are qualitative similarities and differences in the diagnostic and clinical characteristics between children and adolescents with ADHD and/or OCD, whilst these three groups generally differ significantly from healthy control children. The similarities and differences between the ADHD and/or OCD groups on key clinical measures are discussed below.

Symptom Severity

Attention Problems

Child Behaviour Checklist (CBCL) Attention Problem Subscale

The parent reported ratings of attentional problems on the CBCL were significantly greater in children and adolescents with ADHD and/or OCD compared to the healthy control group, whilst the ADHD and comorbid ADHD and OCD group had significantly greater levels of parent-reported attention problems compared to those in the OCD group. These results are consistent with Hypothesis 1a that children and adolescents with ADHD and/or OCD would have significantly higher levels of inattention compared to the healthy
control group, and partly support the hypothesis that those in the comorbid ADHD and OCD group would have higher attention problem ratings compared to those in the ADHD or OCD groups. A recent study by Geller et al. (2004) identified that their comorbid ADHD and OCD group had a mean score on the attention problem scale of the CBCL that was significantly greater than either their ADHD or OCD groups. This suggested that both ADHD and OCD disorders contributed to the very high levels of inattention seen in the comorbid ADHD and OCD group. However, in the present study children and adolescents with comorbid ADHD and OCD did not appear to have additive scores on the attention problem subscale that would reflect the independent contribution of symptomatic and functional impairment from both ADHD and OCD disorders. Rather, parent-reported ratings of attention problems appear to be associated with the presence of ADHD.

**Hyperactive-Impulsive Symptoms**

*Conners Global Index (CGI)*

The results revealed that parent-reported levels of hyperactive-impulsive symptoms on the CGI were significantly higher among children and adolescents in the ADHD and/or OCD groups compared to the healthy control group. Both the ADHD and comorbid ADHD and OCD groups had higher inattention and hyperactive-impulsive symptoms compared to the OCD group and both groups met criteria for ADHD based on CGI scores that were in the clinical range. The results support Hypothesis 1a that children and adolescents with ADHD or comorbid ADHD and OCD would have greater levels of hyperactive-impulsive symptoms compared to the OCD or healthy control groups, but does not support the hypothesis that children and adolescents in the comorbid ADHD and OCD group would have greater levels of hyperactive-impulsive symptoms.
compared to those in the ADHD group. These findings are consistent with previous studies that have found a trend for parents to rate children and adolescents with ADHD or comorbid ADHD and OCD more highly on the hyperactivity subscale of the Conners Rating Scale compared with those in the OCD or healthy control groups (Arnold et al., 2005; Sukhodolsky et al., 2005). Given the externalising nature of hyperactive-impulsive symptoms, children and adolescents with comorbid ADHD and OCD are more likely to have more dominant hyperactive-impulsive characteristics that may lessen the clinical presentation of internalising obsessive-compulsive symptoms.

**Obsessive-Compulsive Symptoms**

*Children’s Yale-Brown Obsessive-Compulsive Scale (CY-BOCS)*

The clinician-rated obsessive-compulsive symptom scores on the CY-BOCS revealed that the OCD group had significantly higher ratings compared to the comorbid ADHD and OCD group on both the obsession and compulsion subscales. These results are not consistent with Hypothesis 1a that the OCD and comorbid ADHD and OCD groups would not differ on CY-BOCS ratings. The obsessive-compulsive symptom profile in children and adolescents with OCD or comorbid ADHD and OCD in the present study was qualitatively different from previous studies that have compared these two groups (Geller et al., 2003a; Sukhodolsky et al., 2005). These two previous studies did not identify significant differences in CY-BOCS ratings scores between children and adolescents with OCD or comorbid ADHD and OCD. The fact that the OCD population in the current study was a clinical sample, and that most of the participants in the OCD group had not previously sought assessment and/or treatment for OCD related symptoms might explain why their symptom severity ratings were higher. In contrast, children and
adolescents with comorbid ADHD and OCD may have been referred to the study because the ADHD related symptoms were more prominent, and thus diminishing the impact of OCD related symptoms.

**Demographic and Clinical Characteristics**

**Academic Functioning**

*Wide Range Achievement Test (WRAT-3)*

The academic screening measures revealed that children and adolescents with ADHD and/or OCD displayed significant spelling, reading, and arithmetic deficits in comparison to the healthy control group. Children and adolescents with ADHD and/or OCD did not significantly differ on the academic measures, except on the spelling subtest where the ADHD group performed significantly worse compared to the OCD group. These findings support Hypothesis 1b that children and adolescents with ADHD and/or OCD would exhibit impairments on academic measures compared to the control group. These results are also consistent with previous reports showing academic underachievement in children and adolescents with ADHD and/or OCD (Antshel et al., 2008; Arnold et al., 2005; Barkley, 1997; Busch et al., 2002; Mariani & Barkley, 1997; Sukhodolsky et al., 2005).

The acquisition of academic skills has often been linked with the functional efficiency of executive functions (EF) (Gioia et al., 2002). Therefore, academic developmental delays in children and adolescents with ADHD and/or OCD may actually reflect inefficient learning caused by EF deficits in the domains of working memory, inhibition, and planning/organisation that set up inefficient encoding and retrieval of
information in short-term and long-term memory (Barkley, 1997, 2002). This is an important consideration given that academic developmental delays in children and adolescents with ADHD and/or OCD can be seen as a secondary outcome of underlying cognitive processes. These processes are dependent on EFs that allow new materials to be learned and build on existing knowledge (Barkley, 2002).

**Intellectual Functioning**

*Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV)*

The current results indicate that children and adolescents with ADHD and/or OCD exhibited intellectual deficits on the verbal comprehension (‘verbal IQ’), perceptual reasoning (‘performance IQ’), and full-scale IQ indices of the WISC-IV compared to the healthy control group. Although all IQ scores were in the average range, the healthy control group had approximately a 10-point higher normative mean compared to children and adolescents with ADHD and/or OCD. However, intellectual functioning did not differ among children and adolescents with ADHD and/or OCD. This finding supports Hypothesis 1c that children and adolescents in the ADHD and/or OCD groups would exhibit intellectual functioning deficits compared to the healthy control group. This is a particularly important finding given that IQ has been found to correlate with performance on most CANTAB subtests (Luciana & Nelson, 2002).

Previous research indicates that children with ADHD often have lower IQs than control children (see Frazier, Demaree, & Youngstrom, 2004 for a meta-analysis). In contrast, individuals with OCD often exhibit higher IQ index scores on standardised intelligence tests, particularly verbal IQ (Boone et al., 1991). In the present study, IQ
scores may have been inflated in the control group because of the nature of the volunteer recruitment process. Healthy control participants who volunteered may have had higher intellectual abilities. On the other hand, lower IQ scores in children and adolescents with ADHD and/or OCD may be linked to underlying EF deficits in the right hemisphere of the prefrontal cortex (Kane & Engle, 2002).

There is debate about the overlap between the concepts of IQ and EF. The argument put forward in this thesis is that there is a stronger case when EF differences on visuospatial attention and memory constructs between the ADHD and/or OCD groups exist after taking IQ into account (Sergeant et al., 2002). Importantly, the CANTAB neuropsychological tasks to be examined in later chapters are independent of verbal ability, and the results covaried for non-verbal ‘performance IQ’. The results should therefore not be affected by group differences in verbal and ‘performance IQ’.

**Family Functioning**

*Family Assessment Device (FAD)*

The results supported Hypothesis 1d that children and adolescents with ADHD and/or OCD had elevated levels of family dysfunction in the clinical range compared to the healthy control group. The results of the present study are consistent with previous research studies that have reported on elevated levels of family dysfunction, stress and parental conflict in children and adolescents with ADHD (Biederman, Faraone, & Monuteaux, 2002; Biederman, Milberger, Faraone et al., 1995a; 1995b), and OCD (Chambless et al., 2007; Hirshfeld-Becker et al., 2004; Piacentini et al., 2003). Thus, impaired family functioning is strongly associated with increased risk and poor prognosis.
for children and adolescents with ADHD and/or OCD. However, the hypothesis that the comorbid ADHD and OCD group would manifest higher levels of family dysfunction compared to those in the ADHD group or OCD group was not supported. These results are inconsistent with previous reports in which children and adolescents with comorbid ADHD and OCD have been shown to live in families with significantly greater levels of family dysfunction compared to those with ADHD alone or OCD alone (Sukhodolsky et al., 2005). The similar high levels of family dysfunction evident among families of children and adolescents with ADHD and/or OCD may be attributed to environmental aetiological factors and/or higher levels of parental psychopathology that often leads to increased dysfunction within the family, or more elevated levels of ADHD and/or OCD symptomatology causing discord within families. From the current study, it is not possible to ascertain in which direction any causal connection may lie.

**Parental Psychopathology**

*Hopkins Symptom Checklist (HSCL)*

Exposure to parental psychopathology has been shown to have an impact to varying degrees on children with ADHD and/or OCD related psychopathology (Johnston & Mash, 2001; Pfiffner et al., 1999; Sukhodolsky et al., 2005). The results showed that significantly elevated levels of self-reported parental psychopathology were found among parents of children and adolescents with ADHD and/or OCD compared with the healthy control group. Whilst the results supported Hypothesis 1e that higher levels of parental psychopathology would be evident among children and adolescents with ADHD and/or OCD compared to the healthy control group, the results failed to support Hypothesis 1e that the comorbid ADHD and OCD group would have greater elevated levels of parental psychopathology.
psychopathology compared to children and adolescents with ADHD or OCD (Arnold et al., 2005). It is also consistent with previous literature that has shown a strong familial ‘cluster’ in relatives of children and adolescents with ADHD (Faraone, Biederman, Mick et al., 2001; Faraone, Biederman, & Friedman, 2000) and OCD (Albert et al., 2002; Bienvenu et al., 2000; Grabe et al., 2006; Hanna et al., 2005; Nestadt et al., 2000; Rosario-Campos et al., 2005). Such a clustering of physiological and emotional psychopathology among parents of children and adolescents with ADHD and/or OCD psychopathology may be due to biological and/or psychosocial aetiological factors. These findings emphasise the importance of parental psychopathology as a risk factor for children who have ADHD and/or OCD.

Social Adversity

Parental Account of Childhood Symptoms (PACS)

Children and adolescents in the ADHD group had significantly higher scores on the social adversity measure relative to the OCD group and the healthy control group. The comorbid ADHD and OCD group did not significantly differ from the ADHD, OCD or control group. Hypothesis 1f which suggested the presence of ADHD and/or OCD would be associated with higher levels of social adversity was only partially supported. This hypothesis was based on the finding that children and adolescents with ADHD (Johnson et al., 2001; Johnston & Mash, 2001; Pfiffner et al., 2001) and/or OCD (Cromer, Schmidt, & Murphy, 2007; de Silva & Marks, 1999; Heim & Nemeroff, 2001; Lochner et al., 2002) would be associated with increased levels of childhood social adversity. Clearly, chronic childhood adversity is a complex construct, involving stressful life events such as loss,
illness, accidents; family environmental factors, such as marital conflict and separation, conflict with parents, financial pressures, parental psychopathology, and maltreatment, and social interactions such as peer network, and relationship break-ups (Biederman, Faraone, & Monuteaux, 2002; Cromer et al., 2007; de Silva & Marks, 1999; Johnston & Mash, 2001). Therefore, this finding may result from the measurement of social adversity used in the current study. It is possible that the childhood social adversity scale was not a sufficiently comprehensive measure of chronic environmental social adversity.

**Clinical Characteristics**

The second major objective of the current study was to compare ADHD and/or OCD and healthy control children and adolescents on adaptive functioning based on parent reported ratings of internalising, externalising, and total problems (the combination of internalising and externalising problems), and emotional functioning based on child self-reported ratings of anxiety and depressive symptomatology.

**Adaptive Functioning**

*Child Behaviour Checklist (CBCL)*

As hypothesised (2a), children and adolescents with ADHD and/or OCD had elevated parent-reported ratings on the internalising, externalising and total symptom scales of the CBCL compared to those in the healthy control group. A closer examination of the results among the ADHD and/or OCD groups revealed that parents reported significantly more internalising symptoms in the OCD group compared to the ADHD group, while the comorbid ADHD and OCD group did not differ from the ADHD or OCD groups. On the contrary, parents reported significantly more externalising symptoms in
both the ADHD and comorbid ADHD and OCD groups compared to the OCD group. Parent-reported ratings on the total problem symptom scale were significantly higher in the comorbid ADHD and OCD group compared to the OCD group, while the ADHD group did not differ from either the OCD or the comorbid ADHD and OCD groups. These findings are partly consistent with the hypothesis that children with comorbid ADHD and OCD would have significantly higher internalising, externalising and total symptom scores compared to either the ADHD or OCD group.

It is notable that the presence of OCD was closely associated with elevated internalising symptom scores, while the presence of ADHD was closely associated with externalising symptom scores. The CBCL findings provide additional support for previous, but limited, research documenting that children and adolescents with comorbid ADHD and OCD have profiles that reflect the independent combined contribution of symptoms and functional impairment from each disorder (Geller et al., 2004; Sukhodolsky et al., 2005). These results are also substantiated by the fact that the comorbid ADHD and OCD group had elevated internalising scores as did the OCD group, and elevated externalising scores, as did the ADHD group.

The high prevalence rates of ADHD and/or OCD in children and adolescents has important clinical and research implications. From a clinical viewpoint, the presence of comorbid ADHD and OCD may help identify a hybrid subtype (the combined symptomatic and impaired functional contribution of both ADHD and OCD disorders) that has a different aetiology, course, and treatment response. From a research viewpoint, the CBCL is an empirically derived scale that provides evidence to suggest that (1) high levels of comorbidity between ADHD and OCD identified in studies using DSM-based
structured diagnostic interview methodology is not a result of assessor bias, but is consistent with a true comorbidity model, and (2) inattention in children with OCD is not simply an artefact of anxiety (Geller et al., 2004).

**Emotional Functioning**

**Anxiety Symptoms**

*Revised Children’s Manifest Anxiety Scale (RCMAS)*

The child self-report measure of anxiety did not reveal significant differences between the ADHD and/or OCD groups, although anxiety symptoms scores were significantly more elevated in the three clinical groups compared to the healthy control group. These findings support Hypothesis 2b that self-reported anxiety symptoms would be higher in children and adolescents with ADHD and/or OCD compared to the control group, but failed to support the hypothesis that the comorbid ADHD and OCD group would report higher levels of anxiety compared to the ADHD or OCD groups.

Previous studies have often reported high rates of comorbid anxiety disorders with ADHD (Angold et al., 1999; Sanders et al., 2005) and OCD (Brown et al., 2001; Carter et al., 2004; Curray, March, & Hervey, 2004; Geller et al., 1996). Consistent with previous research, the findings suggest that for these samples, a diagnosis of OCD was not associated with higher levels of emotional maladjustment, particularly on self-reported anxiety, than was a diagnosis of ADHD, even though OCD shares the same diagnostic classification with other anxiety disorders (Sukhodolsky et al., 2005).
Depressive Symptoms

Children’s Depression Inventory (CDI)

As hypothesised in 2c, the results indicate that according to child self-report, depressive symptom severity was significantly higher among children and adolescents in the ADHD and/or OCD groups compared with the healthy control group. Whilst a diagnosis of ADHD and/or OCD was associated with mild depressive symptomatology, levels of depressive symptoms in the three clinical groups were not in the clinical range. The finding that there were no significant differences on the child self-report depressive symptomatology between the ADHD and/or OCD groups failed to support Hypothesis 2c that children and adolescents with comorbid ADHD and OCD would exhibit more severe depressive symptomatology than those with either ADHD or OCD. The fact that children and adolescents with ADHD and/or OCD exhibited similar levels of depressive symptomatology that was not within the clinical range is probably the result of excluding cases with major depressive disorder (MDD) from this study. Previous studies with different exclusion criteria have often reported high rates of comorbid depressive disorders with ADHD (Angold et al., 1999; Sanders et al., 2005) and OCD (Brown et al., 2001; Carter et al., 2004; Hong et al., 2004).

Executive Function

The primary goal of this study was to examine the neuropsychological profile of children and adolescents with ADHD and/or OCD. To this end, four key neuropsychological tests from the Cambridge Automated Neuropsychological Test Battery (CANTAB) were used to assess the visuospatial attention and memory constructs of EF in children and adolescents with ADHD and/or OCD. These neuropsychological
tests include the attentional set shifting, short-term recognition memory, spatial span and spatial working memory tasks. The neuropsychological profiles of children and adolescents with ADHD and OCD will be examined separately. The neuropsychological profile of the comorbid ADHD and OCD group is only addressed if the group significantly differed from either the ADHD or OCD group.

Visuospatial Attention

Attentional Set Shifting

The results from the Intra-Dimensional/Extra-Dimensional (ID/ED) attentional set shifting task revealed that the more participants in the ADHD group failed to complete the ED shift and the ED reversal shift stages, had taken more trials, and made more errors compared to the healthy control group. The findings of the present study suggest that significantly more children and adolescents with OCD failed the ED shift and ED reversal stages of the ID/ED attentional set shifting task, but did not significantly differ on the number trials or errors made compared to the control group. The comorbid ADHD and OCD group did not differ significantly from the ADHD, OCD or healthy control group on the number of trials taken, or errors made, although more participants in the comorbid ADHD and OCD group passed the ED shift and ED reversal stages compared to the ADHD group. The results partly supported Hypothesis 3a that children and adolescents with ADHD and/or OCD would exhibit greater difficulty using a previously learnt rule and applying this to new exemplars in the attentional set shifting task compared to the healthy control group, but did not support Hypothesis 3a that the comorbid ADHD and OCD group would demonstrate greater deficits than those with ADHD or OCD alone.
ADHD and Attentional Set Shifting

The handful of studies that have utilised the ID/ED attentional set shifting task support the findings of the present study that identified children and adolescents with ADHD exhibit attentional set shifting deficits (Goldberg et al., 2005; Kempton et al., 1999; Mehta et al., 2004; Rhodes et al., 2005; 2006; Vance, Maruff, & Barnett, 2003). Set shifting deficits in these studies were demonstrated by the failure of ADHD participants to be able to complete all 9 stages of the task, taking more trials to reach criterion of each stage, and making more errors compared to healthy control children. Neuroimaging studies using PET have demonstrated that attentional set shifting deficits are associated with abnormal activation within neural networks that involve the lateral dorsolateral and ventrolateral prefrontal cortex in the right hemisphere and the premotor cortex, anterior cingulate, and the insula and cerebellum (Owen et al., 1991; Robbins et al., 2000; Rogers et al., 1999). Consistent with this neuroimaging profile, patients with frontal cortex damage have been found to have difficulty switching between tasks (Aron et al., 2004; Owen et al., 1992; Rogers et al., 1998).

The ID/ED attentional set shifting paradigm is similar to the traditional Wisconsin Card Sorting Test (WCST; Berg, 1948). A number of studies using the WCST have consistently reported that children with ADHD complete fewer categories and make significantly more perseverative errors compared to control participants (Grodzinsky & Barkley, 1999; Lawrence et al., 2004; Pineda, Ardila, & Rosseli, 1999; Seidman et al., 1997; Sergeant, Geurts, & Oosterlaan, 2002; see Willcutt et al., 2005). Performance on the WCST, particularly measures of perseverative errors, is also associated with frontal lobe lesions in human patients and with activation of the
dorsolateral prefrontal cortex. High perseverative error scores have been seen as an indicator of dysfunction of the inhibitory forebrain system in children and adolescents with ADHD (Lawrence et al., 2004).

Deficits in attentional set shifting also implicate associated selective attention, information processing and response inhibition deficits that are consistent with Barkley's (1997) EF model of ADHD (see also Pennington & Ozonoff, 1996). The attentional set shifting profile pattern identified in children and adolescents with ADHD in the current study suggests that they were able to sustain attention on the reinforced stimulus, but were not able to shift attention or inhibit inappropriate responses to a previously irrelevant stimulus in the latter stages of the task. Thus, the findings of the present study are consistent with Barkley’s model of ADHD that posits a central role for EF deficits, specifically, selective attention, attentional set shifting and response inhibitory processes (Barkley, 1997).

**OCD and Attentional Set Shifting**

Evidence of attentional set shifting deficits is based mostly on adult studies of OCD (for review see Kuelz et al., 2004), with relatively little research on children and adolescents by comparison (Shin et al., 2008). This literature has produced inconsistent findings about the association between attentional set shifting and OCD. A few studies have identified attentional set shifting deficits in adults with OCD using the ID/ED task as evidenced by a cumulative increase in the number of participants who failed to complete the task, and the number of errors made (Veale et al., 1996; Watkins et al., 2005). The outcome of these OCD studies support the idea that impaired attentional set
shifting performance may be associated with deficits in selective attention of relevant stimuli when competing stimuli is introduced. However, some studies have failed to replicate these results on the ID/ED set shifting task (Nielen & Den Boer, 2003; Purcell et al., 1998a; 1998b).

Partly consistent with the results of the present study, Fenger et al. (2005) found that adults with OCD displayed attentional set shifting deficits on the extra-dimensional shift (EDS) stage although once the participants had learned the reversal of response and shift of attention, they performed as well as the healthy controls on the extra-dimensional reversal (EDR) stage. The emphasis of attentional set paradigms is on EF processes needed for the response inhibition of inappropriate task sets, as well as, on those attentional control processes required for the preparation for a new task rule (Robbins et al., 2000). Whilst the results of the present study are inconclusive and do not demonstrate that children and adolescents with OCD differed on the number of trials or errors made, they do indicate that children and adolescents with OCD had subtle deficits in selective attention, sustained attention, and response inhibition, in addition to attentional set shifting deficits compared to the control group. These deficits in children and adolescents with OCD are demonstrated by their failure to pass the EDS and EDR stages compared to the healthy control group. The subtle deficits implicate mild abnormalities in the lateral and orbitofrontal prefrontal cortex regions in children and adolescents with OCD (Fenger et al., 2005).

A number of different paradigms have also been used to explore the association between attentional set shifting paradigms and OCD, with inconsistent results. Some studies have identified set shifting deficits in attention on the WCST (Basso, Bornstein,
Carona, & Morton, 2001; Moritz et al., 2002; Okasha et al., 2000; Veale et al., 1996), but others have not identified such deficits (Moritz et al., 2001a; Moritz et al., 2002).

Similarly, some studies have identified attentional set shifting deficits in adults with OCD using the object alternation test (OAT) (Abbruzzese et al., 1995a; Abbruzzese et al., 1997; Aycicegi et al., 2003; Cavedini et al., 1998) and the delayed alternation test (DAT) (Moritz, 2001b), whilst a number of studies have not identified attentional set shifting deficits on these tasks (Deckersbach et al., 2000; Kim et al., 2002; Moritz et al., 2001a; Moritz et al., 2002; Schmidtke et al., 1998).

There are three key explanations to account for the inconsistencies between studies and the failure to identify clearly defined attentional set shifting deficits in children and adolescents with OCD in the current study. First, the cognitive tasks used in the exploration of attentional set shifting in OCD use different components of EF and areas of the frontal lobe (Fenger et al., 2005). The ID/ED (Fenger et al., 2005) and the OAT and DAT tasks (Zald et al., 2002) are more dependent on orbitofrontal cortex function. The WCST task, in contrast, measures behavioural reversal which is a distinct aspect of set shifting. Behavioural reversal requires a rule to be learnt and then inhibited and reversed in order to maintain good performance. These tasks appear to be more dependent on the dorsolateral prefrontal cortex function (Zald et al., 2002). In sum, impairment of attentional set shifting ability in OCD patients remains highly debated owing to the different sensitivity levels of the tasks most commonly used to assess this ability.

Second, the number of predominant responses or familiarity with test responses may provide an explanation for the different results on the various frontal lobe tests of
attentional set shifting. The ID/ED test was used in an animal model to investigate the EF of the prefrontal cortex (Roberts & Wallis, 2000). According to Robert and Wallis, the suppression of predominant responses, or response inhibition control, is an intrinsic property of the prefrontal cortex (particularly the lateral and orbitofrontal cortex). This may explain why performance of OCD patients may be normal on some attentional set shifting tasks as the materials or principles in these tests are familiar to the patients or may not involve a predominant response. However, performance on different tasks may be impaired because the material or principles in the tests are unfamiliar to the patients or involve a shift relative to the predominant response.

Third, deficits in attentional set shifting impairments identified in previous studies of OCD may be caused by the presence of comorbid depressive symptoms, as patients suffering from depressive disorders usually perform poorly on set shifting tasks (Basso et al., 2001; Mortiz et al., 2001a). Studies that carefully controlled for depressive symptoms did not observe attentional set shifting deficits in adults with OCD (Cavedini et al., 1998; Mortiz et al., 2001a; Purcell et al., 1998b). Clearly, further studies are required with larger sample sizes, monitoring of comorbidities, symptom severity and medications.

**Visuospatial Short-Term Memory**

*Delayed Matched to Sample (DMTS) Task*

DMTS tests have been used to assess visuospatial short-term memory (VSTM) recognition in both human and animal models (Owen et al., 1995; Paule et al., 1998). The results of the current study found that children and adolescents with ADHD were
significantly less accurate and made more errors across the MTS and DMTS conditions compared to the healthy control group. The OCD group did not significantly differ from the ADHD, comorbid ADHD and OCD, or healthy control groups on measures of accuracy or error during the MTS and DMTS conditions, although the ADHD group had cumulative less total accuracy across the task compared to the OCD group. The comorbid ADHD and OCD group did not differ significantly from the ADHD, OCD, or healthy control groups in the MTS and DMTS condition on measures of accuracy or error, except the comorbid ADHD and OCD group performed significantly worse on measures of cumulative total accuracy and total errors (particularly during 0 second delay) compared to the healthy control group. Response latency did not significantly between the ADHD and/or OCD, or healthy control groups during the MTS or DMTS conditions. These findings partly support Hypothesis 3b that the ADHD and/or OCD groups would exhibit greater VSTM memory deficits compared to the healthy control group, but failed to identify more distinct VSTM deficits in the comorbid ADHD and OCD group compared with children in the ADHD or OCD groups.

**ADHD and Visuospatial Short-Term Memory**

Numerous studies have consistently identified that VSTM deficits form part of the neuropsychological profile of children and adolescents with ADHD as evidenced by poor performance on MTS and DMTS tasks (Barnett et al., 2005; Kempton, 1999; Rhodes et al., 2005). VSTM deficits have also been identified in children and adolescents with ADHD before the administration of methylphenidate stimulant medication (Coghill et al., 2007; Rhodes et al., 2004; Rhodes et al., 2006; Vance et al., 2003). These studies identified specific impairments in mnemonic recognition,
encoding, recall and learning memory processes of visuospatial material, as well as attentional deficits in children with ADHD. The presence of VSTM impairments in children and adolescents with ADHD in the current study is consistent with these neuropsychological studies.

Neuroimaging models of children and adolescents with ADHD propose that VSTM deficits arises from disruption(s) to neural circuits that (1) involve the prefrontal cortex and the basal ganglia regions, and (2) are modulated by catecholamines such as dopamine and noradrenaline (Castellanos et al., 2006; Vance et al., 2007). Poor performance on MTS and DMTS task conditions has also been observed in individuals with disorders of the basal ganglia and frontostriatal neural networks, including Parkinson’s disease and Huntington’s disease (Lawrence et al., 2000; Owen et al., 1992; Sahakian et al., 1988). However, adults with damage to the hippocampal formation, amygdala or medial temporal lobes in Alzheimer-Type Dementia (Owen et al., 1995; Sahakian et al., 1988), display poor performance on DMTS conditions that increase as the length of the delay increases. This suggests that frontostriatal dysfunction is mainly associated with poor encoding, leading to impaired MTS and DMTS performance, while dysfunction of medial temporal lobe structures primarily leads to deficits in the mnemonic retrieval aspects of VSTM.

Several key aspects from the results of the present study suggest that VSTM deficits reflect an encoding deficit due to frontostriatal abnormalities rather than memory retrieval deficits due to disruptions to the hippocampal memory systems. The current study revealed (1) unlike adult patients with memory retrieval deficits, children in the ADHD group performed poorly in the MTS condition, (2) when the effects of
encoding in the MTS condition were statistically controlled poor performance during the DMTS conditions was largely a consequence of encoding deficits, and not memory retrieval deficits, and (3) children in the ADHD group did not show a delay-dependent forgetting effect. This suggests that VSTM impairments in children and adolescents with ADHD reflect an encoding deficit due to attentional system impairments rather than deficits in the memory network. Poor encoding of visuospatial information also contributed to the inability of children with ADHD to hold information in memory in the DMTS conditions. When considered previous studies, the results suggest that poor performance on the DMTS task arises from disruption to frontostriatal brain networks (Barnett et al., 2001; Kempton et al., 1999).

Consistent with the findings from previous studies (Fenger et al., 2005), VSTM deficits in children and adolescents with ADHD may reflect motor response inhibition deficits, and a tendency to respond to novel versus familiar objects, when there are more than two choices. This theory is consistent with well-know pathophysiological models of ADHD which have found that ADHD children are unable to suppress motor tendency to novel objects (Barkley, 1997). Analysis of the proportion and type of errors (shape, colour or distractor errors), and response latency by children and adolescents with ADHD helps to determine whether non-memory factors, such as motivation, fatigue or response strategies, or memory based decisions influenced performance (Owen et al., 1995). The performance profile of children and adolescents with ADHD indicates that the same decision making strategy was used across the MTS and DMTS conditions as evidenced by the proportion of ‘shape’ type errors. In addition, analysis of response latency reflects that children and adolescents with ADHD were motivated to complete
the task, and there was no evidence of motor dysfunction. This suggests that the ADHD group were not selecting targets at random, but perhaps exhibited response inhibition deficits due to inattentiveness or distraction compared to the healthy control group.

**OCD and Visuospatial Short-Term Memory**

The paucity of VSTM investigations in children and adolescents with OCD limits the discussion and comparison of the present findings to previous adult studies. With respect to VSTM, the response profile of children and adolescents with OCD across the MTS and DMTS conditions was qualitatively similar to the ADHD, comorbid ADHD and OCD, and healthy control groups. This suggests that encoding, maintenance and memory retrieval of object was not impaired in the OCD group (based on performance measures of response accuracy, errors, and latency in the MTS and DMTS conditions). These findings are in agreement with previous neuropsychological studies that have also failed to identify VSTM deficits on CANTAB DMTS and Pattern Recognition tasks in adults with OCD compared to healthy controls (Nielen & Den Boer, 2003; Purcell et al., 1998a; 1998b). The performance profile of children and adolescents with OCD in the present study, however, contrast to some degree with previous CANTAB studies that have reported VSTM pattern recognition deficits in an adult OCD population compared to controls (Chamberlain et al., 2005; Watkins et al., 2005).

While collectively studies utilising CANTAB tasks in OCD have provided limited support for pure VSTM recognition deficits, there is strong evidence for abnormal psychomotor slowing as indexed by lengthened latency time compared to controls (Veale et al., 1996). The findings of the present study, however, do not provide evidence for
selective deficits in VSTM recognition or slower reaction times. This pattern profile does not reflect a speed error trade off strategy that would compensate effectively for VSTM recognition deficits. Further research is needed to delineate the cognitive underpinnings of this slowing phenomenon, as the findings of slower response times has been found to be inconsistent across studies (see Purcell et al., 1998b, for further discussion).

The VSTM system is associated with cortical regions of the temporal lobe as well as subcortical temporal structures including the amygdala and the hippocampus (Fray, Robbins, & Sahakian, 1996b). Adult patients with temporal lobe excisions or amygdalo-hippocampectomies exhibit impairments on all delay conditions of the DMTS task (Owen et al., 1995). Given the known association between VSTM function and temporal lobe structures (Fray, Robbins, & Sahakian, 1996b), it is apparent that OCD may not be associated with abnormalities in frontotemporal neural networks.

There are several possible explanations to account for the failure to identify VSTM deficits in children and adolescents with OCD on the DMTS task. First, children and adolescents with OCD did not significantly differ from the ADHD, comorbid ADHD and OCD, or healthy control groups in the neuropsychological profile of VSTM performance. However, both the ADHD and OCD groups had qualitatively similar VSTM profiles (as evidenced by accuracy and error performance measures) across the MTS and DMTS conditions. Given the number of groups in the present study, subtle VSTM recognition deficits may have been identified in the OCD group had the present study directly compared the OCD and healthy control group.

Second, the DMTS task used in this study may not have been sufficiently demanding or difficult enough to highlight VSTM deficits in children and adolescents
with OCD. Therefore, some children and adolescents with OCD may have been able to compensate sufficiently for their weak visuospatial skills by working efficiently. However, the adoption of a poor strategic approach increases the likelihood of a significant reduction in the level of performance. This might explain why OCD adult patients perform so inconsistently on VSTM tasks even when these tasks engage the same neuropsychological dorsolateral prefrontal cortex network (Owen et al., 1996).

Third, whilst the failure to identify VSTM deficits may reflect the differences in the type of memory task, it may also reflect the influence of verbal mediation on task performance. On the DMTS task, the stimuli pattern can be classified verbally according to colour and shape components. The findings of the present study support the argument that verbal mediation aids performance on cognitive tasks like the DMTS that permit verbal rehearsal of task stimuli (based on colour or shape) (Nielen & Den Boer, 2003; Purcell et al., 1998a; 1998b; Zielenski et al., 1991). However, children and adolescents with OCD may have difficulties on non-verbal tasks that require internal visual representations of stimuli in their memory (see Purcell et al., 1998b).

Fourth, the difference in the VSTM profile between children and adolescents with OCD and those with ADHD on the DMTS task may indicate a developmental effect in the aetiological risk factors for OCD. This highlights the need for research into the neuropsychological deficits of children and adolescents with OCD, examined separately to ADHD, given the possibility of disorder specific and developmental stage dependent aspects of underlying neurobiological risk factors. The exclusion of children and adolescents with comorbid major depressive disorder may have also removed any signs of VSTM deficits in those with OCD given than previous studies have found depressive
disorders are associated with impaired VSTM recognition (Elliott et al., 1996). Future research is required to determine whether these factors provide a valid explanation for the DMTS findings of the OCD group in the present study.

**Visuospatial Working Memory Tasks**

**Spatial Span**

The current study results indicated that children and adolescents with ADHD and/or OCD were significantly impaired on a task that assessed VSWM capacity, evidenced by a reduced spatial span compared to the control group. This finding is consistent with Hypothesis 3c that visuospatial working memory capacity would be more impaired in children and adolescents with ADHD and/or OCD compared to the healthy control group, although the results did not support Hypothesis 3c that the comorbid ADHD and OCD group would display more significant spatial span deficit compared to those in the ADHD or OCD groups. Given that children and adolescents with ADHD and/or OCD differed significantly from healthy control children, a discussion of the spatial span group findings will addressed collectively.

**Spatial Span and ADHD and/or OCD**

The spatial span results suggest children and adolescents with ADHD and/or OCD have not yet developed systematic strategies to assist performance compared with the healthy control group. Reduced spatial span performance on the CANTAB test has previously been demonstrated in children and adolescents with ADHD (Barnett et al., 2001; Rhodes et al., 2005). Neuropsychological studies have not explored spatial span abilities in children and adolescents with OCD. Studies of adults with OCD, however,
have found spatial span deficits (Barnett, 1999; Purcell et al., 1998a; 1998b) indicating a reduction in their ability to hold information in their spatial memory.

The spatial span test (also called the Corsi block test) is thought to be a paradigmatic index of SWM, particularly for clinical populations (Milner, 1971). In monkeys, frontal lobe lesions commonly elicit working memory impairments, however humans with frontal lobe lesions appear to be unimpaired on simple tasks like the Corsi block (for review see Bor et al., 2006). Intact performance in span tests is surprising given common frontal lobe activation in working memory neuroimaging studies. Spatial span activation is often associated with the lateral prefrontal cortex (Bor et al., 2006; Owen et al., 1996). One possible explanation for this apparent inconsistency is that previous testing in this area has not been sensitive enough to elicit a real, yet subtle deficit in low-level working memory tasks. For instance, in spatial span, although no known study has reported a significant deficit in frontal lobe patients (see Bor et al., 2006; Owen et al., 1990) most studies have reported a numerical decrease in spatial span compared to healthy controls.

To present knowledge, this is one of the first studies to identify spatial span deficits using the CANTAB spatial span task in children and adolescents with OCD. These same spatial span deficits abnormalities were observed in previous studies where patients with OCD have difficulty when they must keep an internal and non-verbal representation of task stimuli in order to guide behaviour (see Purcell et al., 1998b, for a more complete discussion of this issue). Ongoing performance on the spatial span working memory task had to be monitored internally, as no information was provided to the participants concerning the accuracy of their selections. The pattern of performance
suggests that executive processes related to organising and executing a series of responses were facilitated by the presence of external information. However, when participants with ADHD and/or OCD had to rely on internal representations to guide their selections, performance was impaired (see Purcell et al., 1998b). The inability to use internal representations to guide ongoing behaviours may have clinical relevance to both ADHD and/or OCD.

**Spatial Working Memory (SWM)**

The findings of the present study indicate that children and adolescents with either ADHD or comorbid ADHD and OCD displayed marked visuospatial working memory (VSWM) deficits as evidenced by high strategy scores (indicating the failure to develop systematic search strategies) and increased between-search error (BSE) rates (at levels 6 and 8) compared to the healthy control group. The OCD group, however, did not differ significantly from the ADHD, comorbid ADHD and OCD, or healthy control groups in terms of the strategy score or the number of BSEs on any of the spatial working memory (SWM) task levels. The findings of the present study partly supported Hypothesis 3c that children and adolescents with ADHD and/or OCD would be identified with VSWM deficits on the SWM task compared to the healthy control group, but failed to support Hypothesis 3c that the comorbid ADHD and OCD group would exhibit greater VSWM deficits compared to children and adolescents with either ADHD or OCD.

**ADHD and Spatial Working Memory**

Previous investigations of VSWM abilities on the SWM task support the findings of the present study that children and adolescents with ADHD present with
VSTM deficits (Barnett et al., 2001; Kempton et al., 1999; Rhodes et al., 2005; Rhodes et al., 2004). VSTM deficits on the SWM task have also been identified in adults with ADHD (Clark et al., 2007; McLean, 2004). These findings have also been supported by recent neuropsychological studies that identified VSTM deficits before the administration of pharmacological stimulant medication (Bedard et al., 2004; Coghill, Rhodes, & Matthews, 2007; Mehta et al., 2004; Rhodes et al., 2006; Vance et al., 2003).

VSTM deficits in children and adolescents with ADHD, in the current and previous studies, are demonstrated by increased numbers of BSEs at the harder levels of difficulty (levels 6 and 8), and elevated strategy scores which indicate the failure to adopt an effective search strategy in the SWM task.

VSTM deficits have previously been linked to deficits in frontostriatal neural networks (Luciana & Nelson, 2002; Luciana et al., 2005; Owen et al., 1990; Owen et al., 1996; Pantelis et al., 1997; Robbins et al., 1998; Sahakian et al., 1988). In particular, the CANTAB SWM task is associated with dorsolateral and ventrolateral prefrontal cortex activation (Owen, Evans, & Petrides, 1996). Further, stimulant medication-induced changes (associated with methylphenidate) in brain activations are often associated with the dorsolateral prefrontal cortex and posterior parietal cortex (Mehta et al., 2004). Disruption to these frontostriatal networks is often associated with impairments in attention and early encoding of stimuli (Barnett et al., 2001; 2005; Lawrence et al., 2000; Vance et al., 2007).

The pattern of abnormal performance (typical pattern of increased BSEs errors and strategy score) in children and adolescents with ADHD on the SWM task is qualitatively similar to the performance pattern profile found in adults with focal lesions of the frontal
lobes, Parkinson's disease and Huntington's disease and in non-human primates with focal lesions of the dorsolateral prefrontal cortex (Owen et al., 1990; Owen et al., 1996; Pantelis et al., 1997). Whilst caution must be taken in comparing VSTM deficits in children to those of adults with focal brain lesions, the results of the current study are consistent with the argument that abnormalities of EF in ADHD reflect a dysfunction of frontostriatal pathways, and that VSTM deficits are a key component of the neuropsychological profile of children and adolescents with ADHD.

**OCD and Spatial Working Memory**

The current results indicated that children and adolescents with OCD did not have VSTM deficits on the SWM task (demonstrated by non-significant differences on strategy score or BSEs) compared to those in the ADHD, comorbid ADHD and OCD, or healthy control groups. Studies using tests for SWM capacity have produced divergent results in OCD child and adolescent populations. Some recent studies have identified VSTM deficits in children and adolescents with OCD relative to healthy controls (Andres et al., 2007), whilst other studies have failed to identify VSTM deficits (Beers et al., 1999; Shin et al., 2008). The lack of neuropsychological studies undertaken with children and adolescents with OCD, and the subsequent inconsistent findings among the studies, directs the focus of the current results to comparisons of VSTM abilities in adults with OCD identified in previous studies. The findings of the present study are not consistent with previous studies that have identified VSTM deficits on CANTAB neuropsychological task in OCD adult patients (Chamberlain et al., 2007a; Nielen & Den Boer, 2003; Purcell et al., 1998a; 1998b).
The results of the current study are consistent with previous findings by Barnett et al. (1999) and Watkins et al. (2005) that failed to identify VSWM deficits on the CANTAB SWM task in their OCD adult samples. Previous investigations have also failed to identify VSWM deficits in adults with OCD on a number of different SWM tasks (Bannon et al., 2006; Kim et al., 2002; Kim et al., 1999; van der Wee et al., 2003). The study by van der Wee et al. (2003) did not find evidence for a SWM deficit, although the researchers suggested that the abnormal performance pattern may be secondary to different aspects of EF deficits in OCD. This substantial body of evidence indicates that children and adolescents with OCD do not show performance deficits across a number of different SWM tasks.

There are several possible explanations as to why SWM deficits were not observed in children and adolescents in the OCD group. First, studies examining the role of the anterior cingulate in EF in healthy controls and non-human primates have led to two main hypotheses regarding the function(s) of the anterior cingulate. One hypothesis postulates that the anterior cingulate plays a key role in the implementation of a strategy, the other hypothesis postulates that its function is crucial in evaluating the effects of a strategy through performance monitoring based on processes like error checking or the detection of conflicting responses (Botvinick et al., 1999; Braver et al., 2001). In this light, the performance of the OCD group on the SWM task may reflect an effort to develop or maintain an efficient strategy to perform this task, or represents increased error monitoring because of hyperactivation in the anterior cingulate cortex (van der Wee et al., 2003).
Several recent functional neuroimaging studies in OCD have demonstrated heightened activation in the anterior cingulate cortex compared to controls at multiple levels of SWM task difficulty (Gehring, Himle, & Nisenson, 2000; Hajcak & Simons, 2002; McGuire, Bence, Frith et al., 1994; van der Wee et al., 2003). Some researchers have concluded that the anterior cingulate is part of an abnormally functioning frontothalamo-basal ganglia circuitry that is suggestive of executive dysfunction rather than a deficit in SWM. This is demonstrated by the normal activation of the lateral prefrontal and parietal regions that were not affected (van der Wee et al., 2003). In other words, deficits in SWM may be secondary to another disturbed aspect of EF in OCD.

Second, as previously stated, VSWM ability has been almost completely unexplored in children and adolescents with OCD, which consequently prevents comparisons with adult studies of OCD. The failure to clearly identify VSWM deficits in children and adolescents with OCD may be associated with the difference in the developmental maturity of VSWM systems between children, adolescents and adults (De Luca et al., 2003; Luciana & Nelson, 2002; Luciana et al., 2005; Robbins et al., 1994). This is supported by evidence that the CANTAB SWM task exhibits the most protracted trajectory of development (Luciana & Nelson, 2002), and thus age may have a moderating effect on the relationship between OCD and SWM deficits.

Third, clinical characteristics (medication status, symptom severity, symptom duration and course) of OCD populations may explain the discrepancy in SWM deficits between children, adolescents and adults in the literature. VSWM deficits on the SWM task may perhaps only emerge with increased developmental stage of onset, increased severity of symptomatology and duration, and possibly, the use of medication in
children and adolescents with OCD (van der Wee et al., 2003). The failure to identify VSWM deficits in the OCD group may also be explained by the fact participants in the present study were well matched and confounding variables such as comorbid major depressive disorder and conduct disorder were controlled. Studies that do not account for confounding variables are more likely find increased variability in cognitive performance, thus making it difficult to detect subtle differences in children and adolescents with OCD.

**The relationship between Visuospatial Working Memory Tasks**

The correlations between BSE, strategy and spatial span among children and adolescents with ADHD and/or OCD show strong relationships between the VSWM tasks. Analysis of the contribution of strategy and spatial span using Pearson’s product moment correlation coefficients revealed moderately large positive correlations between BSE and strategy in the ADHD and/or OCD groups, and the healthy control group. The increased number of BSEs and strategy score on the SWM task indicated that SWM deficits occurred when children and adolescents with ADHD or comorbid ADHD and OCD were required to manipulate spatial information within working memory. Importantly, the OCD group did not differ from the control group in their BSEs or their ability to generate a systematic search strategy during the SWM task.

The ADHD and/or OCD groups relied significantly on spatial span to complete the SWM task. The large negative correlations between BSE and spatial span were found in the ADHD and/or OCD groups and healthy control group. This indicates that VSTM deficits contributed significantly to the number of BSEs in the SWM task, which was consistent with earlier studies (Barnett et al., 2001; Kempton et al., 1999).
Consistent with the conjecture of EF deficits in ADHD and/or OCD, BSE was found to have a moderate to large negative correlation with spatial span. Hence, children with comorbid ADHD and/or OCD were able to draw on both spatial span and strategy approach for their performance on the SWM task.

Initial inferences from the analyses of the spatial span and SWM tasks supported the notion that the ADHD group and the comorbid ADHD and OCD group relied primarily on spatial span capacity during the SWM task. In contrast, the OCD and healthy control participants relied principally on their ability to generate an effective search strategy (measures of spatial span and strategy) during the SWM task, consistent with previous studies (Barnett et al., 2005). However, lower scores on the SWM strategy component also suggests that children and adolescents in the comorbid ADHD and OCD group also relied on their ability to generate an effective search strategy, thereby displaying characteristics qualitatively similar to the OCD group. This supports the inference that comorbid ADHD and OCD is to some extent a hybrid condition.

It is important to note that the performances of the ADHD and/or OCD groups and healthy control group on the spatial span and SWM tasks may be due to visuospatial span and SWM capacities being underdeveloped in children and adolescents (De Luca et al., 2003; Luciana & Nelson, 2002). Normative data from the CANTAB suggests that spatial span and SWM abilities in children and adolescents have not yet reached adults levels, but are equivalent to the developmental period of mid to late adolescence (De Luca et al., 2003). Despite these systems not being fully developed, children and adolescents with ADHD and/or OCD would appear to rely on different components of working memory to complete the SWM tasks. In summary, the
findings show that VSWM deficits are clearly evident in children and adolescents with ADHD or comorbid ADHD and OCD relative to the healthy control group. It is not clear from this study, however, whether children and adolescents with OCD only have immature SWM systems, subtle SWM deficits, or normally functioning systems impaired due to the severity of OCD symptomatology.


Chapter Summary

The present study employed a number of key diagnostic, demographic and clinical measures that provided descriptive information and built on the existing knowledge within the literature on what is known about children and adolescents with ADHD and/or OCD. Without exception, children and adolescents with ADHD and/or OCD had qualitatively different demographic and clinical profiles from those in the healthy control group. An exploration of the group profiles revealed that children and adolescents with comorbid ADHD and OCD were qualitatively similar to the ADHD group on measures of inattention, hyperactive-impulsive symptoms, parent-reported ratings of externalising problems, and social adversity status. On the other hand, the comorbid ADHD and OCD group were qualitatively similar to the OCD group on measures of obsessive-compulsive symptoms, and parent-reported internalising problems. The ADHD and/or OCD groups did not significantly differ in terms of academic or intellectual functioning, self-reported anxiety or depressive symptoms, levels of family dysfunction, or parental psychopathology. The demographic and clinical profile of the groups suggests that to some extent children and adolescents with comorbid ADHD and OCD have the independent contribution of symptomatic and functional impairment of both ADHD and OCD disorders, but also do not qualitatively differ on a number of key measures.

The computer-administered CANTAB was also administered to assess attention and memory constructs of EF relative in children and adolescents with ADHD and/or OCD, and a healthy control group. The results of this study indicate that children and adolescents diagnosed with ADHD have significant visuospatial attention deficits (attentional set shifting, sustained attention, selective attention, and response inhibition),
VSTM (delayed-matched to sample task), and VSWM deficits (on spatial span and spatial working memory task) relative to the healthy control group. This expected finding provides evidence for the hypofunction of frontostriatal functional neural networks in children and adolescents with ADHD. The neuropsychological profile of children and adolescents with OCD is more inconsistent. The results indicate the OCD group had subtle visuospatial attention (based only on the number of stages completed on the attentional set shifting task) and VSWM deficits (spatial span task) compared to the healthy control group, but did not exhibit deficits in VSTM (delayed-matched to sample task). This neuropsychological pattern suggests impairments in frontostriatal neural networks that are purported to underlie the attentional system. It is suggested that OCD in children and adolescents may be on a continuum with ADHD with respect to frontostriatal dysfunctional neural networks.

Children and adolescents in the comorbid ADHD and OCD group did not significantly differ from those with ADHD or OCD on any of the neuropsychological tasks, but did display greater VSWM deficits on the SWM task relative to the healthy control group. The result does not reflect the hypothesised independent additive contribution of EF deficits from both ADHD and OCD disorders in children and adolescents with comorbid ADHD and OCD. In summary, these results provide new and important insights into the current understanding of children and adolescents with ADHD and/or OCD. The findings provide evidence for qualitative clinical and neuropsychological similarities and differences between children and adolescents with ADHD and/or OCD. Taken together, these findings suggest that OCD may influence the degree of ADHD symptomatology and EF deficits experienced by children diagnosed with comorbid ADHD and OCD as
compared to the presence of a single disorder alone. Although the findings require replication in other clinical settings, they do suggest that careful consideration of the presence of ADHD and OCD symptomatology should be given in both the assessment and management of both disorders at all ages in clinical and research settings. The sensitivity and specificity of the ADHD and/or OCD findings in children and adolescents warrants additional future research.
CHAPTER 9
GENERAL DISCUSSION

Introduction

Attention Deficit Hyperactivity Disorder (ADHD) and Obsessive Compulsive Disorder (OCD) have attracted a great deal of attention in the literature as researchers have attempted to shed light on the clinical and neuropsychological profiles of children and adolescents with these disorders. Whilst there is vast amount of research that has explored the clinical and neuropsychological profiles of children and adolescents with ADHD, very little research has explored the neuropsychological profiles of children and adolescents with OCD. Again, despite the high rates of comorbidity between ADHD and OCD, few studies have examined the clinical characteristics associated with the presence of both disorders, and to current knowledge, not one study has explored the neuropsychological profile of children and adolescents with comorbid ADHD and OCD relative to those with ADHD or OCD. Given these facts, the purpose of this chapter is to review the key clinical and neuropsychological findings of the present study, and the clinical and research implications, and limitations of these findings, as well as the direction of future studies.

Clinical Characteristics

The presence of comorbid ADHD and OCD in a substantial proportion of children and adolescents has important clinical and therapeutic implications. The results of the present study revealed that the presence of ADHD was associated with a predominance of males, elevated levels of inattention, hyperactive-impulsive symptoms, social adversity
status, and parent-report ratings of externalising problems. The presence of OCD was associated with elevated levels of obsessive-compulsive symptoms and parent-reported ratings of internalising problems, whilst children and adolescents in the comorbid ADHD and OCD group did not significantly differ from those with ADHD or OCD on any of these reported characteristics. It is important to note that the demographic and clinical profile of children and adolescents with ADHD and/or OCD did not qualitatively differ on measures that may have influenced performance on neuropsychological tests. These factors include academic and intellectual functioning, anxiety and depressive symptoms, family functioning, and parental psychopathology.

The results suggest that whilst children and adolescents with ADHD or OCD differ on some key demographic and clinical measures they also share a number of key characteristics. Therefore, a diagnosis of ADHD and/or OCD was associated with impairment across academic, intellectual, emotional, social and family functioning domains. The findings were consistent with recent reports showing impairment in these functional domains in children and adolescents with ADHD and/or OCD (Arnold et al., 2005; Geller et al., 2002; Geller et al., 2003a; Geller et al., 2004; Masi et al., 2006; Sukhodolsky et al., 2005) relative to healthy control children. The cumulative findings of these research studies also suggest that OCD symptomatology in children and adolescents were independent of the presence or absence of ADHD either in symptoms, or in functional impairment. Therefore, children presenting with comorbid ADHD and OCD arguably have both disorders and consequently suffer the full psychosocial burden of each disorder (Arnold et al., 2005; Sukhodolsky et al., 2005).
Neuropsychological Characteristics

Tasks taken from the Cambridge Neuropsychological Test Automated Battery (CANTAB) were used to assess the executive functions (EF) of attention (attentional set shifting, selective attention, sustained attention, response inhibition) and memory constructs (VSTM and VSWM) in children and adolescents with ADHD and/or OCD. The development of the CANTAB tasks was based on non-human primate research into the brain-behaviour relationships of neuropsychological constructs (Fray, Robbins, Sahakian, 1996b; Weed et al., 1999). Performance deficits on specific tasks of the CANTAB have been associated with specific brain abnormalities in animal and human lesion studies (Owen et al., 1996; Owen et al., 1995; Robbins et al., 1994). The aim of the CANTAB is to identify impaired functioning of specific brain regions that are implicated in the pathophysiology of disorders such as ADHD and OCD. Given that the CANTAB measures break down neuropsychological constructs into clearly defined parts (Fray & Robbins, 1996a), this instrument facilitates a more precise assessment of brain impairment.

The neuropsychological profile of the children and adolescents with ADHD revealed deficits across visuospatial attention, visuospatial short-term memory (VSTM), and visuospatial working memory (VSWM) tasks relative to healthy control children. As previously identified in many neuropsychological studies, the findings of the present study also identified ADHD as a disorder of EF deficit (Barkley et al., 2001a; Barnett, 2005; Kempton et al., 1999; Martinussen et al., 2005; Nigg et al., 2002; Oosterlaan, Scheres, & Sergeant, 2005; Sergeant et al., 2002; Stins et al., 2005; Vance et al., 2006; Willcutt et al., 2005). From a brain-behaviour model, the neuropsychological results of the present study together with previous neuroimaging research are consistent with the
frontostriatal dysfunction theory of ADHD. The results are consistent with the notion that ADHD is associated with hypofunction of the frontostriatal neural networks (decreased right and left anterior prefrontal cortex activity and decreased anterior cingulate gyrus activity), and decreased basal ganglia activity (Konrad et al., 2006; Vance & Luk, 2000; Vance et al., 2007).

Specific attentional set shifting and spatial span deficits in children and adolescents with OCD contrasted with their normal range performance on the VSWM and VSTM tasks of EF. These results suggest only limited involvement of frontostriatal dysfunction in children and adolescents with OCD. Whilst disruption to frontostriatal neural circuits that are associated with impairments in attention and memory constructs of EF have been implicated in adults with OCD (Barnett et al., 1999; Purcell et al., 1998a; 1998b), the present study is one of only a few studies that have identified subtle EF deficits in children and adolescents with OCD. Recent neuroimaging studies suggest that EF deficits identified in children and adolescents with OCD may be consistent with hyperfrontal function (increased right and left anterior prefrontal cortex activity and increased anterior cingulate gyrus activity) and increased basal ganglia activation (Busatto et al., 2001; Castillo et al., 2005; Diler et al., 2004; Friedlander & Desrocher, 2006; Whiteside et al., 2004; Woolley et al., 2008).

The fact that children and adolescents with comorbid ADHD and OCD did not significantly differ from those with ADHD or OCD on visuospatial attention, VSTM, or VSWM tasks has a number of important implications. Taken together, the clinical and neuropsychological profiles of children and adolescents with comorbid ADHD and OCD supports the hypothesis that the presence of both disorders represents (1) a distinct
homogenous subtype of ADHD, or (2) a hybrid comorbid disorder that shares the unique clinical and neuropsychological characteristics of each disorder. The results do not support the hypothesised independent additive contribution of clinical and neuropsychological deficits from both ADHD and OCD disorders in children and adolescents with comorbid ADHD and OCD. Rather, the presence of OCD appears to reduce the severity of the clinical and neuropsychological symptom profile of children and adolescents with comorbid ADHD and OCD.

Explanations for the comorbidity and shared pathophysiology of ADHD and OCD strongly support the involvement of structural frontostriatal and subcortical abnormalities (Bradshaw & Sheppard, 2000; Carlsson, 2001). The association between reduced frontostriatal activation in the dorsolateral and anterior cingulate prefrontal cortex regions in ADHD, and associated increased frontostriatal activation in the dorsolateral and anterior cingulate prefrontal cortex regions and poor regulated inhibitory input to the orbitofrontal cortex with OCD requires further investigation (Bradshaw & Sheppard, 2000; Carlsson, 2000, 2001; Schatz & Rostain, 2006). In addition to the frontostriatal abnormalities identified through neuropsychological and neuroimaging studies, future studies need to focus on the neurochemical deregulation of the frontostriatal system. This would help determine if the results of the present study support the neurochemical theories proposed by Carlsson (2000, 2001) that argue comorbid ADHD and OCD exists due to (1) unstable prefrontal dopamine, serotonin, and glutamate systems fluctuating between hypoactivation, producing ADHD symptoms, and hyperactivation, producing OCD symptoms, or (2) the simultaneous hypoactivation and hyperactivation of the dopamine, serotonin, and glutamate neurotransmitters of the frontostriatal neural network.
Clinical Implications

The comprehensive clinical testing conducted in the present study indicates that children and adolescents with ADHD or OCD were qualitatively different on key phenomenological variables, while the comorbid ADHD and OCD group generally presented with symptomatology that reflected the independent contribution of symptomatic and functional impairment from each disorder. However, children and adolescents with comorbid ADHD and OCD did not have additive symptomatology compared to either the ADHD or OCD groups. As both ADHD and OCD are prevalent childhood disorders and each contributes to its own independent morbidity, children and adolescents with comorbid ADHD and OCD appear to share a similar elevated symptomatic level and impaired academic, intellectual, social and family functioning with children and adolescents with ADHD and OCD. The neuropsychological profile of children and adolescents with comorbid ADHD and OCD indicates that they share similar EF deficits in attention, VSTM and VSWM similar to the ADHD group in comparison to the OCD group. This has important clinical implications in terms of the treatment of children and adolescents with comorbid ADHD and OCD.

Based on the findings of the present, the relationship between ADHD and/or OCD raises several significant clinical implications from both clinical and neurobiological points of view, and also raises many questions that need to be addressed in future research studies. The findings of the present study are clinically relevant because they describe a sample of children and adolescents with ADHD and/or OCD in an ordinary clinical setting. Detailed exclusion criteria were applied (including for major depressive disorder, conduct disorder, mental retardation, pervasive developmental disorders, and
psychosis), and comorbid conditions (including anxiety disorders, dysthymic disorder, oppositional defiant disorder), which are often excluded in controlled trials but represent the rule in clinical settings, were included in the study. Furthermore, all of the participants with ADHD and/or OCD were treated as needed and followed up in a routine clinical setting. Long-term, naturalistic, prospective studies might represent an important source of information regarding the effectiveness of treatment interventions over extended periods under routine clinical conditions.

From a clinical standpoint, the findings of the present study highlight the need for clinicians to conduct comprehensive clinical assessments in order to consider potential comorbid conditions, since a significant proportion of the children and adolescents they assess may have comorbid ADHD and OCD. Thus, careful consideration of the presence of ADHD and OCD symptoms should be given in both the assessment and management of children and adolescents at all ages in clinical and research settings. The accurate identification of each condition will lead to better targeted assessment, diagnosis, and psychological and/or medication treatments for children and adolescents suffering from ADHD and/or OCD.

The identification of comorbid ADHD and OCD may also help to identify a specific subgroup of children and adolescents with a more homogeneous course, outcome, and response to treatments than children with either ADHD or OCD. Since children and adolescents with OCD are often predominately male and have a very early (pre-adolescent) peak of onset that represents the earlier of bimodal peaks of incidence described in the extant OCD literature, some researchers have raised the possibility that children and adolescents who constitute this early peak of onset are aetiologically distinct
from those with adult-onset OCD (Rosario-Campos et al., 2005). Any putative developmental subtype of OCD may need to be broadened to include those with ADHD.

As previously stated, children and adolescents who have a genetic risk of ADHD and/or OCD and experience adverse shared environmental influences tend to show persistent problems that severely influence their ability to function academically, intellectually, socially, and cognitively. For these children the identification and diagnosis of children and adolescents who are at high genetic or shared environmental risk of ADHD and/or OCD is essential to ensure appropriate treatment interventions.

From a neurobiological point of view, the identification of common biological pathways may help to define the links in the pathophysiology of both disorders, which are still under study. For example, children and adolescents with ADHD have been shown to present a variety of cognitive deficits related to frontostriatal functions, which have also been implicated in OCD pathophysiology. Thus, knowledge of the actual genes and the biological pathways that are involved could eventually also be helpful for successful treatment intervention. This could be via medication that targets the relevant biological systems or perhaps early intensive behavioural interventions that may also produce long-lasting and significant gains for a subset of children and adolescents with comorbid ADHD and OCD.

Prospective and systematic studies of treatment of children and adolescents with comorbid ADHD and OCD are needed since standard pharmacological treatment of ADHD do not address OCD symptoms, and vice versa. Given that the most important treatments of ADHD and OCD, that is, stimulants and serotonergic agents, respectively, do not overlap, a careful diagnosis of each disorder can improve the treatment.
effectiveness of children and adolescents with ADHD and/or OCD (Geller et al., 2004). Moreover, stimulant medications used to treat ADHD may exacerbate OCD symptoms in some cases (Geller et al., 2003c; Jensen et al., 1997; Kouris, 1998), whilst SRIs or SSRIs used to treat OCD may worsen core ADHD symptoms (Geller et al., 2003c; Masi et al., 2006). In one large clinical trial of children and adolescents with OCD, both comorbid ADHD and comorbid tics decreased the response to paroxetine compared with participants without these comorbid disorders, underscoring the clinical relevance of this issue (Geller et al., 2003c). Since most placebo controlled trials of SSRI treatment of OCD in children and adolescents have used multiple exclusion criteria (including ADHD and tics), it remains unknown to what extent comorbid disorders impact the clinical effectiveness of these agents for the primary disorder, or what impact medication may have on the comorbid disorders.

Psychosocial treatments of OCD such as cognitive behaviour therapy (CBT) often require adequate attention, concentration and cooperation throughout treatment. However, the core features of ADHD may adversely influence the participation of children with comorbid ADHD and OCD in psychosocial treatment management. Given the relatively high prevalence rates of comorbid ADHD and OCD among children and adolescents, the long-term treatment outcomes for combined pharmacological and psychosocial treatment interventions compared to individual treatment interventions also need to be addressed.

**Developmental Factors**

The current results support the argument that OCD in children and adolescents may be a different disorder from that observed in adults (Greisberg & McKay, 2003).
Many neurobiological systems in humans are not fully developed until adulthood. In particular, a number of systems that are associated with OCD mature at various rates as children and adolescents develop. Such delays in development may reflect differences in underlying neurophysiology in OCD at the different life stages, resulting in such biological differences as those outlined above. The development of neurotransmitter systems in children and adolescents is variable. Serotonin content, activity and receptor expression matures early (Goldman-Rakic & Brown, 1982; Lidow & Rakic, 1992), with serotonergic innervation complete by approximately 6 years of age (Kye, Woo & Lewis, 1996b). However, noradrenaline and dopamine systems continue to develop throughout puberty (Goldman-Rakic & Brown, 1982), with dopaminergic innervation not complete until early adulthood (Rosenberg & Lewis, 1995). It is possible that these varying rates of development of neurotransmitter systems are critical in explaining the discrepancies in neurobiological findings between children and adolescents, and adults with OCD that have been outlined.

**Limitations**

A number of methodological limitations in this study need to be noted. First, as children and adolescents in this study were referred to a clinical research unit, the results may not generalise to community samples. Clinical and community derived samples of children and adolescents reportedly differ on a number of factors including severity of symptomatology, level of functional impairment, and rates of comorbid disorders (Angold et al., 1999; Costello et al., 1996). Furthermore, the assessment of OCD in a clinical setting could result in an overestimate of related disorders such as
ADHD (Biederman et al., 1991). Thus, the generalisability of findings and subsequent implications are limited to the more severe spectrum of these disorders managed in clinical settings. Therefore, more work is needed to address whether similar results would be obtained in non-referred community samples. While this was a methodological limitation of the current study, the clinical sample in the present study was carefully defined both categorically and dimensionally for patterns of symptoms and associated impairment.

Second, the healthy control group was recruited in a very different manner from the clinical ADHD and/or OCD groups, and were unlikely to have been a truly representative control group in the academic, family functioning, and parental psychopathology domains under investigation. The strong performance of the healthy control group on both the WISC and the WRAT indicate that this group may not have been representative of a normative community sample. However, the composition of the healthy control group could not be readily changed, and differences in IQ were taken into account in the statistical analyses of the neuropsychological measures.

Another important difference was the gender distribution and medication status differed between the clinical and healthy control groups. Ideally, children and adolescents would have had equal male and female ratios, although the sample of the ADHD and/or OCD groups is generally representative of the gender ratios reported in epidemiological studies (American Psychiatric Association, 2000). In addition, the effect of stimulant medication or selective serotonin reuptake inhibitors (SSRIs) on memory and attention of children and adolescents taking these medications may have also confounded the results. No patients were taken off or placed on medication for the
purpose of participation in this study. The child or adolescent’s medication status could have confounded the association between the presence of ADHD and/or OCD and functional impairment. Psychotropic medications could have affected the severity of ADHD or OCD, of any comorbid symptoms, and may have limited the ability to see the full effects of OCD on functional variables such as family functioning.

Whilst stimulant medications generally improve the performance of children with ADHD on tests of attention (Bedard et al., 2004; Kempton et al., 1999; Mehta et al., 2004; Vance et al., 2003), its effects on memory have not been clearly established (Rhodes et al., 2004). The impact of SSRI on attention and memory constructs is not known. However, this study was not designed to assess medication effects, and the numbers of participants on medication were too small to allow for reliable estimates of association between neuropsychological measures and medication use. Future studies need to explore the nature of EF deficits before and after medication use to determine the impact they may have on attention and memory constructs of children and adolescents with ADHD and/or OCD.

Third, all participants included in this study had direct clinical assessment and diagnostic confirmation of both ADHD and/or OCD diagnoses by a child psychiatrist using DSM-IV nosology, corroborating structured interview diagnoses. However, though limited, studies of interview techniques indicate that young children may not always provide reliable information about their psychopathology (Schwab-Stone, Fallon, Briggs, & Crowther, 1994). Although future studies could benefit from including more child-appropriate rating scales, it is unlikely that the results of the present study would be very different considering that participants were evaluated clinically.
Fourth, the cross-sectional design of the current study allowed an examination of cognitive function across diagnostic groups matched for age. However, whilst the study obtained information from participants about current psychopathology, this study design was not able to resolve issues such as developmental stage factors, stage of illness factors, or heterogeneity of outcome factors. These factors may have confounded results. Future long-term follow-up studies of children with either ADHD and/or OCD are required in order to address some of these factors.

Fifth, it is problematical to compare the results of the present study to the inconsistent results in previous neuropsychological studies that have examined EF in child and adolescents populations with either ADHD or OCD due to the number of methodological limitations in the extant literature. Previous neuropsychological studies have used a wide variety of tests to measure EF. Future research studies need to develop a standard neuropsychological test protocol that would allow the comparison of EF across groups using the same set of neuropsychological tests. This would also take into account verbal or language-based difficulties, particularly among children with ADHD (Cohen et al., 2000; Tannock et al., 2000), and the possibility that poor performance on EF tasks is the secondary consequence of factors such as low motivation (Sandberg et al., 1996), or low resistance to distraction or interference (Pineda et al., 1998). Therefore, the nature of EF deficits in children with ADHD and/or OCD would be best understood in a larger sample of children and adolescents where these methodological issues are addressed in future studies by using the same neuropsychological testing protocol.
A sixth limitation is the absence of DSM-IV-based teacher reports for the diagnosis of ADHD and/or OCD. Although parent reports on the Child Behaviour Checklist (CBCL; Achenbach, 1991) were independent of assessor bias, it was not free of rater bias or the measurement error inherent in this scale. Despite this limitation, the convergence of the CBCL with structured interview-derived diagnoses of ADHD and/or OCD is clinically meaningful and suggests that the symptomatology of each disorder represents ADHD and/or OCD as based on current DSM nosology. These findings also add weight to the limited research documenting the frequent overlap of these two disorders in children and adolescents. The findings regarding the potential clinical use of the CBCL in children and adolescents with ADHD and/or OCD are based upon group level analysis and further research is needed to determine its sensitivity, specificity and positive and negative predictive value with respect to individual children and adolescents.

**Future Research Directions**

To date, the clinical and neuropsychological profiles of children and adolescents with ADHD and/or OCD have received little attention. From a scientific research viewpoint, systematic investigation of comorbid ADHD and OCD will aid the better identification of this unique group through clinical and neuropsychological markers. In turn, the identification of unique neuropsychological markers for children and adolescents with ADHD and/or OCD would facilitate research that enhances understanding of the aetiology, onset, course, outcome, and treatment responsiveness of these conditions. Neuropsychological test batteries of EF abilities such as the CANTAB appear to be useful in the clinical evaluation of ADHD and OCD, notably for identifying
the cognitive components of attentional and memory dysfunction, which can be used to address specific educational interventions. These instruments may have an even greater application in the research setting in identifying the specific nature of the EF impairments in ADHD and OCD, and as markers in aetiological studies that delineate the relationship between comorbid ADHD and OCD.

Given the pervasiveness of comorbidity in child and adolescent populations, it is important to clarify the implications of comorbidity for clinical presentation, course, and outcome of psychopathology in children and adolescents. Whilst some studies report poorer outcomes for children and adolescents with comorbid ADHD and OCD compared to children and adolescents with a single disorder (Arnold et al., 2005), others reveal better outcomes suggesting moderating effects of these disorders on one another. Further research are needed to clarify the specific nature of ADHD and OCD, notably the influence of either disorder on each the other in terms of clinical characteristics and on the various components of executive attention and memory.

Moreover, the literature regarding the impact of comorbid ADHD and OCD in the domain of child psychopathology is limited by the fact that most investigations have relied on groups of relatively young children and pre-adolescents who likely were not representative of older children and adolescents with more severe forms of comorbid ADHD and OCD. Future longitudinal studies need to determine whether clinical symptomatology and neuropsychological findings are developmental stage specific or independent, whether the hypothesised functional neural networks are associated with the neuropsychological measures presented in this thesis, and whether activation of these functional neural networks are developmental stage-specific or-independent. In
order to more comprehensively examine the effects of developmental stage on neuropsychological function in children and adolescents with ADHD and/or OCD future studies could distinguish between pre-pubertal children and post-pubertal adolescents. Furthermore, longitudinal studies would assist in resolving whether developmental factors, stage of illness factors, or heterogeneity of diagnostic outcome are central to the explanation of research findings such as those in the current study.

While patterns of comorbidity across development are different for males and females, and while the presentation of ADHD and/or OCD may differ when gender is taken into consideration, most clinical research has identified male predominance in children and adolescents with ADHD and/or OCD (Geller et al., 2002; Masi et al., 2006). Thus, more research is needed to determine whether gender may moderate the expression of comorbid ADHD and OCD.

The present study has also provided evidence for some qualitative differences between ADHD and OCD in children and adolescents. Consequently, future research of children and adolescents with ADHD and/or OCD should take into account such differences and routinely examine ADHD and OCD as separate disorders. In addition, it has provided evidence for some differences in attentional set shifting, VSTM recognition, and VSWM between children and adolescents with ADHD and/or OCD. There are several explanations for such discrepancies, none of which are conclusive at this stage. Longitudinal neuropsychological and neuroimaging studies are needed to further explore the association between ADHD and OCD.
Chapter Summary

The findings of the current study found that a diagnosis of ADHD and/or OCD in children and adolescents is associated with impairments in academic, intellectual, emotional, social and family domains of functioning. Internalising problems are more closely associated with OCD, whilst externalising problems are more closely associated with ADHD. The clinical profile of children and adolescents with comorbid ADHD and OCD indicates that they have the symptomatic and functional impairments of both ADHD and OCD disorders. Neuropsychological deficits in EF were identified on the attentional set shifting, delayed-matched to sample, spatial span, and spatial working memory tasks in children and adolescents with ADHD, while more subtle deficits in spatial span and attentional set shifting were identified in children and adolescents with OCD. Children and adolescents with ADHD and OCD did not differ significantly from those with either ADHD or OCD on any of the neuropsychological tasks. Taken together, these findings suggest that ADHD and OCD have a number of qualitative similarities, sharing a number of clinical and neuropsychological characteristics, although the ADHD group had more pronounced EF deficits relative to the healthy control group.

To better understand the pathophysiology of ADHD and OCD and to design effective assessment and treatment programs, uncovering the specificity of clinical characteristics and neuropsychological deficits of children and adolescents with ADHD and/or OCD is an important focus of research into childhood behavioural and anxiety disorders. The results of the current study suggest that an investigation into the specificity of the neuropsychological deficits associated with both ADHD and/or OCD in
comparison with a healthy control group can help to determine whether observed deficits are related to core symptoms of either ADHD or OCD. As such, the findings of the present study offer independent clinical and research implications, and innovative directions for future research. Longitudinal studies are required to investigate the novel findings in these clinical groups. It is anticipated that future explorations will improve knowledge of clinical characteristics underlying executive dysfunction involved in the aetiology and maintenance of both ADHD and OCD disorders.
Reference List


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APPENDEDICES
APPENDIX A

Ethics Approval
APPENDIX B

Explanatory statement and informed consent forms for participants and parents
STANDARD PARENT/GUARDIAN INFORMATION STATEMENT

AND CONSENT FORM

Project Number: 25030A

Title of Project: Cognitive and Behavioural Characteristics associated with Attention Deficit Hyperactivity Disorder (ADHD) and Obsessive Compulsive Disorder (OCD)

Investigators: A/ Prof. Alasdair Vance
A/Prof. Ann Knowles, Marian Kolta

Thank you for taking the time to read this Information Statement.
This information statement and consent is 6 pages long. Please make sure you have all the pages.

For people who speak languages other than English:
If you would also like information about the research and the Consent Form in your language, please
ask the person explaining this project to you.

You and your child are invited to participate in a Research Project that is explained below.

What is an Information Statement?

These pages contain information about a research project we are inviting you and your child to take part
in. The purpose of this information is to explain to you clearly and openly all the steps and procedures
of this project. The information is to help you decide whether or not you and your child would like to
take part in the research.

Please read this information carefully. You can ask us questions about anything in it. You may also
wish to talk about the project with others e.g., friends or health care worker. Once you have understood
what the project is about, if you and your child would like to take part please sign the consent form at
the end of this information statement. You will be given a copy of this information statement and
consent form to keep.
What is the Research Project about?

Attention Deficit Hyperactivity Disorder (ADHD) and Obsessive Compulsive Disorder (OCD) are behavioural disorders. In recent years, reports have suggested a relationship between ADHD and OCD in children and adolescents. However, little research has been done in this area, and we do not really know why some children and adolescents develop both of these problems at the same time. We used to think they were different disorders, but now we think they might be similar in some ways.

We want to understand the way the brain works when a person has both ADHD and OCD. To do this, we will give memory and attention tests to children and adolescents who have these disorders. We will compare these results with the same tests done by children and adolescents who do not have ADHD and/or OCD. The results of our research will help us understand how children and adolescents develop ADHD and OCD in the same person, and develop treatments that are more specific.

We hope that up to 120 people and their parents/guardians will participate in this project. They will include children and adolescents with ADHD, OCD, or both ADHD and OCD.

Who are the Researchers?

- Dr Alasdair Vance is Associate Professor of Child Psychiatry, and the Head of the Academic Child Psychiatry Unit, Department of Paediatrics, Royal Children’s Hospital.
- Associate Professor Ann Knowles is a psychologist at Swinburne University with an interest in developmental psychology.
- Marian Kolta is undertaking a Doctorate of Psychology at Swinburne University, and has a particular research interest in children with behavioural disorders.

Why is my child being asked to be in this research project?

We are asking you and your child to take part in this project because your child is thought to have ADHD or OCD or both ADHD and OCD, and is between 7 and 16 years old. Your child’s recent contact with the Royal Children’s Hospital Mental Health Service (RCHMHS) has also made you eligible to take part in this study.

What are my child's alternatives to participating in this project?

You and your child do not have to take part in this study if you do not want to. Before you make your decision, a member of the research team will answer any questions about the research project. You can ask for any information you want. Sign the consent form only after you have had a chance to ask your questions and have received satisfactory answers.

You and your child can withdraw from the project at any time. Your decision whether or not to take part in the project will not affect any medical care or treatment for you or your child at the Royal Children’s Hospital, or affect the relationship with anyone providing the treatment.
What does my child need to do to be in this research project?

You and your child will need to attend two sessions at the Royal Children’s Hospital, Melbourne. Each session will take approximately 1.5 hours to complete. The total time required is approximately 3 hours. We will explain what you need to do. You can ask any questions before we start.

Session 1:

Parent/guardian:
- Fill in 3 questionnaires about your child’s developmental milestones, feelings, thoughts and behaviours. For example: “Does your child daydream or get lost in his/her thoughts?” “Is your child disobedient at home or school?”
- Will receive a Teacher Report Form to give to your child’s teacher to fill out and return.

Child:
- A computer-administered test. This involves three tasks of memory and attention that are fun and easy to perform using a touch screen computer.
- An interview with the researcher and your child. The researcher will ask your child about their feelings, thoughts and behaviours.
- A medical check-up (e.g., blood pressure, height, weight)

Session 2:

Parent/guardian:
- An interview with the researcher and the parent. The researcher will ask you about your child’s feelings, thoughts and behaviours – this is from the parent’s viewpoint.

Child:
- A Wechsler Intelligence Scale for Children-IV (WISC-IV). This is a series of word, number and picture puzzles.
- A Wide Range Achievement Test (WRAT-3) looks at your child’s reading, arithmetic and spelling.

Is there likely to be a benefit to my child?

We cannot promise that you or your child will receive any benefits from this project. However, the feedback we give you may help you understand some of the ways your child thinks and focuses attention. If you would like to know your child’s individual results, these can be discussed with you and your child at a convenient time with either A/Prof Alasdair Vance or Marian Kolta.

Is there likely to be a benefit to other people in the future?

By investigating how attention and memory works in children and adolescents with ADHD and OCD we hope to gain a better understanding of these disorders. This may lead to improved assessment and treatment.
What are the possible risks and/or side-effects?

There are no perceived physical or psychological risks associated with the research. In the unlikely event that you or your child suffer injury as a result of participating in this project, hospital care and treatment will be provided by the public health service at no extra cost to you.

What are the possible discomforts and/or inconveniences?

The only inconvenience to you and your child is the time that you give up to travel to the Royal Children’s Hospital and do the tasks to help us with our research. If, however, you or your child experience any discomfort or do not want to answer any questions or complete the tasks, you do not have to. The researchers are experienced at giving these tests.

What will be done to make sure the information is confidential?

Any information obtained in connection with the project that can identify you or your child will remain confidential. Such personal information will only be disclosed with your written permission or as may be required by law. The research data collected for this project may be published or presented at conferences. If so, information will be presented in such a way that you and your child cannot be identified.

The confidentiality of your results will be kept by using a research code instead of your name. Only the researchers involved in the study will have access to these research codes, and all the results will be kept locked in cabinets and stored in password protected and encrypted databases. The information will be kept for 7 years and will then be destroyed (deleted or shredded).

Will I be informed of the results when the research project is finished?

If you would like to know your child’s results, these can be discussed with you at a mutually convenient time with either A/Prof Alasdair Vance or Marian Kolta.

At the end of the study, we will write a short report of the group results. If you would like a copy of the report, please call us on (03) 9345 4666.

You can decide whether or not to give permission for your child to take part in this research project. You can decide whether or not you would like to withdraw your child at any time without explanation.

You may like to discuss your child’s participation in this research project with your family and with your doctor. You can ask for further information before deciding to take part.

If you would like more information about the study or if you need to contact a study representative in an emergency, the person to contact is:

Name: Associate Professor Alasdair Vance                     Name: Marian Kolta
Contact Number: 9345 4666                                   Contact Number: 9345 5516

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What are my and my child’s rights as participants?

1. I am informed that except where stated above, no information regarding my or my child's medical history will be released. This is subject to legal requirements.

2. I am informed that the results of any tests involving me or my child will not be published so as to reveal my or my child's identity. This is subject to legal requirements.

3. The detail of the procedure proposed has also been explained to me. This includes how long it will take, how often the procedure will be performed and whether any discomfort will result.

4. It has also been explained that my and my child's involvement in the research may not be of any benefit to him/her or I. I understand that the purpose of this research project is to improve the quality of medical care in the future.

5. I have been asked if I would like to have a family member or a friend with me while the project is explained to me.

6. I understand that this project follows the guidelines of the National Statement on Ethical Conduct in Research Involving Humans (1999).

7. I understand that this research project has been approved by the Royal Children’s Hospital Ethics in Human Research Committee on behalf of the Royal Children’s Hospital Board.

8. I have received a copy of this document.

If you have any concerns about the study, and would like to speak to someone independent of the study, please contact:

Consumer liaison, Clinical Support Services Team
Executive Office, RCH Unit
(Monday to Friday 9 am -5 pm).
Telephone: 9345 5676

The Chair
Human Research Ethics Committee
Swinburne University of Technology
PO Box 218
HAWTHORN VIC 3122
Telephone: 9214 5223
STANDARD INFORMED CONSENT FOR PARENT/GUARDIAN TO GIVE CONSENT FOR THEIR CHILD TO PARTICIPATE IN A RESEARCH PROJECT

Project Number
25030A

Title of Project
Cognitive and Behavioural Characteristics associated with Attention Deficit Hyperactivity Disorder (ADHD) and Obsessive Compulsive Disorder (OCD)

Investigator(s)
A/Prof. Alasdair Vance, A/Prof. Ann Knowles and Marian Kolta

I (Parent/Guardian name) ___________________________________________
voluntarily consent for me and my child to take part in the above titled Research Project, explained to me by

Mr/Ms/Dr/Professor ___________________________________________

- I have received a Parent/Guardian Information Statement to keep and I believe I understand the purpose, extent and possible effects of my and my child's involvement
- I have been asked if I would like to have a family member or friend with me while the project was explained
- I have had an opportunity to ask questions and I am satisfied with the answers I have received
- I understand that the researcher has agreed not to reveal results of any information involving me or my child, subject to legal requirements
- If information about this project is published or presented in any public form, I understand that the researcher will not reveal my or my child's identity
- I understand that if I refuse to consent to my or my child's participation, or if I withdraw myself or my child from the project at any time without explanation, this will not affect my or my child's access to the best available treatment options and care from the Royal Children's Hospital
- I understand I will receive a copy of this consent form
Section 1.01  I have explained the study to the parent/guardian who has signed above, and believe that they understand the purpose, extent and possible effects of their own and their child’s involvement in this study.

RESEARCHER’S SIGNATURE  
Note: All parties signing the Consent Form must date their own signature.
APPENDIX C
DSM-IV-TR Diagnostic Criteria for Attention-Deficit Hyperactivity Disorder
(American Psychiatric Association, 2000, p. 85-93)

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 the 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).

**Code based on type:**

314.01 Attention-Deficit/Hyperactivity Disorder, Combined Type: if both Criteria A1 and A2 are met for the past 6 months.

314.00 Attention-Deficit/Hyperactivity Disorder, Predominantly Inattentive Type: if Criterion A1 is met but Criterion A2 is not met for the past 6 months.

314.01 Attention-Deficit/Hyperactivity Disorder, Predominantly Hyperactive-Impulsive Type: if Criterion A2 is met but Criterion A1 is not met for the past 6 months.

**Coding note:** For individuals (especially adolescents and adults) who currently have symptoms that no longer meet full criteria, “In Partial Remission” should be specified.)
APPENDIX D

DSM-IV-TR Diagnostic Criteria for Obsessive Compulsive Disorder

(American Psychiatric Association, 2000, p. 456-463)

A. Either obsessions or compulsions:

**Obsessions**
- **a.** recurrent and persistent thoughts, impulses, or images that are experienced, at some time during the disturbance, as intrusive and inappropriate and that cause marked anxiety or distress
- **b.** the thoughts, impulses, or images are not simply excessive worries about real-life problems
- **c.** the person attempts to ignore or suppress such thoughts, impulses, or images, or to neutralize them with some other thought or action
- **d.** the person recognizes that the obsessional thoughts, impulses, or images are a product of his or her own mind (not imposed from without as in thought insertion)

**Compulsions**
- **a.** repetitive behaviours (e.g., hand washing, ordering, checking) or mental acts (e.g., praying, counting, repeating words silently) that the person feels driven to perform in response to an obsession, or according to rules that must be applied rigidly
- **b.** the behaviours or mental acts are aimed at preventing or reducing distress or preventing some dreaded event or situation; however, these behaviours or mental acts either are not connected in a realistic way with what they are designed to neutralize or prevent or are clearly excessive

B. At some point during the course of the disorder, the person has recognized that the obsessions or compulsions are excessive or unreasonable. **Note:** This does not apply to children.

C. The obsessions or compulsions cause marked distress, are time consuming (take more than 1 hour a day), or significantly interfere with the person's normal routine, occupational (or academic) functioning, or usual social activities or relationships.

D. If another Axis I disorder is present, the content of the obsessions or compulsions is not restricted to it (e.g., preoccupation with food in the presence of an Eating Disorders; hair pulling in the presence of Trichotillomania; concern with appearance in the presence of Body Dysmorphic Disorder; preoccupation with drugs in the presence of a Substance Use Disorder; preoccupation with having a serious illness in the presence of Hypochondriasis; preoccupation with sexual urges or fantasies in the presence of a Paraphilia; or guilty ruminations in the presence of Major Depressive Disorder).

E. The disturbance is not due to the direct physiological effects of a substance (e.g., a drug of abuse, a medication) or a general medical condition. **Specify if:**

**With Poor Insight:** if, for most of the time during the current episode the person does not recognise that the obsessions and compulsions are excessive or unreasonable
APPENDIX E
Administration Guidelines for CANTAB tasks

1. Delayed Matching to Sample task
   (Demonstrate 3 trials, 40 test trials in total)

   “In front of you is a red box that has opened up to show a pattern. Below the red box are four boxes each with its own pattern. Touch the box that has a pattern which is exactly the same as the one in the red box. This time you have to remember the pattern in the red box. It will be covered over before the pattern appears in the boxes below. Now you can see the four patterns. Touch the one that is exactly the same as the one you saw in the red box. Now there will be some more patterns to match. Sometimes the pattern will stay on the screen and other times it will be covered up and there will be a longer wait before the patterns below appear, so always try to remember the pattern in the red box”.

2. Spatial Span task
   (Demonstrate 1 trial, up to 18 trial runs)

   “For this test you will see some squares on the screen and these will change colour one by one. What you have to do is remember the order in which the squares change colour. To begin with two squares will change colour. The beep means that the sequence has finished. Now the idea is to touch the squares in the same order that they changed colour. I will demonstrate the first one”.

3. Spatial Working Memory task
   (Demonstrate 1 trial, up to 20 trials)

   “For this test you will see some coloured boxes on the screen. You have to look for a blue token that the computer has hidden inside one of the boxes. Only one token will be hidden at a time. You have to collect enough blue tokens to fill the black hole on the right of the screen. To look inside a box all you have to do is touch it like this. Once you have found a blue token in a box there will never be another one in that box again, so do not go back to that box again. The computer never uses the same box twice for the blue token. Now there are N boxes and N blue tokens to find. As the test goes on the number of boxes you can search will increase”.

4. Attentional Set Shifting task

(Demonstrate 1 trial)

“Now you can see two patterns. One of the patterns is correct and the other is wrong. What you have to do is touch the one you think is correct. There is a rule that you can learn and follow to make sure you get it correct each time. The computer will be keeping track of how well you are doing and when it is clear that you know the rule, the computer will change it, but remember, this will not happen very often. When the rule is changed you will have to think of a different rule in order to go on doing well. To begin with, there is nothing on the screen to tell you which on the two patterns is correct so your first choice will be a simple guess. However, the computer will give a message after each attempt to tell you whether you are right or wrong. You can start now.”

Note. As long as it is clear that the participant has understood the instructions, no further instructions or help should be given. Where necessary, neutral prompts such as “well done” or “you are doing fine” may be used. Under no circumstances should any mention be made of ‘pink shapes’ or ‘white lines’, as this may alert the participant to the distinction and therefore help in performing the task.
APPENDIX F

Table F1

Proportion of Comorbid Disorders Present in the Sample using Chi-Square Analysis

<table>
<thead>
<tr>
<th>Measure</th>
<th>ADHD (N = 35)</th>
<th>OCD (N = 29)</th>
<th>ADHD &amp; OCD (N = 34)</th>
<th>Control (N = 32)</th>
<th>Group Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>(X^2)</td>
</tr>
<tr>
<td><strong>Depressive Disorders</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dysthymic Disorder</td>
<td>42.9</td>
<td>53.3</td>
<td>55.9</td>
<td>0.0</td>
<td>27.52 **</td>
</tr>
<tr>
<td>Past Major Depressive Disorder</td>
<td>17.1</td>
<td>16.7</td>
<td>20.6</td>
<td>0.0</td>
<td>7.00 ns</td>
</tr>
<tr>
<td><strong>Behavioural Disorders</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oppositional Defiant Disorder</td>
<td>82.9</td>
<td>60.0</td>
<td>85.3</td>
<td>0.0</td>
<td>63.52 **</td>
</tr>
<tr>
<td><strong>Anxiety Disorders</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific Phobia</td>
<td>20.0</td>
<td>36.7</td>
<td>44.1</td>
<td>3.1</td>
<td>16.95 **</td>
</tr>
<tr>
<td>Social Phobia</td>
<td>14.3</td>
<td>33.3</td>
<td>47.1</td>
<td>0.0</td>
<td>23.48 **</td>
</tr>
<tr>
<td>Separation Anxiety Disorder</td>
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<td>40.0</td>
<td>32.4</td>
<td>3.1</td>
<td>14.43 **</td>
</tr>
<tr>
<td>Generalised Anxiety Disorder</td>
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<td>66.7</td>
<td>64.7</td>
<td>0.0</td>
<td>30.11 **</td>
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<tr>
<td>Panic Disorder</td>
<td>2.9</td>
<td>20.0</td>
<td>11.8</td>
<td>0.0</td>
<td>4.75 ns</td>
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<tr>
<td>Agoraphobia</td>
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<td>13.3</td>
<td>11.8</td>
<td>15.6</td>
<td>5.54 ns</td>
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<tr>
<td>Post-Traumatic Stress Disorder</td>
<td>5.7</td>
<td>23.3</td>
<td>17.6</td>
<td>3.1</td>
<td>8.24 *</td>
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<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sleep Terror Disorder</td>
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<td>0.0</td>
<td>20.6</td>
<td>0.0</td>
<td>17.11 **</td>
</tr>
<tr>
<td>Enuresis</td>
<td>11.4</td>
<td>10.0</td>
<td>11.8</td>
<td>0.0</td>
<td>3.95 ns</td>
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<tr>
<td>Interpersonal Problems</td>
<td>31.4</td>
<td>33.3</td>
<td>47.1</td>
<td>0.0</td>
<td>48.50 **</td>
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<tr>
<td>School Refusal Behaviour</td>
<td>22.9</td>
<td>60.0</td>
<td>44.1</td>
<td>0.0</td>
<td>29.83 **</td>
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</table>
APPENDIX G

Table G1

Mean and Standard Deviations of Child Behaviour Checklist (CBCL) DSM Oriented Scales

<table>
<thead>
<tr>
<th>Measure</th>
<th>ADHD (n=35)</th>
<th>OCD (n=29)</th>
<th>ADHD &amp; OCD (n=34)</th>
<th>Control (n=32)</th>
<th>Group Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F</td>
</tr>
<tr>
<td>Affective Problems</td>
<td>66.26 b (8.87)</td>
<td>70.03 b (8.54)</td>
<td>70.53 b (8.55)</td>
<td>52.31 a (5.02)</td>
<td>39.76 **</td>
</tr>
<tr>
<td>Anxiety Problems</td>
<td>62.09 b (9.83)</td>
<td>70.19 c (8.24)</td>
<td>67.79 c (8.81)</td>
<td>53.15 a (4.91)</td>
<td>29.65 **</td>
</tr>
<tr>
<td>Somatic Problems</td>
<td>60.60 c (8.95)</td>
<td>64.29 b (9.90)</td>
<td>63.06 c (11.36)</td>
<td>54.13 a (5.76)</td>
<td>8.15 **</td>
</tr>
<tr>
<td>Attention-Deficit/Hyperactivity</td>
<td>71.89 c (6.54)</td>
<td>60.71 b (6.90)</td>
<td>71.26 c (6.99)</td>
<td>51.44 a (2.71)</td>
<td>84.84 **</td>
</tr>
<tr>
<td>Oppositional Defiant Problems</td>
<td>72.97 c (7.85)</td>
<td>62.74 b (9.62)</td>
<td>70.68 c (7.40)</td>
<td>52.53 a (3.97)</td>
<td>50.75 **</td>
</tr>
<tr>
<td>Conduct Problems</td>
<td>76.80 c (9.58)</td>
<td>62.87 b (10.69)</td>
<td>71.79 c (11.26)</td>
<td>51.44 a (4.02)</td>
<td>46.74 **</td>
</tr>
</tbody>
</table>

Note. Denotes significance \( p < .01 \)
APPENDIX H

Table H1

*Mean and Standard Deviations of Spatial Working Memory Task (SWM) Within Search Errors and Double Search Errors*

<table>
<thead>
<tr>
<th>Measure</th>
<th>ADHD (n=35)</th>
<th>OCD (n=29)</th>
<th>ADHD &amp; OCD (n=34)</th>
<th>Control (N=32)</th>
<th>Group Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F</td>
</tr>
<tr>
<td><strong>Spatial Working Memory</strong></td>
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<td></td>
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<tr>
<td>Within Search Errors</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSE Level 3</td>
<td>0.00 a</td>
<td>0.00 a</td>
<td>0.00 a</td>
<td>0.03 a</td>
<td>0.55 ns</td>
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<tr>
<td>WSE Level 4</td>
<td>0.11 a</td>
<td>0.07 a</td>
<td>0.15 a</td>
<td>0.03 a</td>
<td>0.60 ns</td>
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<tr>
<td>WSE Level 6</td>
<td>0.69 a</td>
<td>0.93 a</td>
<td>0.71 a</td>
<td>0.41 a</td>
<td>0.61 ns</td>
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<tr>
<td>WSE Level 8</td>
<td>1.31 a</td>
<td>1.34 a</td>
<td>2.15 a</td>
<td>0.84 a</td>
<td>1.18 ns</td>
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<td>Total WSE’s</td>
<td>2.11 a</td>
<td>2.34 a</td>
<td>3.00 a</td>
<td>1.28 a</td>
<td>1.02 ns</td>
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<td><strong>Double Search Errors</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSE Level 3</td>
<td>0.00 a</td>
<td>0.00 a</td>
<td>0.00 a</td>
<td>0.00 a</td>
<td>-  ns</td>
</tr>
<tr>
<td>DSE Level 4</td>
<td>0.03 a</td>
<td>0.00 a</td>
<td>0.00 a</td>
<td>0.03 a</td>
<td>0.78 ns</td>
</tr>
<tr>
<td>DSE Level 6</td>
<td>0.40 a</td>
<td>0.72 a</td>
<td>0.44 a</td>
<td>0.25 a</td>
<td>0.89 ns</td>
</tr>
<tr>
<td>DSE Level 8</td>
<td>0.80 a</td>
<td>0.90 a</td>
<td>1.18 a</td>
<td>0.59 a</td>
<td>0.38 ns</td>
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<tr>
<td>Total DSE’s</td>
<td>1.23 a</td>
<td>1.62 a</td>
<td>1.62 a</td>
<td>0.88 a</td>
<td>0.59 ns</td>
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</table>

*Note. WSE: Within Search Errors; DSE: Double Search Errors.*

* p-value for the ANCOVA * Denotes significance at p<.05.
APPENDIX I

Table I1

Group comparisons of Means and Standard Deviations of the Clinical Measure of the Child Behaviour Checklist between the Clinical and Control Groups

<table>
<thead>
<tr>
<th>Measures</th>
<th>ADHD (n = 35)</th>
<th>OCD (n = 29)</th>
<th>ADHD &amp; OCD (n = 34)</th>
<th>Control (n = 32)</th>
<th>Group Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F (3,127)</td>
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<tr>
<td>Adaptive Functioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Child Behavioural Checklist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anxious/Depressed</td>
<td>66.00&lt;sup&gt;b&lt;/sup&gt; (12.86)</td>
<td>74.33&lt;sup&gt;c&lt;/sup&gt; (9.77)</td>
<td>70.47&lt;sup&gt;bc&lt;/sup&gt; (11.53)</td>
<td>51.72&lt;sup&gt;a&lt;/sup&gt; (3.38)</td>
<td>15.85</td>
</tr>
<tr>
<td>Withdrawn/Depressed</td>
<td>66.06&lt;sup&gt;b&lt;/sup&gt; (15.59)</td>
<td>68.17&lt;sup&gt;b&lt;/sup&gt; (11.61)</td>
<td>67.18&lt;sup&gt;b&lt;/sup&gt; (10.81)</td>
<td>52.03&lt;sup&gt;a&lt;/sup&gt; (4.01)</td>
<td>19.45</td>
</tr>
<tr>
<td>Somatic Complaints</td>
<td>60.57&lt;sup&gt;b&lt;/sup&gt; (7.72)</td>
<td>64.77&lt;sup&gt;b&lt;/sup&gt; (9.16)</td>
<td>65.00&lt;sup&gt;b&lt;/sup&gt; (10.23)</td>
<td>52.69&lt;sup&gt;a&lt;/sup&gt; (4.33)</td>
<td>29.86</td>
</tr>
<tr>
<td>Social Problems</td>
<td>67.23&lt;sup&gt;b&lt;/sup&gt; (9.89)</td>
<td>65.07&lt;sup&gt;b&lt;/sup&gt; (10.38)</td>
<td>70.65&lt;sup&gt;b&lt;/sup&gt; (10.87)</td>
<td>51.34&lt;sup&gt;a&lt;/sup&gt; (2.12)</td>
<td>28.33</td>
</tr>
<tr>
<td>Thought Problems</td>
<td>64.94&lt;sup&gt;b&lt;/sup&gt; (9.93)</td>
<td>70.40&lt;sup&gt;c&lt;/sup&gt; (8.09)</td>
<td>75.21&lt;sup&gt;c&lt;/sup&gt; (6.26)</td>
<td>50.94&lt;sup&gt;a&lt;/sup&gt; (7.92)</td>
<td>53.50</td>
</tr>
<tr>
<td>Attention Problems</td>
<td>71.57&lt;sup&gt;c&lt;/sup&gt; (10.54)</td>
<td>64.07&lt;sup&gt;b&lt;/sup&gt; (9.16)</td>
<td>75.03&lt;sup&gt;c&lt;/sup&gt; (13.04)</td>
<td>50.94&lt;sup&gt;a&lt;/sup&gt; (1.99)</td>
<td>39.78</td>
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<tr>
<td>Rule-Breaking Behaviour</td>
<td>73.23&lt;sup&gt;c&lt;/sup&gt; (7.33)</td>
<td>61.33&lt;sup&gt;b&lt;/sup&gt; (7.92)</td>
<td>69.26&lt;sup&gt;c&lt;/sup&gt; (9.35)</td>
<td>50.25&lt;sup&gt;a&lt;/sup&gt; (8.43)</td>
<td>49.37</td>
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<td>Aggressive Behaviour</td>
<td>79.14&lt;sup&gt;c&lt;/sup&gt; (11.52)</td>
<td>66.53&lt;sup&gt;b&lt;/sup&gt; (12.35)</td>
<td>78.00&lt;sup&gt;c&lt;/sup&gt; (11.97)</td>
<td>51.69&lt;sup&gt;a&lt;/sup&gt; (3.36)</td>
<td>48.73</td>
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<td>Total Scales</td>
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<td>Internalizing Problems</td>
<td>65.31&lt;sup&gt;b&lt;/sup&gt; (10.79)</td>
<td>72.03&lt;sup&gt;c&lt;/sup&gt; (8.37)</td>
<td>70.03&lt;sup&gt;bc&lt;/sup&gt; (9.50)</td>
<td>45.06&lt;sup&gt;a&lt;/sup&gt; (11.63)</td>
<td>46.98</td>
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<td>Externalizing Problems</td>
<td>75.23&lt;sup&gt;c&lt;/sup&gt; (8.60)</td>
<td>63.70&lt;sup&gt;b&lt;/sup&gt; (11.18)</td>
<td>73.59&lt;sup&gt;c&lt;/sup&gt; (8.28)</td>
<td>40.72&lt;sup&gt;a&lt;/sup&gt; (14.63)</td>
<td>70.05</td>
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<tr>
<td>Total Problems</td>
<td>72.66&lt;sup&gt;bc&lt;/sup&gt; (7.10)</td>
<td>69.03&lt;sup&gt;b&lt;/sup&gt; (7.18)</td>
<td>74.62&lt;sup&gt;c&lt;/sup&gt; (6.99)</td>
<td>43.91&lt;sup&gt;a&lt;/sup&gt; (8.41)</td>
<td>120.08</td>
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</table>

Note. ADHD: Attention-Deficit Hyperactivity Disorder Group; OCD: Obsessive-Compulsive Disorder Group; ADHD + OCD: Comorbid Attention-Deficit Hyperactivity Disorder Group and Obsessive-Compulsive Disorder Group; ** Denotes significance at p<.01
Figure J1. Mean t-scores of the Child Behaviour Checklist (CBCL) symptom category scores.
### APPENDIX K

Table K1  
*Cohen’s d Effect sizes for the group comparisons*

<table>
<thead>
<tr>
<th>Measures</th>
<th>Group Comparisons</th>
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<tbody>
<tr>
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<td>Control vs. ADHD</td>
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<tr>
<td><strong>Spatial Span</strong></td>
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<tr>
<td>Spatial Score</td>
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<tr>
<td><strong>Spatial Working Memory</strong></td>
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<tr>
<td>Total BSE’s</td>
<td>1.15</td>
</tr>
<tr>
<td>Strategy Score</td>
<td>1.06</td>
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<tr>
<td><strong>Delayed Matched to Sample</strong></td>
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<tr>
<td>12 Second Delay</td>
<td>0.69</td>
</tr>
<tr>
<td>Total Correct</td>
<td>1.13</td>
</tr>
<tr>
<td>Total Latency</td>
<td>0.20</td>
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<tr>
<td><strong>Attentional Set Shifting</strong></td>
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<tr>
<td>Total Trials</td>
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<tr>
<td>Total Errors</td>
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<tr>
<td>Total Latency</td>
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