Academic Predictors of Achievement in Children with ADHD and Clinical-Referred Comparisons

by

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Abstract

While previous studies have examined the relationship between the symptoms of ADHD and academic achievement, as well as cognitive ability and academic achievement, fewer studies have simultaneously examined the relative contribution of demographic, cognitive and behavioural factors to academic achievement. The current study examined the predictors of academic achievement in a large, rigorously diagnosed sample of clinical-referred school-age children. Participants in the study included 288 school-age children, between the ages of 6-12 years, referred to a regional ADHD Clinic that operates under a formal partnership between the local health authority and regional school board. The results of the present study indicated that a number of demographic, cognitive and behavioural factors were related to achievement; however, after controlling for known risk factors, the symptoms of ADHD did not predict academic performance. Overall, children with a diagnosed learning disability, regardless of comorbidity, were most academically impaired. Findings from the study hold important implications for the practice of school psychology and educational professionals involved in the identification of and intervention with students at risk for, or currently experiencing academic underachievement.

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Literature Review

Attention-Deficit/Hyperactivity Disorder (ADHD) is a highly prevalent mental health disorder, usually diagnosed in school-age children, that affects multiple areas of functioning. In addition to the primary impairments in inattention, impulsivity, and hyperactivity, children with ADHD may experience a variety of other difficulties, including cognitive, developmental, academic and even medical or health-related difficulties (Barkley, 2006). In particular, one of the most persistent and pervasive areas of difficulties for children with ADHD is academic achievement. In fact, almost all clinic-referred children with ADHD are performing poorly in school (Barkley, 2006). Given that academic underachievement has been linked to poor occupational and functional outcomes later in life, identifying the predictors of academic achievement in children with ADHD holds important real-life implications.

Although findings in research literature highly suggest that children with ADHD are academically underachieving, and numerous potential predictors have been proposed to explain the relationship between ADHD and academic achievement, the exact nature of this relationship remains unclear. Therefore, the current study seeks to examine the predictors of academic achievement in children with ADHD and a clinic-referred comparison group. In the following literature review the characteristics of ADHD and the underlying theoretical constructs proposed to explain the disorder are discussed first. We then describe the predictors of achievement in the general population, followed by a focus on the proposed predictors of achievement in children with ADHD. Finally, we describe the background information for the current study, followed by the methods, results and discussion of our findings.

Characteristics of ADHD

ADHD represents one of the most common reasons children are referred to both medical and mental health practitioners, affecting an estimated 3-7% of school-aged children (Barkley, 2006). ADHD is a persistent mental health disorder in which developmentally inappropriate levels of inattention and/or hyperactivity and impulsivity cause impairment in academic, social or occupational functioning (DSM-5; APA, 2013). The diagnosis of ADHD is based on the presence of elevated symptoms of inattention, hyperactivity, and/or impulsivity, and is categorized according to the current presenting cluster of mostly inattentive symptoms (Predominately Inattentive presentation; ADHD-I), hyperactive and impulsive symptoms (Predominately Hyperactive-Impulsive presentation; ADHD-HI), or a combination of both (Combined presentation; ADHD-C). In past literature, children with ADHD have been previously categorized according to subtype (e.g., Predominantly Inattentive subtype, Predominantly Hyperactive-Impulsive subtype, Combined subtype; DSM-IV-TR; APA, 2000). However, current literature has organized classification according to presentation to reflect the developmental manifestation of the disorder, wherein symptoms of hyperactivity/impulsivity tend to predominate in early development, and symptoms of inattention eventually become more prominent throughout later development (DSM-5; APA, 2013; Turgay et al., 2012). The symptoms must be present in two or more settings (i.e., home, school, work), must have onset prior to the age of twelve, and must impact the quality of social, occupational, and/or academic functioning (DSM-5; APA, 2013). However, a diagnosis of ADHD should not be given if the symptoms occur exclusively within the course of a psychotic disorder (e.g., schizophrenia), and should not be better accounted for by another mental disorder such as anxiety, mood, or personality disorders.

Many of the symptoms and behaviours associated with ADHD greatly impact learning. For instance, inattentive behaviours such as failure to listen to lessons and instructions, frequent shifting between classroom tasks, and difficulties remembering to take home, complete or hand-in assignments may adversely affect learning. Likewise, behaviours associated with hyperactivity and impulsivity may also adversely impact learning through difficulty staying seated during classroom instructions, excessive motor or verbal activity, or difficulty inhibiting responses such as speaking out of turn. It has been hypothesized that ADHD is often associated with lower academic performance as a result of the particular behavioural expression of the disorder, which in turn causes, poor standardized test performance, increased grade retention, increased rates of detention and expulsion, as well as higher rates of school dropout (Galera, Melchoir, Chastang, Bouvard & Fombonne, 2009; Loe & Feldman, 2007).

In addition to academic difficulties, individuals with ADHD have a higher likelihood of having other developmental, adaptive, behavioral and emotional difficulties than their typically developing (TD) peers (Mash & Barkley, 2007). For instance, ADHD is associated with a high incidence of comorbid or coexisting disorders, including learning disabilities (LD), anxiety disorders, mood disorders, oppositional defiant disorder and/or conduct disorder (CD) (Barnard-Brak, Sulak, & Fearon, 2010; Barkley, 2006; Daley & Birchwood, 2010). In fact, as many as 87% of children diagnosed with ADHD have one other disorder, and as many as 67% have at least two other disorders (Mash & Barkely, 2007). Patterns of comorbidity may vary according to whether the study sample was recruited from community or clinic-settings and according to presentation (DSM-5; APA, 2013; Weiss, Worling, & Wasdell, 2003; Wilcutt, et al., 2012). In particular, children with ADHD characterized by significant inattention (ADHD-I; ADHD-C) are more likely to meet criteria for Major Depressive Disorder and specific learning disorders, whereas individuals with elevated symptoms of hyperactivity and/or impulsivity are significantly more likely to meet criteria for externalizing disorders such as ODD and CD (Willcutt et al., 2012).

Furthermore, ADHD is often associated with particular deficits in higher cognitive abilities referred to as executive functions (Daley & Birchwood, 2010). Executive functions (EF) refer to a group of higher-order skills required for “effective and efficient future-oriented behaviour” (Diamantopoulou, Rydell, Thorell & Bohlin, 2007, p. 522). Weaknesses in EF skills (e.g., response inhibition, working memory, and planning), have been consistently linked to ADHD symptoms in studies using both clinical and community-based samples, and represent a critical component of a popular, widely-accepted theory of ADHD (Barkley, 1997; Barkley, 2006; Diamantopoulou et al., 2007).

Theoretical Constructs of ADHD

Despite the overwhelming interest in and the development of multiple models of the disorder, ADHD remains “one of the least well-characterized mental health disorders” (Sonuga-Barke, 2002, p. 29). The diversity in the clinical expression and proposed etiology of ADHD makes the identification of a single underlying mechanism that could provide a unifying theory of ADHD difficult. Nonetheless, multiple prominent theories attempt to explain or identify the underlying processes associated with ADHD and to move toward a more comprehensive, unifying theory of the disorder. In particular, numerous theories converge on the view that ADHD is associated with or caused by deficits in higher order cognitive processes or executive functions (Barkley, 1997; Sonuga-Barke, 2002). Specifically, according to neuropsychological theories of the disorder, ADHD represents a developmental delay or deficit in executive functions such as inhibition and working memory that may extend to processes such as planning and regulation (Barkley, 1997; Sonuga-Barke, 2002). However, current models of ADHD differ in their conceptualization of these deficits.

For instance, according to the model proposed by Barkley (1997; 2006), ADHD is characterized by a primary deficit in behaviour inhibition, during which self-regulation and self-directed executive processes (e.g., working memory) have been suggested to occur. Barkley's model of ADHD (1997; 2006) proposes a hierarchical view of the underlying neuropsychological mechanisms linked to ADHD, in which deficits in executive functioning occur secondarily to the primary deficit in behaviour inhibition. Furthermore, Barkley (1997; 2006) suggests that this model is only applicable to the Hyperactive/Impulsive and Combined subtypes of ADHD. Competing models propose that deficits in cognitive inhibition, and working memory are not hierarchical, but rather, co-occur (Sonuga-Barke, 2002). Contrary to Barkley's model, this model argues that deficits in executive functions are relevant to the Inattentive subtype of ADHD, while separate factors (e.g., delay aversion) are responsible for the expression of the Hyperactivie/Impulsive and Combined subtypes (Sonuga-Barke, 2002).

Although the exact nature of the neuropsychological mechanisms responsible for the disorder remains unclear, the association between ADHD and EF deficits has been supported through neuroimaging and neuropsychological research literature. Findings from neuroimaging studies strongly suggest a decrease in size of the prefrontal cortex of children with ADHD, the same area associated with higher order EF processes (Hill, Yeo, Campbell, Hart, Vigill, & Brooks, 2002). Furthermore, various studies of neuropsychological profiles of clinical populations demonstrate that children with ADHD perform significantly worse across measures of EF. For instance, Beiderman et al. (2004) found substantial differences between children with ADHD and TD controls across a general neuropsychological battery of EF measures, with ADHD participants demonstrating more impairment across measures. In particular, research literature often suggests children and adolescents with ADHD demonstrate significant impairments in specific EF, particularly in the areas of working memory and inhibition. A meta-analysis conducted by Martinussen, Hayden, Hogg-Johnson, and Tannock (2005) lends additional support to the hypothesis that individuals with ADHD often exhibit deficits in executive functions such as working memory and inhibition.

The finding that deficits in EF processes, including inhibition and working memory, predispose children and adolescents to risk for later academic underachievement is concerning. In particular, typically developing children with poor EF skills in inhibition and working memory have been shown to be at risk for poor academic performance in subject areas such as reading and mathematics (Bull, Andrews-Epsy, & Weibe, 2008). Similar associations exist in children with ADHD, and may be further exacerbated by the interaction between EF and the symptoms of ADHD (Diamantopoulou et al., 2007). Given that children with ADHD are a group thought to be characterized by deficits in executive functions, it is not surprising that individuals with ADHD have also been identified as a group that are at risk for academic underachievement.

Academic Achievement

Academic achievement often refers to an individual's academic level of accomplishment or proficiency across subject areas such as reading, math and writing. This is often considered in contrast to their potential or ability (e.g., cognitive or intellectual ability) to meet the demands of the academic curriculum. Academic success or academic achievement has long been considered to be a significant protective factor against various adverse outcomes, including school dropout and failure, and increases the likelihood of positive psychosocial outcomes later in life (Stewart & Suldo, 2011)**.** In contrast, academic underachievement or low academic achievement has been identified as a considerable risk factor for a range of negative outcomes. Such negative outcomes include increased grade retention, aggressive behaviour, higher rates of suspension or expulsion, academic failure, and school-dropout (Darney Reinke, Herman, Stormont & Ialongo, 2012; Loe & Feldman, 2007). Furthermore, academic underachievement has also been associated with an increased probability of adverse developmental pathways toward lower occupational attainment, higher use of social welfare, and higher rates of incarceration (Galera et al., 2009).

Academic underachievement can be defined in many ways, but is broadly viewed as academic performance that falls below the expected level for an individual's normative age level (Rogers, Heungsun, Toplak, Weiss, & Tannock, 2011). This may be subjectively viewed as teacher-rated performance (e.g., grades, failure to meet outcomes); however, caution is required when interpreting subjectively defined academic achievement, as these ratings may be influenced by or based on additional academic factors such as productivity or output rather than actual academic skill. Objectively defined, academic performance that falls one standard deviation or more below the mean of various standardized tests of academic achievement is often considered academic underachievement (Rogers et al., 2011).

The wide range of adverse outcomes associated with academic underachievement highlight the importance of identifying both risk factors and potential underlying mechanisms that significantly increase the likelihood of academic success. According to Darney et al. (2012), children come to school with individual, family, and environmental characteristics that interact with school characteristics, which may either help or hinder their current and future academic success. Current research literature has established several variables that have been shown to place children at risk of experiencing academic underachievement, the majority of which can be categorized by two classifications: environmental and individual factors.

Environmental Predictors of Academic Achievement

Although various environmental predictors of academic achievement have been examined in the literature, including family transitions, same-sex marriage, and parental involvement, the majority of research investigates the relationship between two prominent environmental factors with academic performance. In particular, the current literature review will provide a brief overview of the general research examining the relationship between socioeconomic status, family structure and academic achievement.

Socioeconomic status.

Socioeconomic status (SES) is used to describe an individual or family's social ranking according to access to wealth, education, and social status, and is typically quantified using parent income, education, and/or occupation (Bradley & Corwyn, 2002; Sirin, 2005). Parental income, education and occupation reflect the potential for social and economic resources and may influence academic performance by providing the economic resources, developmental opportunities, and social supports that are necessary to succeed academically (Sirin, 2005). SES exerts its influence on academic achievement through multiple avenues including child health, cognitive and socioemotional development, as well as access to both tangible and intangible resources (Bradley & Corwyn, 2002) such as access and exposure to early literature in the home, pre-school care, and parental time and support.

Research has demonstrated that in general, children from low SES families are at risk of starting school at an academic disadvantage compared to peers from high SES families, and that if these academic difficulties are not remediated, such differences may persist throughout development (D'Angiulli, Seigel, & Hertzman 2004; Sirin, 2005). For instance, a longitudinal study conducted by D'Angiulli and colleagues (2004) examined the association between SES, basic cognitive skills related to reading, and academic achievement in reading and literacy with early elementary students. The relationship between SES, cognitive skills and achievement was especially evident in kindergarten students prior to exposure to literacy activities, suggesting children from low SES families come to school already at risk for academic underachievement, particularly in reading and literacy. Furthermore, a recent meta-analysis of 75 empirical studies found an overall medium effect size for the association between SES and academic achievement across subject areas, suggesting family SES was the strongest predictor of academic progress and success across grade level (Sirin, 2005). Overall, available literature strongly suggests that children from low SES families are at significantly greater risk for not entering school with the academic readiness skills necessary to be successful throughout school, and as such, may be at significant risk for academic underachievement throughout school (Darney et al., 2012).

Family Structure

There is a growing body of literature that suggests children living in alternative family structures, such as single parent families, demonstrate lower academic achievement and are at a greater risk for academic difficulties than those children residing with both biological parents (Heard, 2007; Jeynes, 2005; Shriner, Mullis, & Shriner, 2010). For example, studies comparing the achievement of adolescents in single versus two-parent homes suggest that children from single parent families have lower grade averages (e.g., GPA), have lower school attendance, and are more likely to be suspended or expelled (Heard, 2007; Shriner et al., 2010). Interestingly, similar relationships have been observed in children living in cohabitating step families, with some studies suggesting these children may be more academically at risk than their single-parent peers (Jeynes, 2005; Tillman, 2007). However, the association between family structure and academic performance is complex, with family structure proposed to contribute to achievement through multiple channels. For instance, family structure has often been hypothesized to influence academic achievement through parental involvement (Jeynes, 2005). Presumably, single parents must take on full ownership of household responsibilities, and therefore, have less time to spend helping with homework, discussing issues surrounding school, or monitoring school progress.

One of the better documented explanations for the impact of family structure on academic achievement is SES. In particular, living in a single parent or cohabitating stepfamily home may influence achievement by increasing the likelihood of coming from a lower SES family. For example, research suggests that children living in alternative families (e.g., single- or step-family) are more likely to live in families that have a lower income, less parental education, or to be living in poverty (Shriner et al., 2010). Consequently, these children may be subject to an increased risk of academic difficulties through the barriers related to SES. The findings of a study by Jeynes (2005) lend additional support to this hypothesis. Specifically, when SES variables (e.g., parent education, income) were included as covariates in the analyses, the effect sizes for the association between family structure and achievement were reduced. Whether family structure influences achievement through SES, parental involvement, or a combination of the two remains unclear; however, literature consistently indicates that living in an alternative family structure significantly increases the risk of academic underachievement in school-age children and adolescents (Jeynes, 2005; Shriner et al., 2010).

Individual Predictors of Academic Achievement

The following section will examine individual developmental considerations and characteristics that have been linked with academic achievement. The individual predictors of academic achievement examined in the current literature review include birth weight and preterm birth, cognitive ability, and child mental health.

Birth Weight and Preterm Birth

Although often overlooked, factors that occur early in development or at birth, particularly low birth weight or preterm birth, can have long-lasting implications for academic outcomes later in life. Preterm birth is typically defined as birth prior to 37 gestational weeks, while low birth weight (LBW) is often classified as a birth weight of 5.5 pounds or less (Vanderbilt & Gleason, 2011). With numerous advances in medicine and healthcare, the rate of survival for infants born preterm or LBW has increased. Consequently, there has been an increasing interest in the cognitive and academic outcomes of these individuals. In particular, children born preterm or LBW have been shown to demonstrate significant impairments in cognitive ability, attention and executive functions (Aylward, 2002). For instance, a particular study examining the cognitive ability of children born preterm found that on average, preterm children had a 4-10 point mean group difference in IQ compared to their TD term-born peers (Aylward, 2002). Interestingly, even those preterm children found to have normal IQ scores were still found to exhibit significant difficulties with cognitive processes including attention, memory and executive functions, specifically working memory. In addition, studies suggest that deficits in executive functions, such as working memory, may be negatively correlated with birth weight, with lower birth weight children exhibiting significantly more difficulties with working memory (Andrews-Epsy, 2002; Taylor, 2010).

In addition to deficits in cognitive processes and ability, children born preterm or LBW have also been identified as a group that is underachieving academically. For instance, one study found that compared to their typically developing term-born peers, school-age children born preterm were at a significantly higher risk of special education placement, grade repetition, and use of school-based remedial services (Buck, Msall, Schisterman, Lyon & Rogers, 2000). According to a review by Taylor (2010), many LBW or preterm children have deficits in academic achievement that occur across skill areas including reading, writing and math. Furthermore, LBW and preterm children score lower on standardized tests of academic achievement when compared to their term-born peers, and significantly more of these children meet criteria for a learning disability in one or more areas (Taylor, 2010). Interestingly, children born preterm or LBW are often a group identified as having difficulty with attention and hyperactivity, with symptoms of ADHD occurring 2-6 times more frequently in LBW infants than controls (Taylor, 2010).

Cognitive ability.

Successful academic performance will also depend to some extent on the underlying cognitive abilities that support more complex academic abilities (Bull et al., 2008). Tests of cognitive ability or intelligence tests are currently conceptualized as measuring general thinking and reasoning abilities that are said to be predictive of academic achievement (Watkins, Lei, & Canivez, 2007). There has been a long-standing history of interest in the role of intellectual ability in determining academic success, and although the link between intelligence and achievement is an age-old debate, substantial evidence suggests that psychometrically measured intelligence is substantially correlated with and predicts future academic achievement (Fergusson, Horwood, & Ridder, 2005; Watkins et al., 2007). For example, Watkins and colleagues (2007) examined the predictive relationship between measured intelligence and tests of standardized achievement in a sample of 289 students, aged 6-13 years. Students were given individually administered tests of intelligence (WISC-III) as well as a standardized test of academic achievement at two points over a 2-3 year interval. Using structural equation modeling to examine the relationship between intelligence and achievement between time points, the results of the study demonstrated that intelligence measured at time point one significantly predicted both intelligence and academic achievement years later, suggesting intelligence predicts both later intelligence as well as achievement (Watkins et al., 2007).

Likewise, a 25-year longitudinal study followed a cohort of approximately 1000 children in New Zealand (Fergusson et al., 2005). The study examined cognitive ability at ages 8 to 9 years and again between the ages of 18 to 25 years. Fergusson et al. (2005) found that intelligence measured in early childhood was related to a range of outcomes; in particular, the study found a significant positive association between intelligence and academic achievement, with higher intelligence associated with a significantly increased likelihood of high school graduation and post-secondary qualifications. Interestingly, after controlling for early conduct problems, family factors (i.e., single-parent) and demographic variables (i.e., socioeconomic status), the association between early intelligence and later academic achievement remained. The results of this study suggest that a strong relationship exists between early intelligence and later academic achievement independent of additional factors (Fergusson et al., 2005). These findings are largely supported by additional literature that report moderate correlations between general cognitive ability and academic achievement (Duncan et al., 2007; Mayes & Calhoun, 2007a). Overall, measured intelligence is often considered to be predictive of academic achievement, with lower intelligence considered to be a significant risk for later academic difficulties. However, it is important to note that both intelligence and the underlying cognitive processes that feed into intelligence can be largely influenced by early environmental variables that also carry substantial risk for academic underachievement. Likewise, the underlying cognitive processes that contribute to intelligence may also differ as a function of characteristics of child mental health.

Child mental health.

Early behavioral and emotional problems of childhood represent major determinants of academic difficulties in multiple areas of academic achievement (Kamphaus, Thorpe, Winsor, Kroncke, Dowdy, & Van Deventer, 2007). In fact, children who are considered unlikely to underachieve academic academically due to high IQ or moderate-to-high socioeconomic background may actually be at risk when early behavioral and emotional problems are considered. Epidemiological research demonstrates that approximately twenty percent of school-age students exhibit symptoms consistent with a psychological or mental health disorder, yet few youth are identified, and even fewer receive psychological care (Stewart & Suldo, 2011). This is particularly concerning given that a growing body of literature has provided notable evidence that early child mental health difficulties are largely predictive of later academic achievement. For instance, Kamphaus and colleagues (2007) followed a sample of preschool students screened using the brief teacher-rated version of the Behavior Assessment System for Children (BASC) from preschool to early elementary. Using the overall total problem score, the authors of the study found a strong negative correlation between early risk for mental health difficulties and academic achievement one year later in elementary school. In particular, early symptoms or risk for mental health difficulties was particularly predictive of achievement in reading and mathematics.

Similarly, Guzman et al. (2011) examined whether mental health problems identified through a general screener administered in first grade were linked to later academic achievement in fourth grade. The authors screened a large, nationally representative sample of students using a standardized teacher questionnaire based on classroom observation of general symptoms of mental health, as well as a standardized checklist for children. The results of the study demonstrated that students identified to be at risk for general mental health difficulties in first grade were more likely to be struggling academically in fourth grade (Guzman et al., 2011). Furthermore, the relationship between child mental health and academic achievement remained significant after controlling for other known predictors of achievement including parent income and education among other variables. According to the authors of the study, the findings suggest that mental health stands on its own as an independent risk factor for academic underachievement (Guzman et al., 2011). Perhaps more importantly, studies have shown that early onset difficulties with mental health are associated with not only early academic achievement, but also long-term outcomes for students including increased likelihood of grade retention, suspension, academic failure and school dropout (Darney et al., 2012). Therefore, early risk or presence of mental health problems represents a significant risk for academic underachievement throughout schooling that may persist into adolescence and adulthood.

When examining particular aspects of child mental health that contribute to or increase the likelihood of academic difficulties, studies typically find that mental health may be linked to achievement through specific symptoms and behaviour associated with mental health disorders. For example, although Kamphaus and colleagues (2007) suggested that overall mental health difficulties predicted academic achievement one year later in preschoolers, the authors found that when examining specific symptom subscales, symptoms of inattention were a particularly powerful predictor of academic achievement. Furthermore, using a secondary analysis of six longitudinal studies, Duncan et al. (2007) examined the link between three aspects of school readiness and later reading and math achievement in a large community sample. With the exception of baseline academic skills at school entry, the strongest predictor of later reading and math achievement across all studies was level of inattention (Duncan et al., 2007). These findings are further supported by additional literature suggesting attention predicts later achievement in young children (Daley & Birchwood, 2010). Interestingly, much less evidence exists to support the predictive role of hyperactivity/impulsivity in later academic achievement. For example, when examining the effect of ADHD symptoms on early academic skills, Thorell (2007) found that while symptoms of inattention were significantly correlated with academic skills, hyperactivity and impulsivity were not. In addition, when examining attention and hyperactivity/impulsivity separately, research suggests that difficulty with attention may be more predictive of later academic success, while hyperactivity and impulsivity may be more predictive of general problem behaviour such as juvenile delinquency or substance abuse (Daley & Birchwoord, 2010; Duncan et al., 2007). In particular, these findings highlight the importance of attention in academic achievement. As previously mentioned, ADHD is a mental health disorder that is characterized by difficulties with attention and is also often associated with academic underachievement.

ADHD and Academic Achievement

In general, poor academic performance is among one of the most prominent features associated with ADHD, with some studies reporting rates as high as 80% of children and adolescence with ADHD underperforming relative to their ability (Barkley, 2006; Corkum, McGonnell & Schachar, 2010; Frazier, Youngstrom, Glutting, & Watkins, 2007; Galera et al., 2009; Langber et al., 2011; Loe & Feldman, 2007). In fact, some researchers have suggested that nearly all clinic-referred children and adolescents with ADHD are underachieving academically (Barkley, 2006). In particular, children with ADHD have a significantly higher incidence of learning disabilities, lower scores on standardized testing, higher rates of grade retention and an increased likelihood of school failure (Loe & Feldman, 2007). Individual studies, systematic reviews, and meta-analyses all consistently demonstrate that across studies, individuals with ADHD display significantly lower overall levels of achievement relative to their TD peers (Frazier, Demaree & Youngstrom, 2004; Frazier et al., 2007; Loe & Feldman, 2007).

Interestingly, even after controlling for comorbid learning disabilities, the association between ADHD and academic underachievement remains (Gropper & Tannock, 2009). In fact, studies examining academic achievement in children with ADHD suggest that these children may show performance that is lower than their classmates by as much as 10-30 standard score points on various standardized tests of achievement (Barkley, 2006). Additionally, TD peers typically demonstrate higher reading, math, spelling and written expression achievement scores than children with ADHD, suggesting academic difficulties characteristics of ADHD are pervasive across the academic curriculum (Mayes & Calhoun, 2007a).

Even more concerning is the finding that academic difficulties in children with ADHD are also persistent across development. Evidence for impairment in academic achievement and academic skills may be seen as early as school entry and often persists into later childhood, adolescence and adulthood (Loe & Feldman, 2007; Rogers, Heungsun, Toplak, Weiss, & Tannock, 2011). For instance, studies examining the achievement and academic skills of preschoolers with ADHD have shown that difficulties with working memory, general cognitive ability and acquiring basic pre-reading and pre-numeracy skills may be apparent prior to school-entry (Daley & Birchwood, 2010). Likewise, a meta-analysis of six longitudinal studies found that baseline teacher-ratings of inattention in preschool predicted a significant amount of variance in later achievement in reading and math (Duncan et al., 2007). As children with ADHD progress through elementary school, they are more likely to use remedial academic services, be held back a grade, and to obtain poor reading and mathematics achievement scores in comparison to their TD classmates (Daley & Birchwood, 2010; Mayes & Calhoun, 2007a; Loe & Feldman, 2007). Although some adolescents may successfully continue on to post-secondary institutions, empirical literature suggests they may continue to experience academic difficulties (Gropper & Tannock, 2009).

Available literature suggests that not only do children with ADHD perform below their TD peers, but they also obtain lower achievement scores when compared with other clinical groups. For instance, Mayes and Calhoun (2007a) contrasted the academic achievement of children with ADHD to other clinical groups including children with depression, anxiety and ODD. In general, the performance of clinical comparison groups was more similar to that of TD children, while children with ADHD performed significantly below the clinical comparisons on achievement measures of reading and math (Mayes & Calhoun, 2007a). Likewise, a study conducted by McConaughy, Volpe, Antshel, Gordon and Eraldi (2011) compared the academic achievement of over 100 children with ADHD to a sample of clinic-referred children who did not meet criteria for ADHD, as well as TD controls. The findings of the study showed that not only did children with ADHD demonstrate significantly lower achievement than their TD peers, but across academic domains, they also obtained lower achievement scores than clinic-referred controls.

The finding that a significant proportion of children with ADHD are underachieving, and that on average, in comparison with both TD children and clinical-comparisons, children with ADHD perform significantly worse across achievement measures of reading, writing, and mathematics is concerning. Taken together, these findings suggest that there is a specific link between ADHD and underachievement, rather than an association between general mental health difficulties and academic performance (McConaughy et al., 2011). Although the finding that ADHD is significantly associated with academic underachievement is often supported in research literature, less consistency exists surrounding the underlying mechanisms or factors that mediate the relationship between the two. Although the nature of the link between academic achievement and ADHD remains unknown, various hypotheses have been proposed as potential mediating or causal factors (Corkum et al., 2010).

ADHD, SES, and Achievement

SES has been consistently linked to achievement across populations and confers risk for academic underachievement through its various influences on child health, cognitive and socioemotional development, and access to resources (Bradley & Corwyn, 2002). Not only has SES been shown to be a strong determinant of academic achievement in the general population, but similar relationships have also been observed in children with ADHD. For example, using data from the Multimodal Treatment of ADHD study, Langber and colleagues (2011) found that family income and parent education were significant predictors of scores on test of academic achievement and school grades respectively. This association has been confirmed in the other literature, suggesting environmental risk factors such as low SES may substantially increase or exacerbate the probability that a child with ADHD is likely to be performing below his or her TD peers academically (Galera et al., 2009).

ADHD, Intelligence, and Achievement

Group studies have shown that on average, children with ADHD score significantly lower on tests of cognitive ability than their TD classmates. For instance, using the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV), a recent study by McConaughy et al. (2011) found a mean difference of 19 standard points between typically developing controls and children with ADHD, with participants with ADHD scoring significantly lower. These findings are consistent with previous studies and have been confirmed in meta-analyses. For example, a meta-analysis of 123 published studies examining cognitive ability in individuals with ADHD found an average effect size of .61 for full-scale intelligence quotient (FSIQ) across studies, roughly equivalent to children with ADHD scoring approximately 9 points lower than controls on most commercially available tests (Frazier et al., 2004). Studies have demonstrated that intelligence is highly correlated with subsequent achievement in the general population (Naglieri & Bornstein, 2003) and appears to demonstrate a similar relationship in children and adolescents with ADHD.

Using standardized tests of cognitive ability and academic achievement, Mayes and Calhoun (2007a) demonstrated that the mean correlation between FSIQ and academic achievement was high for both TD children and children with ADHD, and that FSIQ explained a significant proportion of the variance in achievement seen in their sample. In fact, FSIQ was found to be the best single predictor of achievement in all subject areas including reading, writing and mathematics. Although research consistently illustrates a negative association between ADHD and intelligence, it is not clear that this is the primary cause of academic underachievement in ADHD. Studies continue to find that children with ADHD perform below predicted levels on academic tests given their age and intelligence quotient (IQ). Interestingly, although the study conducted by Mayes and Calhoun (2007a) found FSIQ to be the best independent predictor of academic achievement, the findings also suggested that cognitive processing scores (i.e., working memory, processing speed) made a significant and unique contribution beyond FSIQ and increased the explained variance in academic achievement.

ADHD, Cognitive Processes and Achievement

Empirical literature examining how children acquire academic skills in subject areas such as reading and math has established the importance of general cognitive processes (Duncan et al., 2007). More recent research continues to confirm the importance of working memory and processing speed to cognitive ability, and therefore the contribution of these processes to academic achievement (Raiford, Weiss, Rolfhus, & Coalson, 2005). Working memory refers to the ability to consciously store, manipulate and recall information, while processing speed represents the proficiency with which an individual can process certain types of cognitive information. In particular, the efficient use of working memory and processing speed facilitates the acquisition of new academic material and academic skills by reducing the cognitive demands of novel or abstract tasks (Weiss & Dilworth-Gabel, 2008). Both of these processes may contribute to achievement through their influence on FSIQ, or through their impact on classroom behaviour and learning required for academic success (Raiford et al., 2005). Interestingly, research suggests children and adolescents with ADHD are a population with deficits in both working memory and processing speed, among other cognitive processes (Martinussen, et al., 2005; Shanahan et al., 2006; Willcutt, Pennington, Olson, Chhabildas & Hulslander, 2005).

Numerous studies demonstrate that children with ADHD perform poorly on measures of working memory and processing speed and that these difficulties may persist into adolescence and adulthood in a subset of individuals (Gropper & Tannock, 2009). For instance, Mayes and Calhoun (2007b) examined the learning, attention, visual-motor, working memory and processing speed scores of a large clinical sample and smaller sample of typically developing children. The results of the study suggest that low scores on attention, working memory, visual-motor and processing speed reliably differentiated children with ADHD and learning disabilities from TD children (Mayes & Calhoun, 2007b). Although the authors found that FSIQ was generally more powerful in predicting achievement, working memory and processing speed were the best overall predictors of learning disabilities in reading, math and written expression in children with ADHD, suggesting this cluster of weaknesses significantly contributed to academic underachievement. Interestingly, low scores on these measures were able to reliably differentiate children with ADHD from other clinical groups including children with depression, anxiety and ODD.

ADHD, Comorbidity, and Achievement

A recent meta-analysis suggested that in comparison to other clinical and non-clinical groups without ADHD, individuals with a diagnosis of ADHD have significant elevations of symptoms of all measured disorders and higher rates of most diagnoses (Barkley, 2006; Wilcutt et al., 2012). It has been proposed that an increase in coexisting disorders is associated with a decrease in academic achievement scores in children with ADHD (Barnard-Brak et al., 2010; Crawford, Kaplan & Dewey, 2006). For instance, a study conducted by Crawford and colleagues (2006) examined the relationship between the presence of coexisting disorders and daily functioning, memory and visual-motor skills in children with ADHD. The findings of the study suggested that the presence of coexisting disorders might have a significant influence on the cognition and behaviour of children with ADHD, all of which may contribute to difficulties with learning and achievement. In particular, children with two or more additional disorders displayed significantly poorer performance on tests of memory and visual-perceptual skills and were typically more impaired in everyday general functioning (Crawford et al., 2006). Additionally, various studies find children with ADHD and comorbid learning disabilities appear to have more severe academic difficulties than children with ADHD alone (Barnard-Brak et al., 2010; Mayes & Calhoun, 2007a). Overall, the empirical evidence suggests that the presence of additional disorders may increase the risk for academic underachievement in ADHD. However, it remains unclear as to whether this relationship is mediated by additive influences of a comorbid disorder, or rather that the comorbid disorders (e.g., LD and ADHD) share a common characteristic that contributes to academic achievement, exerting a synergistic influence.

Summary

In general, academic underachievement is one of the most notable features associated with ADHD. In comparison to their TD peers, children and adolescents with ADHD are significantly more likely to underperform academically, and experience difficulty across a range of academic domains (Barkley, 2006; Frazier et al., 2007; Loe & Feldman, 2007). Interestingly, few studies have compared the relationship between ADHD and academic achievement to that in other clinical samples. Those that have made this comparison suggest that not only are children with ADHD underachieving relative to their TD peers, they may also be underachieving when compared with clinic-referred groups, including children with anxiety, depression, and ODD (Mayes & Calhoun, 2007a; McConaughy et al., 2011). Despite the consistent finding that children with ADHD are underachieving relative to their ability and their age-matched TD peers, less consistency exists for the underlying mechanisms responsible for the relationship between ADHD and achievement. Numerous mechanisms have been proposed to explain the association, as noted above, which generally fall into two broad categories: performance-based deficits (e.g., behavioural manifestations of ADHD) and cognitive deficits (e.g., cognitive ability, working memory). Numerous studies suggest low achievement seen in children with ADHD is due to the behavioural manifestations of the disorder (e.g., inattention, hyperactivity, impulsivity), resulting in impaired classroom performance (Barkley, 2006; DuPaul & Stoner, 2003; McConaughy et al., 2011). However, studies examining the achievement of children with ADHD following treatment with methylphenidate (e.g., stimulant medication taken to improve the core symptoms of ADHD) do not consistently demonstrate corresponding academic gains, suggesting additional factors play a role in predicting achievement in ADHD (Corkum et al., 2010). In contrast, additional studies suggest that the academic underachievement typically seen in individuals with ADHD is a result of the cognitive deficits associated with the disorder (Mayes & Calhoun, 2007a; 2007b). However, research literature has yet to clearly identify the causal mechanism behind the link between academic achievement and ADHD. The current study seeks to further examine the relationship between ADHD and academic achievement and the potential underlying mechanisms of underachievement in ADHD.

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a common mental health disorder involving developmentally inappropriate levels of inattention, hyperactivity, and impulsivity that occur in approximately 5% of school-age children (DSM-5; APA, 2013; Barkley, 2006). In general, children with ADHD have a higher incidence of comorbid conditions including learning disabilities, anxiety, depression, and behaviour disorders, when compared with other clinical samples. In addition to a higher incidence of comorbid conditions, ADHD has often been associated with a variety of negative functional outcomes, including an increased likelihood of anti-social behaviour, substance abuse, and in particular, low academic achievement. In fact, as many as 80% of children with ADHD experience academic underachievement and an estimated one-third of children with ADHD meet criteria for a learning disability (Barkley, 2006; Corkum, McGonnell, & Schachar, 2010). Furthermore, evidence suggests that the risk of such negative academic outcomes may be substantially elevated in children with ADHD and multiple comorbid disorders (Barnard-Brak, Sulak, & Fearon, 2010; Daley & Birchwood, 2010; Crawford, Kaplan & Dewey, 2006).

Children with ADHD may experience persistent and pervasive impairments in academic performance across development, from as early as school entry, up to and including post-secondary education (Daley & Birchwood, 2010). Furthermore, these difficulties are observed across subject areas and remain significant after controlling for comorbid learning difficulties (Gropper & Tannock, 2009; Rogers, Heungsun, Toplack, Weiss & Tannock, 2011). Individual studies, systematic reviews and meta-analyses consistently support the finding that on average, individuals with ADHD display significantly lower levels of achievement relative to their typically developing (TD) peers as well as other clinical comparison groups (Frazier, Demaree & Youngstrom, 2004; Frazier, Youngstrom, Glutting & Watkins, 2007; Loe & Feldman, 2007;

Mayes & Calhoun, 2007a; Mayes & Calhoun, 2007b). Data obtained from the use of subjective measures of achievement (i.e., teacher-rated academic achievement), objective measures of achievement (i.e., GPA, years of schooling), and standardized tests of achievement in particular, suggest impairments in academic performance generalize to functional achievement outcomes, and do not simply reflect poor test-taking behaviour (Frazier et al., 2007). Despite the overwhelming and consistent finding that children with ADHD are academically underachieving relative to their peers, the exact nature of the association between ADHD and academic achievement remains unknown.

Current literature has identified several broad factors that both help and hinder academic performance. These factors include socioeconomic status (SES), developmental factors such as birth weight, intelligence, and mental health, each of which have been shown to predict academic achievement. For instance, SES has been shown to be significantly correlated with later academic success, suggesting that children coming to school from low-SES backgrounds may be at risk of starting school at a considerable academic disadvantage (D'Angiulli, Seigel, & Hertzman, 2004; Guzman et al., 2011). Likewise, children delivered with low birth weight (e.g., 5 pounds or less) have also been suggested to be significantly more likely to struggle academically (Taylor, 2010). Research literature has also demonstrated the substantial correlation between measured intelligence (intelligence quotient; IQ) and academic success (Naglieri & Bornstein, 2003; Watkins, Lei & Canivez, 2007). Furthermore, children at risk for difficulties with mental health in early elementary school may be more likely to be academically underachieving later in school (Guzman et al., 2011). In particular, when examining mental health in general, symptoms of inattention have been found to be particularly important in predicting academic achievement (Breslau, Breslau, Peterson, Miller, Bohnert & Nigg, 2010).

The same risk factors have also been shown to be predictive of academic achievement in children with ADHD. For instance, a large-scale study found that family income and parent education were significantly correlated with scores on a test of academic achievement and school grades in children with ADHD, with students from low-income families scoring significantly lower than their advantaged ADHD peers (Langber et al., 2011). Furthermore, Mayes and Calhoun (2007a) found that full-scale intelligence quotient (FSIQ) on the Wechsler Intelligence Scale for Children (WISC-III and WISC-IV) explained a significant proportion of variance in achievement scores in their sample of children with ADHD. Likewise, a study examining the impact of comorbid mental health disorders on the behaviour and cognition of children with ADHD found that individuals with two or more additional disorders displayed significantly more overall impairment including poorer memory, visual-perceptual performance, and parent-reported achievement (Crawford et al., 2006). In addition, children with ADHD and comorbid learning disabilities have been shown to be more severely impaired academically than those with ADHD alone (Barnard-Brak et al., 2010).

Although an association between the above-noted risk factors and academic achievement has been established in children with ADHD, literature has yet to determine the exact nature of the relationship between these factors and achievement in children with ADHD. Studies controlling for background risk factors such as SES, intelligence and number of comorbid disorders continue to demonstrate the maintenance of a significant association between ADHD and academic achievement (Pastura, Mattos & Araujo, 2009). In addition, research studies continue to demonstrate similar findings after controlling for the diagnosis of comorbid learning disabilities, suggesting the relationship between ADHD and underachievement is not solely attributable to diagnosed learning disabilities (Mayes, Calhoun & Crowell, 2000; McConnaughy, Volpe, Antshel & Gordon, 2011; Rogers et al., 2011). Overall, numerous studies provide evidence to support the finding that children with ADHD perform significantly below their TD peers academically, as well as below clinical comparison groups (i.e., anxiety, depression, ODD). In fact, evidence suggests that in comparison to children with ADHD, clinical-referred comparison groups without ADHD (e.g., depression, anxiety, or ODD) do not differ significantly from TD community samples on learning, and are not typically characterized by neuropsychological deficits often seen in children with ADHD and/or learning disabilities (Mayes, Calhoun & Crowell, 2000; Mayes & Calhoun, 2007b; Pickering & Gathercole, 2004). In general, these findings suggest that the diagnosis of ADHD itself confers risk for academic underachievement (Mayes & Calhoun, 2007a; 2007b; McConaughy et al., 2011). More recent literature examining the potential mechanisms underlying the relationship between ADHD and achievement points to the importance of two broad constructs in predicting achievement in children with ADHD: underlying cognitive processes (e.g., IQ, working memory, processing speed) associated with the disorder, and the behavioural manifestations of ADHD (e.g., symptoms of inattention, hyperactivity, and/or impulsivity).

Empirical literature examining how children acquire academic skills in general, highlight the importance of general cognitive processes (Duncan et al., 2007). In particular, recent literature has pointed to the contribution of working memory and processing speed to cognitive ability. Considering the significant correlation between cognitive ability and achievement, and the relative contribution of working memory and processing speed to cognitive ability, both cognitive processes (e.g., working memory and processing speed) have been proposed to be linked with academic success (Raiford, Weiss, Rolfhus, & Coalson, 2005). Working memory, the ability to store, manipulate and recall information, and processing speed, the proficiency with which an individual is able to process certain types of cognitive information, significantly influence Full Scale IQ (FSIQ) and facilitate learning by reducing the cognitive demand of novel or abstract tasks (Weiss & Dilworth-Gabel, 2008). Interestingly, these processes are among the most impaired in children with ADHD. For instance, Mayes and Calhoun (2007b) examined the learning, attention, visual-motor, working memory and processing speed scores of a large clinical sample and smaller sample of typically developing (TD) children. The results of the study indicated that low scores on working memory and processing speed, as well as attention and visual-motor skills, reliably differentiated children with ADHD, as well as children with learning disabilities, from TD children and other clinical controls (Mayes & Calhoun, 2007b). In particular, impairments in the aforementioned cognitive processes have often been proposed to be involved in the link between ADHD and achievement.

Likewise, research examining the impact of the behavioural manifestations of ADHD strongly suggests that symptom type and symptom severity may significantly influence achievement. For example, symptom severity may negatively impact school performance by directly impeding the student's ability to learn and master new academic material. In general, the majority of studies find that symptom severity is negatively correlated with low academic performance in reading, writing and mathematics, suggesting increasing difficulty with attention, hyperactivity, and/or impulsivity, may be linked to low school performance (De-Shazo-Barry, Lyman & Klinger, 2002; Diamantopoulou, Rydell, & Thorell, 2007). Furthermore, these associations continue to exist after controlling for IQ and additional confounding factors, such as SES. In order to improve the core symptoms of ADHD, and the resulting behavioural manifestations of the disorder, stimulant medication such as methylphenidate (MPH), is often recommended as one of the most common treatment options (Barkley, 2006). Numerous studies have demonstrated that not only does treatment with MPH ameliorate the core symptoms of ADHD, it has also been shown to increase academic productivity, and has been proposed to improve academic performance in children with ADHD (Evans et al., 2001).

In particular, although ADHD encompasses a triad of symptoms, it appears academic achievement may be explained by symptoms of inattention more so than by symptoms of hyperactivity and/or impulsivity (Langber et al., 2011). In fact, cross-sectional and longitudinal studies suggest that academic impairments seen in children with ADHD are primarily related to symptoms of inattention. Attention may influence achievement through the ability to maintain focus and take advantage of learning opportunities provided by classroom instruction (Duncan et al., 2007). For instance, a longitudinal study conducted by Breslau and colleagues (2010) examined the predictive relationship of teacher-rated symptoms of ADHD with later academic achievement. The study found that teacher's ratings of inattention in early elementary significantly predicted academic achievement in math and reading in middle- and high-school, even after controlling for IQ and SES (Breslau et al., 2010). Interestingly, no correlation was observed between teacher-rated hyperactivity or impulsivity and later academic achievement, highlighting the importance of attention in predicting school performance. Additionally, the authors of the study emphasized the finding that changes in teacher's ratings of inattention were negatively associated with a change in later academic achievement, with students whose ratings of inattention increased over time also demonstrating a decrease in achievement (Breslau et al., 2010). In particular, these results strengthen the hypothesis that early difficulties with attention may play a substantial role in predicting subsequent academic performance, by showing that a change in symptoms of attention over time was highly correlated with later achievement.

Overall, it is clear that many children with ADHD achieve at a level lower than expected given their ability, as well as in comparison to the performance of their TD peers and other clinical samples (Frazier et al., 2007; Loe & Feldman, 2007; McConnaughy et al., 2011).

Although numerous potential predictors of academic achievement in children with ADHD have been identified, the extent to which academic underachievement is due to the behavioral expression of ADHD and/or the cognitive deficits associated with the disorder remains uncertain.

In general, findings from group studies have suggested that children with ADHD score significantly lower on standardized tests of cognitive ability than their same-age TD peers, and that Full Scale IQ (FSIQ) may explain a significant proportion of variance in the academic performance of children with ADHD (Frazier et al., 2007; Mayes & Calhoun, 2007a; McConnaughy et al., 2011). In addition, both working memory and processing speed have been proposed to contribute to academic outcomes through their influence on general cognitive ability, and their impact on learning (Raiford et al., 2005). Given that children with ADHD have been described as a group characterized by deficits in working memory and processing speed (Gropper & Tannock, 2009; Mayes & Calhoun, 2007a; Wilcutt, Pennington, Olson, Chhabildas & Hulslander, 2005), it has been proposed that the relationship between achievement and ADHD can be explained through these processes. Interestingly, recent literature also suggests visual-motor deficits may co-occur with processing speed and working memory deficits, and therefore, may further contribute to academic underachievement in children with ADHD (Mayes & Calhoun, 2007b). Furthermore, cross-sectional and longitudinal studies also highlight the importance of attention in academic success. Numerous research studies highly suggest that the academic difficulties seen in children with ADHD are primarily related to symptoms of inattention (Breslau et al., 2010; Duncan et al., 2007; Langber et al., 2011).

To our knowledge, few studies have thoroughly examined the association between background characteristics, behavioral manifestations associated with ADHD (e.g., inattention, hyperactivity, impulsivity), as well as cognitive processes (e.g., working memory, processing speed, visual-motor ability, IQ), in relation to academic achievement within a diverse, rigorously diagnosed clinical sample. Of these studies, the majority have examined cognitive processes other than those noted above (e.g., specific executive functions), have narrowly defined cognitive ability (e.g., examining IQ only), or have defined academic performance subjectively, using functional academic outcomes rather than standardized tests of academic achievement (Diamantopolou, et al., 2007; Langber et al., 2011; Massetti et al., 2008). In addition, the majority of studies examine teacher-rated attention in relation to academic achievement, but fewer include parent-rated attention, or examine both simultaneously.

The identification of factors that are linked with academic achievement outcomes in clinical-referred samples of children, including children with ADHD, holds important implications for the assessment, academic planning, and educational intervention of students who are underachieving academically. To better understand the factors that predict standardized academic achievement generally, it would be beneficial to identify the cognitive, behavioral, and demographic factors that are significantly associated with academic outcomes. Therefore, a key research goal of the current study is to examine the relationship between demographic characteristics, cognitive ability and processes, the core symptoms of ADHD, and standardized achievement in a large, diverse, and rigorously diagnosed sample of clinical-referred children. In particular, the sample was composed of children with ADHD, children with ADHD and comorbid learning disabilities (ADHD + LD), learning disability without comorbid ADHD (LD), and clinical comparisons (e.g., clinical referred children with mental health diagnoses other than ADHD or LD, or who did not meet criteria for any mental health diagnosis at the time of assessment).

Empirical findings from the literature suggest that the factors most likely to be significantly correlated with poor academic achievement are three background factors, four cognitive factors, two distinct behavioural factors, and number of comorbid mental health diagnoses. The demographic factors are (1) socioeconomic status, (2) birth weight, and (3) family structure (e.g., the presence of a single parent and/or parental separation). The cognitive factors include (1) general cognitive ability, (2) working memory, (3) processing speed, and (4) visual-motor ability. The behavioural factors are (1) level of inattention and (2) level of hyperactivity/impulsivity. Lastly, it was anticipated that the number of comorbid diagnoses would also be associated with academic achievement.

In general, numerous studies support the finding that children with ADHD are significantly more likely to be performing below their TD peers across a range of academic subjects (Barkley, 2006; Frazier et al., 2007; Loe & Feldman, 2007). Interestingly, studies comparing the academic achievement of children with ADHD to that of other clinical samples suggest that not only do children with ADHD appear to perform below their TD peers, but they are also more likely to underachieve compared to other clinical-referred groups (Mayes & Calhoun, 2007a; McConnaughy et al., 2011). The finding that children with ADHD are underachieving relative to their ability, their TD peers, and their clinical-referred peers suggests mechanisms unique to the diagnosis of ADHD, rather than mechanisms associated with mental health diagnoses in general, may confer risk for academic underachievement.

Although numerous studies suggest low achievement seen in children with ADHD is linked to impaired classroom functioning due to the behavioral manifestations of the disorder (e.g., inattention, hyperactivity, impulsivity), studies examining the achievement of children with ADHD following treatment with methylphenidate (e.g., stimulant medication taken to improve the core symptoms of ADHD) do not consistently support this hypothesis (Corkum et al., 2010).

In addition, a small number of studies have examined whether the core symptoms of ADHD continue to predict achievement after controlling for other risk factors that have been demonstrated to be linked to academic achievement. Furthermore, even fewer have controlled for medication status (e.g., past or current treatment with psychotropic medication), contributing to potential methodological limitations in those studies that have examined the contribution of the symptoms of ADHD to achievement. Therefore, another research goal of the current study was to examine whether the core symptoms of ADHD continue to predict academic achievement after controlling for risk factors associated with academic achievement in a medication naïve clinical-referred sample.

Despite the abundance of literature examining academic achievement in children with ADHD compared to TD peers, fewer studies have examined the academic predictors of achievement in children with ADHD relative to a clinical-referred sample, including children with learning disabilities (Mayes et al., 2000; Mayes & Calhoun, 2007b; McConaughy et al., 2011). Although previous studies that have examined the performance of children with ADHD and comorbid LD have suggested that these children are more impaired academically than those with ADHD alone (Mayes et al., 2000), limited research has examined the performance of children with ADHD and comorbid LD in relation to children with ADHD without comorbid LD, and LD without comorbid ADHD. Likewise, a small amount of literature has examined the academic performance of these groups in relation to clinical-referred comparisons with clinical diagnoses other than ADHD or LD. Therefore, a further goal of the current research study was to examine which clinical-referred group (e.g., ADHD + LD, ADHD, LD, and clinical comparison) was most academically impaired.

Children with ADHD and comorbid learning disabilities were anticipated to be most academically impaired given previous findings that children with ADHD and comorbid learning disabilities have greater neuropsychological and academic deficits (Barnard-Brak et al., 2010; Mayes et al., 2000; Mayes & Calhoun, 2007a; Willcutt et al., 2001). Moreover, research examining the academic achievement of clinical-referred children with diagnoses other than ADHD and/or LD, and clinical-referred children without diagnoses, suggest that these children do not differ significantly from TD community control samples on learning or achievement (Mayes & Calhoun, 2007b). Therefore, clinical comparisons were anticipated to be the least academically impaired. Finally, given that diagnosis of LD is contingent upon academic underachievement, it was expected that children with LD would demonstrate more academic difficulty than participants with ADHD without comorbid LD (Mayes et al., 2000).

To achieve the research goals noted above, a number of specific research questions were examined:

Primary Research Questions

Prior to examining the primary research questions of interest, a number of analyses were conducted to gain descriptive information concerning the cognitive, behavioural and academic strengths and weaknesses of the sample in order answer the following questions.

1. Which demographic, cognitive and behavioral factors are significantly correlated with overall standardized academic achievement?

It was anticipated that the three demographic factors, four cognitive factors, one behavioral factor, and comorbidity would be significantly correlated with standardized academic achievement. In particular, given previous literature, it was expected that low socioeconomic status, low birth weight, and family structure (e.g., presence of single parent or parental separation) would be associated with poor academic performance on standardized academic achievement. This would be consistent with previous research on general background characteristics linked to academic achievement (Buck, Msall, Schisterman, Lyon & Rogers, 2000; D'Angiulli, Seigel & Hertzman, 2004; Heard, 2007; Jeynes, 2005; Taylor, 2010). It was also expected that cognitive ability and cognitive processes, including working memory, processing speed, and visual-motor integration would demonstrate a positive correlation with academic achievement (Mayes & Calhoun, 2007a; 2007b; Raiford, Weiss, Rolfhus, & Coalson, 2005). Furthermore, given the finding that inattention has been suggested to predict academic achievement (Breslau et al., 2010; Duncan et al., 2007; Preston, Heaton, McCann, Watson & Selke, 2009), it was anticipated that level of inattention would be negatively correlated with standardized achievement scores. Moreover, although academic difficulty is often linked to the behavioural symptoms of ADHD, past literature suggests this relationship may be more uniquely explained by inattention than by hyperactivity/impulsivity (Breslau et al., 2010). Therefore, the current study did not expect level of hyperactivity/impulsivity to be correlated with achievement. Finally, it was also anticipated that comorbidity (e.g., number of comorbid diagnoses) would demonstrate a significant negative correlation with achievement (Barnard-Brak et al., 2010).

2. Do the core symptoms of ADHD continue to predict academic achievement when controlling for known risk factors associated with academic achievement?

In line with the findings of Breslau and colleagues (2010), as well as De-Shazo et al. (2002), it was expected that the behavioral symptoms of ADHD, specifically level of inattention, would predict overall performance on standardized academic achievement. Furthermore, it was anticipated this relationship would remain after controlling for known risk factors linked to academic underachievement, including demographic factors, comorbidity, and cognitive ability and underlying processes (Duncan et al., 2007; Pastura et al., 2009).

3. Which clinical-referred group is most academically impaired?

Children with ADHD and comorbid learning disabilities (LD) were anticipated to be the most academically impaired based on previous research finding that suggest children with ADHD and comorbid LD demonstrate greater neuropsychological deficits and difficulty with learning. This would be consistent with previous research findings by Barnard-Brak et al. (2010), Mayes and Calhoun (2007b) and Willcutt et al. (2001). Children with LD were expected to be more academically impaired than children with ADHD considering diagnosis of LD is contingent upon academic underachievement and impairment (DSM-5; APA, 2013). Finally, clinical comparison participants with mental health diagnoses other than ADHD and/or LD were anticipated to be least academically impaired. This would be consistent with research that suggests that community samples of TD children do not significantly differ from clinical-referred controls on neuropsychological measures or measures of learning (Mayes & Calhoun, 2007b; Pickering & Gathercole, 2004)

Secondary Research Questions

4. What are the cognitive strengths and weaknesses of clinical-referred groups relative to one another, and in relation to a normative sample?

Consistent with previous research findings that children with ADHD demonstrate lower performance on measures of cognitive ability relative to their TD peers, it is anticipated that children with ADHD, with or without comorbid learning disability, will demonstrate performance on measures of cognitive ability (e.g., working memory, processing speed, and visual-motor integration) falling significantly below that of a normative sample (Beery, 1997; Wechsler, 2003). In addition, it was anticipated that children with ADHD, with or without comorbid learning disability, would demonstrate significantly more impairment than clinical comparisons on performance on measures of cognitive ability, working memory, processing speed, and visual-motor integration. This would be in line with previous research findings by Mayes and Calhoun (2007b), and Willcutt et al. (2005).

Furthermore, it was expected that performance of children with learning disabilities (without comorbid ADHD) would also fall below the mean of the normative sample, as well as the performance of clinical comparisons, on measures of working memory, processing speed, and visual-motor integration. It was not anticipated that children with ADHD would differ significantly from children with LD (Mayes et al., 2000; Mayes & Calhoun, 2007b; Willcutt, et al., 2005). However, it was hypothesized that children with ADHD and comorbid LD may demonstrate greater deficits in underlying cognitive processes relative to children with ADHD, LD, and clinical comparisons (Willcutt et al., 2005).

5. What are the behavioral strengths and weaknesses (e.g., symptoms of inattention, hyperactivity and/or impulsivity) of clinical-referred groups relative to one another?

It was anticipated that children with ADHD, with or without comorbid learning disabilities, would differ significantly from other participants on the mean number of symptoms of inattention and hyperactivity/impulsivity endorsed on semi-structured clinical interviews (e.g., Parent Interview for Child Symptoms; Schachar, Ickowicz, & Sugarman, 2000; Teacher Telephone Interview; Tannock, Hum, Masellis, Humphries & Schachar, 2002). Such findings would be consistent with the diagnostic criteria required to receive a diagnosis of ADHD (DSM-5; APA, 2013).

Given the finding that learning disabilities, particularly those impacting academic performance in reading, are often associated with symptoms of inattention (Mayes et al., 2000; Willcutt & Pennington, 2001), it was also anticipated that children with learning disabilities would differ significantly from children with ADHD, but would demonstrate elevated symptoms of inattention relative to clinical-referred children without ADHD and/or LD. However, given the limited literature examining hyperactivity in children with LD compared to clinical-referred children without ADHD or LD, it was difficult to anticipate whether the groups would differ significantly from one another on symptoms of hyperactivity and/or impulsivity.

6. What are the academic strengths and weaknesses of clinical-referred children in comparison relative to a normative sample?

It was expected that children with ADHD, with or without comorbid learning disabilities, would differ significantly from the normative sample (Wechsler, 2002). This would be consistent with previous research studies by Mayes and Calhoun (2007b), McConaughy et al., (2011), and with meta-analyses by Frazier, Youngstrom, Glutting and Watkins (2007). Given that academic underachievement is a necessary prerequisite to the diagnosis of a learning disability (DSM-5; APA, 2013), it was also anticipated that the performance of children with learning disabilities would also fall significantly below standardized means of the normative sample. Clinical-referred comparisons without ADHD or LD were not anticipated to fall significantly below the mean of the normative sample.

Method

Data for the current study were drawn from a research database composed of children assessed at the Colchester East Hants Health Authority (CEHHA) ADHD Clinic (referred to as the ADHD Clinic for the purposes of this paper). The database is used to store and organize clinical information, but is available for research use pending ethical approval through the appropriate research ethics boards. All participants give consent for the use of the data collected during the assessment to be used for future research purposes, pending ethical approval.

The ADHD Clinic operates under a formal partnership between the Colchester East Hants Health Authority and the Chignecto-Central Regional School Board. In order to attend the clinic, children were required to attend school within the designated health district catchment area, must have been between the ages of six and twelve at the time of the assessment, and could not have had a previous psycho-educational assessment within a two year period prior to the assessment. Referral to the clinic is restricted to children without a previous diagnosis of ADHD and children who are psychotropic medication-naïve.

The methods used in this study adhere to the Canadian Code of Ethics for Psychologists (Canadian Psychological Association, 2000), as well as the Tri-Council Policy Statement for Ethical Conduct for Research Involving Humans (TCPS-2, 2010). The current study received ethical approval through the Colchester East Hants Health Authority (CEHHA) Research Ethics Board as well as through Mount Saint Vincent University Research Ethics Board.

Participants

Participants for the current study were restricted to ADHD Clinic clients who consented to have the clinical information obtained during their visit to the ADHD Clinic used for research purposes. The total sample for the current study included 288 children referred to the ADHD Clinic to investigate the possibility of a diagnosis of ADHD due to difficulties with attention, hyperactivity, impulsivity and/or learning. Eleven participants were excluded from the final analyses due to missing standardized cognitive and academic data. For the current study, the overall sample was organized according to four broad clinical groups including children with ADHD and comorbid learning disability (referred to as the ADHD and comorbid LD group), ADHD without comorbid learning disability (referred to as the ADHD group), learning disability without comorbid ADHD (referred to as the LD group), and children with mental health diagnoses other than ADHD or LD (referred to as the clinical comparison group). It is important to note that children in the ADHD, LD, and ADHD and comorbid LD group may have also met criteria for additional mental health diagnoses (e.g., anxiety, depression, ODD).

Of the total sample, 146 participants met DSM-IV-TR (APA, 2000) criteria for ADHD (Predominantly Inattentive presentation (n= 36; 25%); Predominantly Hyperactive/Impulsive presentation (n = 12; 8 %); Combined presentation (n= 98; 67%))[1]. Additionally, of the 146 participants who met criteria for ADHD, 65 participants also met criteria, or were considered 'at risk', for the diagnosis of a comorbid learning disability. Furthermore, 73 participants of the total sample met criteria for the diagnosis of, or were considered 'at risk' of, a learning disability. Regardless of primary diagnosis (e.g., ADHD or LD), participants considered at risk of a learning disability were coded as meeting criteria for the diagnosis of a learning disability (LD) [2]. Finally, 58 participants of the total sample met criteria for another mental health disorder (e.g., not ADHD or LD), or did not meet criteria for a diagnosis at the time of assessment (clinical comparisons).

Participants for the current study were diagnosed using comprehensive assessment procedures considered best practice for the clinical diagnoses of ADHD and other mental health disorders. Comprehensive assessment at the ADHD Clinic included diagnostic interviews with multiple informants, rating scales completed by multiple informants, psychoeducational assessment, classroom observations, academic cumulative file review, and collection of developmental and historical information. The aforementioned measures and diagnostic procedures are described in further detail below.

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[1] Considering the diagnostic criteria have not changed in from the previous edition (DSM-IV-TR; APA, 2000), it is assumed participants would continue to meet diagnostic criteria for ADHD under the most current edition of the DSM (DSM-5; APA, 2013).

[2] Analyses were initially run with children considered 'at risk' of learning disability grouped separately; however, children at risk of learning disability were not found to differ significantly from those who received a diagnosis of a learning disability on key variables of interest.

Measures

Parent Interview for Child Symptoms (PICS; Schachar, Ickowicz, & Sugarman, 2000). The PICS is a semi-structured diagnostic interview developed for use with parents. The PICS is designed to systematically assess symptoms of childhood disruptive behaviour disorders (i.e., ADHD, Oppositional Defiant Disorder (ODD), and Conduct Disorder (CD)) and to screen for symptoms of emotional and psychiatric disorders (i.e., anxiety, depression, psychosis) based on the DSM-IV criteria (Schachar, Ickowicz, Sugarman, 2005). The interview consists of three separate modules including (1) the General Information module, (2) the Disruptive Disorder module, and (3) the General Psychopathology module. Using the General Information module, the psychologist and pediatrician elicit information about family history and composition, medical history, developmental milestones, and school history. Demographic information such as child age, sex, and medical history were collected through this module for sample description. The Disruptive Behaviours module examines behaviours associated with the diagnostic criteria for ADHD, ODD and CD. The General Psychopathology module probes for information about symptoms relating to other mental health disorders often diagnosed in childhood including various anxiety, mood and psychotic disorders, as well as autism spectrum disorders and Tourette's syndrome.

The interview takes approximately 1.5-2.5 hours to administer. During the interview, the clinician elicits information about the child's behaviour in a variety of situations based on standardized probes (Schachar et al., 2005). The clinician is responsible for encouraging the informant(s) to provide sufficient detail upon which the clinician can rate both the presence and severity of symptoms. At the ADHD Clinic, the severity of symptoms is rated on a 3-point scale, anchored by 0 (absent), 1 (dubious or trivial abnormality), 2 (definite abnormality) and 9 (not known or unable to rate). Symptoms must be rated as “2” in order to be regarded as clinically significant.

At the ADHD Clinic, the PICS is used in conjunction with additional measures, including the Teacher Telephone Interview (TTI), and behaviour rating scales, to diagnose ADHD. The PICS has been shown to have good reliability for diagnosis of ADHD, ODD, and CD (Ickowicz, Schachar, Sugarman, Millette, Cook, 2006). The number of symptoms of ADHD endorsed on the PICS was used as a measure of inattentive symptoms and hyperactive/impulsive symptoms in the current study.

Teacher Telephone Interview (TTI; Tannock, Hum, Masellis, Humphries & Schachar, 2002). The TTI is a semi-structured diagnostic interview designed for use with the participant’s teacher over the phone. The structure and format of the TTI is similar to that of the PICS, and is designed to be used in conjunction with the PICS. This interview has three components: (1) the academic placement review, (2) the symptom review, and (3) the impact review (Tannock et al., 2002). The academic placement review examines the participant’s current classroom to determine whether additional teachers are required for an interview, as well as to discuss classroom environment, teaching style and current supports and interventions in place for the child. During the symptom review section, the clinician asks the teacher to describe the participant’s behaviour in various school settings to elicit information about symptoms, academic functioning, classroom behaviour, and relationships with both peers and other adults in the school. Based on information elicited during this model, the ADHD Clinic interviewer rates the presence and severity of symptoms on a 3-point scale (0 = Absent, 1 = Dubious or trivial abnormality, 2 = Definite abnormality, and 9 = Not known or unable to rate). Finally, the interviewer completes the impact review with the teacher by asking the teacher to describe his or her main concerns surrounding the participant, the persistence of the problem, and to the extent to which these difficulties affect students and staff both in the class and the school (Tannock et al., 2002). The TTI was used in conjunction with the PICS to provide a measure of inattention symptoms and hyperactivity/impulsivity symptoms in the current study.

As a measure of ADHD symptoms for this study, the number of symptoms endorsed on both the PICS and TTI were combined to produce a mean number of symptoms of inattention and mean number of symptoms of hyperactivity/impulsivity.

Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV; Wechsler, 2003). The WISC-IV is an individually administered test of intelligence for children from ages 6 to 16 years, 11 months that was standardized on a sample (*N* = 2200) representative of the 2002 United States Census on sex, race and ethnicity, parent education, as well as geographic region. The WISC-IV has also been adapted and standardized in Canada (*N* = 1100) and provides Canadian norms representative of the 2001 Canadian Census. The WISC-IV consists of 14 individual subtests (*M* = 10, *SD* = 3), 10 standard and 4 supplementary, that combine to produce three composite scores: Full Scale IQ (FSIQ), General Ability Index (GAI), and Cognitive Proficiency Index (CPI; *M* = 100, *SD* = 15). In addition, the WISC-IV provides four factor-based index scores (*M* = 100, *SD* = 15). The four index scores include the Verbal Comprehension Index (VCI: measure of verbal thinking and reasoning abilities), Perceptual Reasoning Index (PRI: measure of non-verbal thinking and reasoning abilities), Working Memory Index (WMI: measure of ability to hold, manipulate and recall verbal information) and Processing Speed Index (PSI: measure of ability to efficiently process nonverbal information).

The FSIQ is composed of the core subtest of the WISC-IV and provides an aggregate score that summarizes performance across cognitive abilities. The VCI and PRI are composed of three subtests respectively, and are thought to provide measures of verbal and non-verbal reasoning abilities that promote understanding and comprehension of new material. Both the

VCI and PRI were included in the current study as measures of higher-order thinking and reasoning abilities. The WMI and PSI reflect an individual's ability to process verbal and visual information efficiently. The ability to efficiently process particular information enables both reasoning and learning new material by reducing the cognitive demands required by novel tasks (Weiss & Dilworth-Gabel, 2006; Weiss, Saklofske, Schwartz, Prifitera, & Holdnack, 2006). The WMI and PSI were used as measures of basic processing ability in the current study. Full details of the WISC-IV and its standardization are described in Wechsler (2003). Further reliability and validity data are presented in Sattler (2001).

Overall, 23% (n = 64) of participants' cognitive performance was evaluated using the *Wechsler Intelligence Scale for Children – Third Edition (*WISC-III; Wechsler, 1991). The remaining 77% (n = 184) of participants were evaluated using the most recent edition of the *Wechsler Intelligence Scale for Children* (WISC-IV; Wechsler, 2003). Standardized data obtained from the WISC-III and WISC-IV were both used in the current study given reported correlations between the WISC-III and WISC-IV FSIQ (0.89), as well as the correlation between WISC-III and WISC-IV index scores (0.72 to 0.88) were high (Wechsler, 2003).

Beery-Buktenica Developmental Test of Visual-Motor Integration – Fourth Edition (VMI; Beery, 1997). The VMI is an individually administered test of integration of visual perceptual and motor abilities for individuals from 2 to 100 years. The VMI consists of three subtests (M = 100, SD = 15): the Test of Visual Perception, Test of Motor Coordination, and the Test of Visual-Motor Integration. Only the standard score for the Test of Visual-Motor Integration (VMI), for which the individual is asked to copy designated target lines and shapes of increasing complexity within the provided space, was used in this study. Overall, the VMI has demonstrated good test-retest reliability and concurrent validity (Beery, 1997)

Wechsler Individual Achievement Test – Second Edition (WIAT-II; Wechsler, 2002). The WIAT-II is an individually administered test of academic achievement in subject areas including reading, writing and mathematics, for individuals age 4-85 years. The WIAT-II was co-normed with, and is empirically linked to the WISC-IV, allowing for valid and reliable comparison between achievement and ability (Wechsler, 2003). In addition to the subtest scores, the WIAT-II provides standard scores (M = 100, SD = 15) that combine to produce four composite scores for Reading, Mathematics, Written Language and Oral Language.

The WIAT-II manual reports high internal consistency and test-retest reliability (Wechsler, 2002). Canadian norms are available for the WIAT-II. The WIAT-II provided a measure of academic achievement for the current study. Given the substantial amount of missing subtest data for certain subtests (e.g., Pseudoword Decoding, Reading Comprehension, Written Expression), the composite scores for Reading, Mathematics and Written Language could not be consistently calculated for a significant proportion of participants. Instead, the standard scores from consistently administered subtests (e.g., Word Reading, Numerical Operations, and Spelling) were combined to produce an overall mean estimate of academic achievement. In addition, these subtests represent basic foundational skills for reading, writing, and mathematics, and are often used as core subtests in other measures of standardized achievement. Furthermore, academic subtests of reading, math, and spelling are often used as measures of academic achievement in other studies examining similar research questions (Corkum et al., 2010; Langber et al., 2011; Preston et al., 2009). Academic underachievement was defined by mean overall performance on subtests of the WIAT-II that fell at least one standard deviation or more below the mean (e.g., overall mean standard score $\leq$ 85).

Procedure

The ADHD Clinic uses an interdisciplinary diagnostic approach and employs a team consisting of mental health psychologists, school psychologists, and pediatricians. Prior to arriving at the clinic, the participant's parent(s) and teacher were asked to complete screening measures (e.g., Conners Parent and Teacher Rating Scales; Conners, 1997). Parents were also asked to complete a demographic questionnaire. The ADHD Clinic mental health psychologist completed a diagnostic telephone interview with the participant's teacher (i.e., TTI), while the school psychologist completed an in-class observation of the child, as well as a cumulative review of the participant's academic record. During the clinic assessment, the mental health psychologist and pediatrician completed a semi-structured diagnostic interview (i.e., PICS) with the parent(s) of the participant. During the same time, the children completed a standard psycho-educational assessment battery with the school psychologist. The battery consisted of a measure of intellectual ability (i.e., WISC-IV), academic achievement (i.e., WIAT-II), and processing skills (i.e., VMI). Following completion of the assessment, the ADHD clinic team met to determine diagnoses based on the results of the aforementioned measures.

Once the diagnosis was established, the pediatrician, mental health psychologist and school psychologist met with the parents or guardians to summarize the results of the assessment, provide the diagnosis/diagnoses, and discuss potential treatment and intervention strategies. Prior to leaving the clinic, informed consent was obtained from the parents or guardian of the child to allow for the data generated from the assessment to be used for future research purposes. Only data for participants from whom consent was provided were included in the current study. A detailed description of the ADHD Clinic assessment procedures can be found in McGonnell et al. (2009).

Statistical Analyses

Data for the current study were analyzed using IBM SPSS software (version 20). Prior to addressing our primary research questions of interest, a number of analyses were conducted to gain descriptive information concerning the demographic composition of our sample. A number of secondary analyses were also conducted to examine the cognitive, behavioural, and academic strengths and weaknesses of our sample.

Primary analyses.

To address the first research question (which cognitive, behavioural and demographic factors are significantly correlated with overall academic achievement?), Pearson's correlations were performed to determine which factors were significantly correlated with standardized achievement. The standard scores of three WIAT-II subtests, including Word Reading, Numerical Operations, and Spelling, were averaged to provide a measure of overall academic achievement. It was this overall mean that was used as a measure of overall academic achievement to investigate the correlation between academic achievement and cognitive, behavioral, and demographic factors.

In addressing the second primary research question (do the symptoms of ADHD continue to predict achievement after controlling for the influence of known risk factors for academic underachievement?), multiple regression analysis was performed. Cognitive, behavioural, and demographic variables that were significantly correlated with academic achievement were included in the regression analysis. Overall academic achievement, as measured by the mean of three WIAT-II subtest standard scores (Word Reading, Numerical Operations, Spelling), was used as the dependent variable. For the first step, the independent variables were demographic characteristics, followed by cognitive factors for the second step, the symptoms of ADHD for the third step, and number of comorbid diagnoses for the fourth and final step.

To investigate the third research question (which clinical group is most academically impaired?), a one-way between subjects ANOVA was performed with post hoc comparisons, using overall academic achievement (e.g., as measured by mean performance on three WIAT-II subtest standard scores) as the dependent variable of interest.

Secondary analyses.

To address the fourth research question (what are the cognitive strengths and weaknesses of the sample relative to a normative sample and to one another?), a one-sample t-test was performed with each clinical group (e.g., ADHD, ADHD + LD, LD and clinical comparison) to determine the extent to which groups differed from the standardized mean of the normative sample. In addition, one-way between subjects ANOVA were performed with post-hoc analyses to investigate which clinical-referred groups significantly differed on cognitive variables of interest. Considering each index of the WISC has been proposed to measure distinct areas of cognitive ability (Wechsler, 2003), a series of four separate one-way between subjects ANOVAs were performed for each WISC index.

To investigate the fifth research question (what are the behavioural strengths and weaknesses of the sample relative to one another?), a one-way between-subjects MANOVA was performed with post-hoc analysis to investigate which clinical-referred groups differed significantly on mean number of symptoms of inattention and hyperactivity/impulsivity endorsed on semi-structured interviews (PICS, TTI).

Finally, to examine the final research question (what are the academic strengths and weaknesses of the sample in relation to a normative sample?) a one-sample t-test was performed with each clinical-referred group to determine which groups differed significantly from the standardized mean of the normative sample.

Results

For each variable grouping of interest in the current study (e.g., demographic, cognitive, and behavioural factors), an overview of data for the total sample are presented first, and are then followed by data analyzed according to group membership (e.g., ADHD, LD, ADHD and comorbid LD, and clinical comparisons). When examining data according to group membership, groups were first examined relative to the normative sample for relevant measures (e.g., cognitive and academic variables), and were then examined according to group differences within the current sample.

Demographic Characteristics

Overall, the sample for the current study consisted of 288 children referred to the ADHD clinic for difficulty with attention, hyperactivity and/or impulsivity. Eleven participants were excluded due to missing standardized cognitive and achievement data. Therefore, the final sample of the current study consisted of 277 children (n= 193 male; n = 84 female) assessed through the ADHD Clinic. Refer to Table 1 for a comprehensive summary of demographic statistics for overall sample and Table 2 for means, standard deviations, and minimum and maximum scores by diagnostic group.

Of the total sample, 53% (n = 146) of the participants met DSM-IV criteria for Attention-Deficit/Hyperactivity Disorder (ADHD), which included the following subtypes: 25% (n = 36) met diagnostic criteria for ADHD Predominantly Inattentive Type, 8% (n = 12) were diagnosed with ADHD Predominantly Hyperactive-Impulsive Type, and 67% (n = 98) met criteria for

ADHD Combined Type.[3] Of the participants meeting diagnostic criteria for ADHD, 45% (n = 65) were also diagnosed with, or considered at risk for a comorbid learning disability (LD). In addition, 26% (n = 73) of the final sample met diagnostic criteria for an LD without comorbid ADHD. For children in the LD sample, over half (n = 50) of participants did not meet criteria for additional comorbid diagnoses, while approximately 32% (n = 23) of these children met criteria for at least one comorbid diagnosis other than ADHD. Moreover, 21% (n = 58) of participants met diagnostic criteria for mental health diagnoses other than ADHD and/or LD. Of participants meeting criteria for diagnoses other than ADHD and/or LD, 50% (n = 29) did not meet diagnostic criteria for any mental health disorder at the time of their assessment.

In terms of comorbid diagnoses, 56% (n = 155) of the total sample met diagnostic criteria for one DSM-IV mental health disorder, but did not meet criteria for additional comorbid mental health diagnoses (i.e., did not have any comorbid diagnoses). Approximately 33% (n = 92) of participants were diagnosed with one comorbid mental health disorder (i.e., in addition to their primary diagnosis), while 9% (n =24) met criteria for two comorbid diagnoses, and 2% (n = 6) met diagnostic criteria for three comorbid disorders.

Participant age ranged from 5 years, 11 months to 12 years, 8 months, with a mean age of 8.10 years (*SD* = 1.71). Participant grade level ranged from grade primary to grade eight, with the average participant enrolled in Grade Two at the time of assessment (*SD* = 1.74). On average, parents of participants reported a mean birth weight of 7 lb, 2 oz (*SD* = 1.35). According to

[3] In the current edition of the DSM (DSM-5; APA, 2013), Predominantly Inattentive, Predominantly Hyperactive-Impulsive, and Combined subtypes would be referred to as ‘presentations’.

parent report, 6% (n = 18) of participants were born at a low birth weight (e.g., 5 lb, 5 oz or less). Reportedly, participant birth weight ranged from 3 lbs, 4 oz to 11 lbs, 1 oz.

In terms of family structure, 45% (n = 124) of the sample lived with both biological parents, while 42% (n = 116) of participants lived in single parent families or in families in which biological parents had separated. Information about family structure was unavailable for the remaining 13% (n= 37) of participants. Participant socioeconomic status (SES) was calculated using Boyd-NP occupational scores that were generated based on the Canadian National Census (2001). The scores represent a composite of educational-level and occupational income scores, and range from 0 to 100 with lower scores representing lower SES (Boyd, 2008). In families in which both parents were employed, the highest Boyd-NP score was used as a measure of SES (Boyd, 2008). In the current sample, participant SES ranged from Boyd-NP scores of 9 to 100, with a mean score of 55.41 (*SD* = 22.73) suggesting the educational and income characteristics of our sample was relatively evenly distributed, and on average participants came from family's considered 'middle-SES'.

Further analyses were performed to determine whether groups differed significantly on any demographic variables of interest. For F-values, degrees of freedom, Wilks Lambda values, and p-values, refer to Table 3. Overall, a one-way between subjects multivariate analysis of variances (MANOVA) indicated there was a statistically significant difference in demographic factors based on group membership, F (9, 667) = 3.42, $p < .001$; *Wilk's* $\Lambda = .88$. In particular, groups significantly differed on age, F (3, 255) = 7.79, $p < .001$; and number of comorbid diagnoses, F (3, 255) = 31.16, $p < .001$, but did not significantly differ on SES, F (3, 255) = 1.03, $p = .38$, or birth weight, F (3, 255) = 2.22, $p = .09$.

Refer to Table 4 for post-hoc analysis comparison values for age. Post-hoc analysis using the Tukey HSD test indicated that participant age at the time of assessment significantly differed between participants with ADHD with and without comorbid LD (ADHD; *M* = 7.48 years, *SD* = 1.57 years; ADHD + LD; *M* = 7.83 years, *SD* = 1.54 years) and participants with LD (*M* =8.72 years, *SD* = 1.66 years), with participants with ADHD, on average, being seen for assessment at an earlier age than participants with LD. Participants with ADHD and participants with ADHD and comorbid LD did not significantly differ from one another. In addition, the average age for participants with LD did not significantly differ from clinical comparisons (*M* = 8.46 years, *SD* = 1.79 years) at the time of assessment. Furthermore, clinical comparison participants significantly differed (*p* = .03), from participants with ADHD on mean age at the time of assessment, but did not differ significantly from participants with ADHD and comorbid LD (*p* = .42).

Post-hoc analysis also indicated that participants with ADHD and comorbid LD significantly differed from all other groups (see Table 5) on the number of comorbid diagnoses they met criteria for, with participants with ADHD and comorbid LD (*M* = 1.27, *SD* = 0.08) having significantly more comorbid diagnoses than participants with ADHD (*M* = 0.31, *SD* = 0.07), LD (*M* = 0.48, *SD* = 0.08), and clinical comparison participants (*M* = 0.29, *SD* = 0.09). However, this finding was due to the confound that participants with ADHD meeting criteria for a comorbid LD were grouped together. In order to investigate this possibility, a one-way between subjects MANOVA was performed with children in the ADHD and comorbid LD group re-coded as having one comorbid diagnosis less (e.g., to account for having ADHD and LD). When accounting for ADHD and comorbid LD, groups no longer differed significantly on number of comorbid diagnoses, F (3, 255) = 1.54, p = .21, suggesting LD diagnosis did indeed account for the aforementioned finding.

Refer to Table 6 for Chi-Squared values. Chi-squared analysis was performed for categorical variables to determine whether groups differed significantly on sex or family structure (e.g., presence of single parent or parental separation). Chi-squared analyses indicated that groups did not significantly differ on sex, X^2 (3) = 5.40, *p* = .15, or family structure, X^2 = 10.40, *p* = .11.

Cognitive Ability

Refer to Table 7 for means, standard deviations, and minimum and maximum cognitive scores for participants by group. Overall, performance on the Full Scale IQ (FSIQ) index ranged from 64 to 127, with a mean composite score of 95.20 (*SD* = 12.56). In general, participants' performance on the Verbal Comprehension Index (VCI) ranged from standard scores of 63 to 138, with a mean standard score of 97.25 (*SD* = 13.28), while their performance on the Perceptual Reasoning Index (PRI) ranged from 56 to 136, with a mean standard score of 100.43 (*SD* = 13.91). Performance on the Working Memory Index (WMI) ranged from standard scores of 56 to 124 (*M* = 92.09, *SD* = 12.20), and performance on the Processing Speed Index ranged from scores of 56 to 128 (*M* = 92.04, *SD* = 13.13).

Further analyses were performed to determine whether groups differed significantly from the normative sample, or from one another on any cognitive variables of interest. Refer to Table 8 for t-values, degrees of freedom, and p-values for WISC indices scores by group. One-sample t-tests were performed for each WISC-IV index composite score to examine whether groups differed significantly from the mean of the normative sample (*M* = 100, *SD* = 15; Wechsler, 2003).

On the VCI, participants with ADHD, *t* (80) = -1.85, *p* = .07, ADHD and comorbid LD, *t* (64) = -1.87, *p* = .07, LD, *t* (72) = -1.21, *p* = .23, or clinical comparisons, *t* (57) = -1.93, *p* = .06, did not significantly differ from the mean of the normative sample. Findings for performance on the PRI yielded similar results, where participants with ADHD, *t* (80) = 0.30, *p* =.76, ADHD and comorbid LD, *t* (64) = 0.50, *p* = .62, LD, *t* (72) = 1.25, *p* = .22, or clinical comparisons, *t* (57) = .36, did not significantly differ from the mean of the normative sample.

However, performance on the WMI fell significantly below the mean of the normative sample (*M* = 100, *SD* = 15) for all groups including participants with ADHD, t (80) = -5.53, $p <$ .001, participants with ADHD and comorbid LD, t (64) = - 6.81, $p < .001$, participants with LD, t (72) = -5.68, $p < .001$, and clinical comparisons, t (57) = -3.93, $p < .001$. In addition, all groups fell significantly below the mean of the normative sample on the PSI: t (80) = -3.32, $p = .001$, ADHD and comorbid LD, t (64) = -7.66, $p < .001$, LD, t (72) = -7.14, $p <.001$, and clinical comparisons, t (57) = -3.26, $p = .002$, also.

Refer to Table 9 for individual F-values, degrees of freedom, and p-values for WISC indices by group. After controlling for age, separate one-way between subjects ANOVAs were performed for each WISC index score. The analyses indicated groups did not differ significantly on Verbal Comprehension Index (VCI), F (3, 272) = 0.30, $p = .83$, Perceptual Reasoning Index (PRI), F (3, 272) = 0.83, $p =.48$, Working Memory Index (WMI), F (3, 272) = 0.35, $p = .80$. However, groups did differ significantly on the Processing Speed Index (PSI), F (3, 272) = 2.97, $p = .03$.

Refer to Table 10 for post-hoc comparisons values for PSI. Post-hoc analysis using Tukey's HSD test indicated that in particular, children with ADHD (*M* = 94.84, *SD* = 13.96) performed significantly better on measures of processing speed than children with ADHD and comorbid LD (*M* = 88.97, *SD* = 11.60). On measures of processing speed, children with LD (*M* = 90.30, *SD* = 11.60) and clinical comparisons (*M* = 93.78, *SD* = 14.54) did not significantly differ from children with ADHD or from one another.

Visual Motor Integration

Refer to Table 11 for group means, standard deviations, and minimum and maximum visual-motor integration scores. For the total sample, performance on the VMI ranged from standard scores of 65 to 133. On the VMI, the sample mean was 93.12 (*SD* = 12.16).

Refer to Table 12 for t-values, degrees of freedom and p-values for VMI scores by group. To investigate whether groups differed significantly from the mean of the normative sample on the VMI ($M = 100$, $SD = 15$; Beery, 1999), one-sample t-tests were performed. The analysis indicated the performance of all groups on the VMI fell significantly below the mean of the normative sample. This included participants with ADHD, t (79) = -4.06, $p < .001$, ADHD and comorbid LD, t (63) = -5.94, $p < .001$, LD, t (72) = -5.63, $p < .001$, and clinical comparisons, t (55) = -3.36, $p = .001$.

A one-way between subjects analysis of variance (ANOVA) was performed to investigate whether groups differed significantly on visual-motor integration (VMI) scores (refer to Table 13). After controlling for age, there was no significant main effect of group membership on performance on the VMI, F (3, 272) = 0.66, $p = .58$, partial $\eta^2 = .01$.

Behavioural Symptoms of ADHD

Refer to Table 14 for group means, standard deviations, and minimum and maximum scores for the PICS and TTI measures of inattention and hyperactivity/ impulsivity. On the PICS and TTI, the mean number of symptoms of inattention endorsed ranged from 0 to 9 (M = 5.00 symptoms; SD = 2.37 symptoms), while the number of symptoms of hyperactivity/impulsivity endorsed also ranged from 0 to 9 symptoms ($M = 4.21$ symptoms, $SD = 2.58$ symptoms).

Refer to Table 15 for F-values, degrees of freedom, and p-values for symptoms of ADHD endorsed according to group. A one-way between subjects MANOVA was conducted to determine whether groups differed significantly on the core symptoms of ADHD. After controlling for age, a one-way between subjects MANOVA indicated there was a statistically significant difference in ratings of the core symptoms of ADHD based on group membership, F (6, 540) = 29.60, $p < .001$; *Wilk's* $\Lambda = .57$.

Participants differed significantly according to group membership on the mean number of symptoms of inattention endorsed (PICS, TTI), *F* (3, 271) = 48.59, *p* < .001. Refer to Table 16 for post-hoc comparison values for symptoms of inattention. Specifically, participants with ADHD (*M* = 6.26 symptoms, *SD* = 1.91 symptoms), as well as participants with ADHD and comorbid LD (*M* =6.36 symptoms, *SD* = 1.71 symptoms), were reported by parents and teachers to have significantly more symptoms of inattention (*p* < .001) than participants with LD (*M* = 3.27 symptoms, *SD* = 1.73 symptoms) and clinical comparisons (*M* = 3.85 symptoms, *SD* = 2.35 symptoms). Participants with ADHD and ADHD with comorbid LD did not differ significantly from one another (*p* = .99). Furthermore, clinical comparisons did not differ significantly from participants with LD (*p* = .32).

Groups also differed significantly on the mean number of symptoms of hyperactivity/impulsivity endorsed (PICS, TTI), *F* (3, 271) = 33.34, *p* < .001. Using the Tukey HSD test, post-hoc analysis indicated that all groups significantly differed from one another (see Table 17). In particular, participants in the ADHD group (*M* = 5.89 symptoms, *SD* = 2.15 symptoms) endorsed the most symptoms of hyperactivity/impulsivity, followed by participants in the ADHD + LD group (*M* = 4.95 symptoms, *SD* = 2.50 symptoms) and clinical comparisons (*M* = 3.62 symptoms, *SD* = 2.25 symptoms), respectively. The LD group had the least number of symptoms of hyperactivity/impulsivity endorsed (*M* = 2.14 symptoms, *SD* = 1.63 symptoms).

Academic Achievement

Refer to Table 18 for group means, standard deviations and minimum and maximum scores for overall academic achievement. For the total sample, scores for overall academic achievement, ranged from 62 to 127, with a sample mean of 92.44 (*SD* = 11.70).

On overall academic achievement, 10% (n = 8) of participants with ADHD were considered to be underachieving academically (e.g., academic performance one standard deviation or more below the mean on the composite achievement score). In addition, 32% (n = 21) of participants with ADHD and comorbid LD, 44% (n = 73) of participants with LD, and 20% (n = 10) of clinical controls were also considered to be academically underachieving according to measures of overall academic achievement.

Given that percentage of overall academic underachievement observed in the current study were lower than expected on the basis of previous literature, academic underachievement was further examined. In particular, groups were examined according to individual academic subtests to determine whether academic difficulties presented differently according to areas of academic skill. When examining individual areas of academic achievement, over half (n = 165) of participants were academically underachieving in one or more specific academic area. In particular, 41% (n = 33) of children with ADHD were underachieving in one or more academic areas, while 71% (n = 46) of children with ADHD and comorbid LD, 75% (n = 55) of children with LD, and 53% (n = 31) of clinical comparisons were underachieving in at least one academic area.

In order to examine whether clinical groups differed significantly from a normative sample, separate one-sample t-tests were conducted using overall academic achievement as the dependent variable (see Table 19). The academic performance of participants with ADHD, t (80) = -2.27, p = .03, ADHD with comorbid LD, t (64) = -8.61, p < .001, LD, t (72) = -9.96, p < .001, and clinical comparisons, t (57) = -2.80, p = .01, fell significantly below the mean of the normative sample (M = 100, SD = 15; Wechsler, 2002).

To investigate whether groups differed significantly from one another on overall academic achievement, a one-way between subjects ANOVA was conducted with age as a covariate. Refer to Table 20 for one-way between subjects ANOVA F-values, degrees of freedom, and p-values for academic achievement. The analysis indicated that participants differed significantly on overall academic achievement according to group membership, F (3, 272) = 11.55, $p < .001$.

Post-hoc analysis was performed using the Tukey HSD test, to determine which group was most academically impaired (see Table 21). The analysis indicated that on average, ADHD and comorbid LD (*M* = 88.50, *SD* = 10.76), as well as participants with LD (*M* = 88.19, *SD* = 10.13), scored significantly lower on overall academic achievement than participants with ADHD (*M* = 97.22, *SD* = 11.05) and clinical comparisons (*M* = 95.51, *SD* = 12.20). Interestingly, participants with ADHD did not differ significantly from clinical comparisons on overall achievement ($p = .80$). Likewise, participants with ADHD and comorbid LD, and participants with LD, also did not significantly differ from one another ($p = .99$).

To determine the relationship between demographic variables and overall academic achievement (e.g., mean performance on three WIAT-II subtests), Pearson's correlations were performed (refer to Table 22). Interestingly, few demographic variables were significantly correlated with overall academic achievement. Both age, r (275) = -.20, $p = .001$, and number of comorbid diagnoses, r (275) = -. 18, $p = .003$, demonstrated significant negative correlations with achievement. However, when Pearson's correlations were performed with children with ADHD and comorbid LD recoded, the association between number of comorbid diagnoses and overall achievement was no longer significant, r (277) = - .07, $p = .28$. Furthermore, sex, r (275) = .02, $p = .75$, SES, r (265) = .04, $p = .57$, birth weight, r (266) = .01, $p = .89$, and family structure, $r = .03$, $p = .67$, were not significantly correlated with academic achievement.

Refer to Table 23 for Pearson's correlations for WISC indices and achievement. Pearson's correlations were performed to investigate which WISC index scores were significantly related to academic achievement. All index standard scores demonstrated a significant positive correlation with academic achievement including FSIQ, r (275) = .56, p <

.001, VCI, r (275) = .51, p < .001, PRI, r (275) = .37, p < .001, WMI, r (275) = .44, p < .001, and PSI, r (275) = .37, p < .001.

Refer to Table 24 for Pearson's correlation for VMI scores and academic achievement. The relationship between visual-motor integration and academic achievement was examined using Pearson's correlations. Performance on a measure of visual-motor integration demonstrated a small, positive correlation with overall academic achievement, r (277) = .35, p < .001.

Refer to Table 25 for Pearson's correlations for behavioural symptoms of ADHD and achievement. To investigate whether the core symptoms of ADHD were associated with academic achievement, Pearson's correlations were performed with mean number of symptoms of inattention and hyperactivity/impulsivity endorsed (PICS, TTI). The symptoms of inattention demonstrated a negative correlation with achievement, r (274) = -.12, p = .05. However, the mean number of symptoms of hyperactivity/impulsivity, r (274) = .09, p = .13, were not significantly correlated with overall achievement.

To investigate whether particular demographic, cognitive, and behavioural factors predicted overall academic achievement hierarchical regression analysis was performed. Refer to Table 26 for the results of the multiple regression analysis for mean overall achievement on the WIAT-II subtests of Word Reading, Numerical Operations, Spelling. Variables that were not significantly correlated with the dependent variable (e.g., mean academic achievement) were not included in the regression analysis. The final model included age for the independent variable for the first step, the four indices of the WISC (VCI, PRI, WMI, PSI) and visual-motor integration for the second step, symptoms of inattention for the third step, and number of comorbid diagnoses for the fourth and final step. Mean achievement scores were used as the dependent variable of interest.

For the first step of the hierarchical regression analysis, age accounted for a significant amount of variance in achievement, R^2 =.04, F (1, 270) = 11.44, p = .001, and significantly predicted mean academic achievement scores, β = -.20, t (270) = -3.38, p = .001.

For the second step of the model, after controlling for the influence of age, thinking and reasoning abilities and underlying cognitive processes were also found to predict a significant amount of variance in achievement, R^2 = .41, F (6, 265) = 31.11, p < .001. In particular, verbal comprehension (VCI), β = .33, t (265) = 5.44, p < .001, working memory (WMI), β = .26, t (265) = 4.68, p < .001, processing speed (PSI), β = .11, t (265) = 1.97, p = .05, and visual-motor integration (VMI), β = .18, t (265) = 3.07, p = .002, significantly predicted mean achievement scores on the WIAT-II. However, perceptual reasoning (PRI) did not, β = -.04, t (265) = -0.63, p = .53.

Although the third step of the regression analysis contributed to a significant proportion of variance in academic achievement, R^2 = .41, F (6, 264) = 26.57, p < .001, the mean number of symptoms of inattention endorsed by parents and teachers did not significantly predict achievement above other variables entered in the model, β = 0.01, t (264) = 0.19, p = .85

Finally, for the fourth and final step, number of comorbid diagnoses significantly predicted academic achievement, β = -.16, t (263) = -3.28, p =.001, with increasing comorbidity predicting lower overall achievement. Overall, the full model accounted for a significant amount of variance in overall academic achievement, R^2 = .43, F (7, 263) = 25.45, p < .001. However, it is important to note that when controlling for the number of comorbid diagnoses in the ADHD and comorbid LD group, number of comorbid diagnoses did not significantly predict achievement, β = -.06, t (263) = -1.24, p = .22, suggesting the diagnosis of comorbid LD was responsible for the relationship between number of comorbid diagnoses and achievement, rather than comorbidity in general.

Discussion

Overall, the general goal of the current study was to further examine the relationship between ADHD and achievement, and to contribute to the substantial area of literature examining this relationship. In order to accomplish the overall goal of the study, a number of specific objectives were proposed for the present study. Specifically, the objectives of the current study were to (1) examine which demographic, behavioral, and cognitive factors were significantly associated with academic achievement in a rigorously diagnosed clinical sample, (2) to determine whether the behavioral symptoms of Attention-Deficit/Hyperactivity Disorder (ADHD) continue to predict academic performance after controlling for known risk factors associated with academic underachievement, and (3) to determine which clinical-referred group was most academically impaired. Based on information collected from semi-structured interviews, and standardized measures of cognitive ability and achievement, a number of factors were found to be significantly correlated with academic achievement. In particular, age, verbal comprehension, working memory, processing speed, visual motor integration and number of comorbid diagnoses (specifically comorbid LD) predicted overall academic achievement. Interestingly, the symptoms of ADHD were not found to significantly predict achievement when considering known risk factors. Moreover, participants with a diagnosis of a learning disability, regardless of comorbid diagnoses (including ADHD), were found to be most academically impaired, while children with ADHD and no LD and clinical-referred comparisons without ADHD or LD were found to be least academically impaired.

Demographic Characteristics

Overall, approximately 53% of the sample met diagnostic criteria for ADHD. In terms of subtype and sex, the composition of the ADHD group for the current study was consistent with prevalence estimates and with samples in previous literature examining similar research questions (Barkley, 2006; Barnard-Brak, Sulak & Fearon, 2010; McConaughy, Volpe, Antshel, Gordon & Eraldi, 2011; Langber, et al., 2011). Approximately 45% of participants diagnosed with ADHD were also diagnosed with, or were considered at risk for a comorbid learning disability (LD). Although this proportion was slightly higher than those reported in some studies (Barnard-Brak et al., 2010; Corkum, McGonnell & Schachar, 2010; McConaughy et al., 2011), it was significantly lower than those reported in others (Mayes, Calhoun & Crowell, 2000; Mayes & Calhoun 2007a).

On average, participants differed significantly on age at the time of assessment, with participants with ADHD, with or without comorbid LD, being assessed significantly earlier than participants with LD or other mental health diagnoses. However, with regard to current diagnostic practices, ADHD is a behaviourally defined disorder (DSM-5; APA, 2013), whereas learning disabilities are often diagnosed on the basis of characteristics that are not as easily observable (e.g., cognitive processing deficits and academic impairment). Therefore, the characteristics considered typical of children with ADHD are more easily observable than those of other mental health diagnoses at an early age (Turgay et al., 2012), making the early identification of difficulties with attention and/or hyperactivity more likely than the early identification of difficulties with other areas, such as learning. This is an important consideration for school psychologists and educational professionals when attempting to identify children in need of academic support, and highlights the importance of psychoeducation surrounding the early markers of learning disability, as well as the importance of early identification and assessment efforts.

Overall, the sample differed significantly on the number of comorbid diagnoses according to diagnostic group membership, with participants with ADHD and comorbid LD having significantly more comorbid disorders than participants with ADHD, LD, and clinical comparisons. However, this finding is not surprising given that group membership for the ADHD and comorbid LD sample was contingent upon the presence of at least one comorbid diagnosis. In fact, when data were re-analyzed without including comorbid LD (in the ADHD and comorbid LD group), groups no longer differed significantly from one another on number of comorbid diagnoses. This suggests the finding was indeed attributable to the presence of comorbid LD. Aside from age and number of comorbid diagnoses, participants did not differ significantly on any other demographic variables of interest, including socioeconomic status (SES), family structure, or birth weight.

Cognitive Ability

Considering past research findings, the current study hypothesized that children with ADHD, children with LD, and children with ADHD and comorbid LD would demonstrate deficits in cognitive abilities relative to clinical comparisons (Mayes, Calhoun, & Crowell, 2000; Mayes & Calhoun, 2007b; Willcutt et al., 2005). With the exception of processing speed, the groups in the current study did not significantly differ from one another on any measure of cognitive ability. In terms of clinical comparisons, the current study employed the use of a heterogeneous group that included children with a number of mental health diagnoses (e.g., anxiety, depression, ODD, autism spectrum, enuresis, etc.), as well as children who did not meet criteria for a mental health diagnosis. Similar studies that have observed group differences between clinical comparisons and children with ADHD, and children with LD, have typically limited clinical comparison participants to those with particular mental health disorders, or have used only clinic-referred children without mental health diagnoses (Mayes et al., 2000; Mayes &

Calhoun, 2007b; McConnaughy et al., 2011). Few studies have used both. Considering that in contrast to past research (Mayes & Calhoun, 2007b; McConnaughy et al., 2011), the clinical comparison group in the current study did demonstrate cognitive deficits (e.g., working memory, processing speed, and visual-motor integration) relative to a typically developing normative sample (Beery, 1997; Wechsler, 2003), the inclusion of children with and without mental health diagnoses may have impacted the results of the present study.

Children with ADHD and comorbid LD were also expected to demonstrate significant deficits on measures of cognitive processes (e.g., working memory, processing speed, visual-motor integration). However, children with ADHD and children with LD were not expected to differ significantly from one another. On measures of processing speed children with ADHD and comorbid LD demonstrated significant deficits in processing speed relative to children with ADHD; however, neither group differed significantly from participants with LD or clinical comparisons. In addition, children with LD and clinical comparisons did not differ significantly from one another. This finding is partially consistent with previous literature that indicates children with both ADHD and comorbid LD demonstrate significant deficits in working memory and processing speed relative to their ADHD and their LD peers (Willcutt, Pennington, Olson, Chhabildas, & Hulslander, 2005). In the current study, the performance of clinical groups on measures of processing speed was consistent with previous literature; however, the performance of clinical groups on measures of working memory was not.

Although participants in the current study did not differ significantly from one another on most cognitive variable of interest (e.g., verbal comprehension, perceptual reasoning, working memory, or visual-motor integration), they did perform significantly below the mean of the normative sample on measures of underlying cognitive processes (e.g., working memory, processing speed and visual-motor integration). As anticipated, this finding was in line with previous research (Martinussen, Hayden, Hogg-Johnson & Tannock, 2005; Mayes et al., 2000; Mayes & Calhoun, 2007a; 2007b), general reviews (Diamantoupoulus et al., 2007) and meta-analyses (Frazier, et al., 2007) that find on average, children with ADHD perform below their TD peers on measures of underlying cognitive processes relative to measures of overall thinking and reasoning abilities. However, the finding that clinical comparison participants demonstrated some degree of cognitive deficit relative to the normative sample was unexpected, and is in contrast to previous literature (Mayes & Calhoun, 2007b). Furthermore, none of the clinical-referred groups differed significantly from the normative mean on measures of verbal comprehension or perceptual reasoning. However, this finding was consistent with the majority of previous research studies (Mayes, Calhoun, & Crowell, 2000; Mayes & Calhoun, 2007b; McConnaughy et al., 2011).

Behavioural Symptoms of ADHD

Overall, groups differed significantly from one another on mean number of symptoms of inattention endorsed on semi-structured clinical interviews (PICS, TTI). Participants with ADHD, with or without comorbid LD, differed significantly from participants with LD, and from clinical comparison participants, but did not differ significantly from one another. Numerous studies have demonstrated similar findings (Mayes et al., 2000; Parker in press.; Willcutt et al., 2001), with children with ADHD demonstrating more difficulty with inattention than children with LD and children with other mental health diagnoses. However, on the basis of previous research findings (Mayes et al., 2000), participants with ADHD and comorbid LD were anticipated to demonstrate more severe attentional difficulties than children with ADHD alone. The findings of the current study did not support this prediction.

All clinical-referred groups were differentiated from one another based on the mean number of symptoms of hyperactivity/impulsivity endorsed by parents and teachers on clinical interviews (e.g., PICS, TTI). Children with ADHD received the highest level of endorsement of hyperactivity and/or impulsivity symptoms across settings, followed by children with ADHD and comorbid LD, and clinical comparisons respectively. Children with LD were rated as having the least difficulty with hyperactivity/impulsivity. Limited research has examined group differences in children with ADHD, LD, ADHD and comorbid LD, and clinical comparisons (Parker et al., in press); however, this finding is convergent with the diagnostic criteria for ADHD (DSM-5; APA, 2013).

Academic Achievement

In terms of overall academic achievement, the proportion of children considered to be underachieving was lower than expected based on past literature. When examining individual academic skill areas, over half (n = 165) of children referred to the ADHD Clinic were considered academically underachieving in one or more academic area (e.g., academic achievement one standard deviation or more below the mean on at least one subtest; Wechsler, 2002). In particular, 41% (n = 33) of children with ADHD were underachieving in one or more academic areas, while 71% (n = 46) of children with ADHD and comorbid LD, 75% (n = 55) of children with LD, and 53% (n = 31) of clinical comparisons were currently underachieving in at least one academic area. The finding that over half of the clinical-referred sample, and just over one third of children with ADHD without comorbid LD were considered academically underachieving in one or more academic areas was generally consistent with previous literature (Barkley, 2006; Corkum et al., 2010; McConnaughy et al., 2011).

In comparison to the normative sample (Wechsler, 2002), the overall academic achievement of the total sample fell significantly below the mean of the general population. This finding is supported by the results of previous research studies that suggest clinical-referred children with ADHD, LD, or with both, demonstrate significant academic impairments relative to their typically developing (TD) peers (Mayes et al., 2000; Mayes & Calhoun, 2007a; 2007b; McConaughy et al., 2011; Preston et al., 2009). However, it is interesting to note that on average, children with ADHD without comorbid LD performed three standard points below the mean of the normative sample. Although statistically significant, it is important to consider this particular outcome in terms of clinical significance. In particular, this finding suggests that on overall, basic academic skill acquisition, children with ADHD without comorbid LD are not as significantly impaired relative to their same-age peers with a diagnosis of LD.

Demographic characteristics and academic achievement.

In contrast to research literature in the general population, few demographic variables of interest in the current study were correlated with academic achievement, including socioeconomic status (SES), birth weight and family structure. This finding was not consistent with literature examining demographic risk factors for academic achievement in the general population (D'Angiulli, Seigel & Hertzman, 2004; Sirin, 2005; Heard, 2007; Taylor, 2010). However, the results of the current study suggest that variables known to predict achievement in the general literature may not consistently demonstrate similar relationships in clinical-referred samples.

Nonetheless, the current study did find a significant correlation between age, number of comorbid diagnoses, and measures of overall achievement. However, as previously noted, these relationships may be confounded by secondary findings in the current study. For example, although age was found to be significantly correlated with achievement, children with LD were also found to be significantly older (e.g., approximately a year on average) than participants with ADHD at the time of assessment. Likewise, while number of comorbid diagnoses was found to demonstrate a significant negative correlation with academic achievement, participants with ADHD and comorbid LD were also found to demonstrate significantly more comorbid diagnoses than other clinical groups on the basis of group membership. However, when controlling for comorbid LD, the relationship between number of comorbid diagnoses and overall achievement was no longer significant. In particular, this highly suggests that the relationship between comorbidity and achievement was better accounted for by comorbid LD diagnosis, and should be interpreted with caution.

Cognitive ability and academic achievement.

On all measures of cognitive ability, including verbal comprehension, perceptual reasoning, working memory, processing speed, and visual-motor integration, a significant positive correlation was observed with academic achievement. Overall, these findings are supported by an abundance of empirical literature demonstrating a significant relationship between cognitive ability, as well as underlying cognitive processes, and academic performance (Corkum et al., 2010; Mayes et al., 2000; Mayes & Calhoun, 2007b; Sattler, 2001; Watkins & Lei, 2007; Wechsler, 2003). Interestingly, the correlations observed in the current study, were not as high as those reported in the typically developing linking sample of the WISC-IV and WIAT-II (Wechsler, 2003), suggesting that for clinical samples, factors in addition to cognitive ability are related to academic achievement. This finding is also consistent with previous studies examining similar research questions, and using similar standardized measures, with clinical samples of children with ADHD and/or LD (Mayes & Calhoun, 2007a).

Behavioural symptoms of ADHD and academic achievement.

Given previous research literature (Deshazo-Barry, Lyman, & Klinger, 2002; Duncan et al., 2007), and reviews (Daley and Birchwood, 2010; Diamantopoulou, Rydell, Thorell & Bohlin, 2007), it was anticipated that symptoms of ADHD, specifically symptoms of inattention, would be significantly correlated with measures of overall academic achievement. Consistent with this hypothesis, the mean number of symptoms of inattention endorsed by parents and teachers demonstrated a significant negative correlation with academic achievement. However, symptoms of hyperactivity/impulsivity did not demonstrate a significant relationship with achievement. This is also consistent with previous literature, as a number of studies examining the symptoms of ADHD and achievement do not find significant associations between symptoms of hyperactivity/impulsivity and academic performance (Breslau et al., 2010; Duncan et al., 2007).

Predictors of overall academic achievement.

Without considering other known predictors of achievement, age was found to account for a small proportion of variance in academic achievement (e.g., approximately 4%). This finding was likely attributable to the significant difference between children with ADHD and children with LD on age at the time of assessment. Consistent with previous research literature, cognitive abilities including verbal comprehension, working memory, processing speed, and visual-motor integration significantly predicted academic achievement (Watkins & Lei, 2007). Approximately 37 % of the variance observed in overall academic performance was accounted for by cognitive abilities measured by the WISC (Wechsler, 1991; Wechsler, 2002) and VMI (Beery, 1997).

Based on previous research, symptoms of ADHD, specifically symptoms of inattention, were anticipated to predict achievement in addition to known risk factors for academic difficulties. However, although inattention demonstrated a negative correlation with overall academic performance, after controlling for known risk factors (e.g., cognitive and demographic factors), the symptoms of inattention did not predict academic achievement in clinical-referred children. In particular, the symptoms of inattention did not contribute additional predictive ability to the overall model over and above cognitive or demographic variables. Although inconsistent with predictions of the current study, this finding is supported by more recent research literature. For instance, studies examining the impact of methylphenidate (MPH; e.g., medication taken to alleviate the symptoms of ADHD, including inattention) on academic achievement in children with ADHD lend additional support to the results of the currents study. While studies examining the impact of MPH on academic performance often find increased academic productivity, such studies do not consistently find corresponding academic gains on standardized measures of achievement in children with ADHD (Corkum et al., 2010). If the symptoms of inattention were to predict academic achievement, it should follow that treatment with MPH would result in academic improvement; however, this finding is not consistently observed in the literature.

Nonetheless, the results of the current study may be due in part to the measure of attention employed. For instance, a recent study conducted by Preston and colleagues (2009) examined the relationship between cognitive ability on the WISC-IV, parent-reported attention, attentional networks on an objective measure of attention, and academic achievement (WIAT-II). Similar to the current study, Preston and colleagues (2009) demonstrated that although parent-reported attention did not account for a significant amount of variance in performance on the WIAT-II, objective measures of attentional control/switching consistently predicted achievement across academic areas. In particular, attentional control/switching has been proposed to involve components of executive functions (Preston et al., 2009).

Finally, when controlling for demographic and cognitive risk factors, number of comorbid diagnoses also predicted academic achievement in clinical-referred children. However, number of comorbid diagnoses did not contribute substantially to the predictive ability of the overall model, contributing an additional two percent (e.g., from 41% to 43%). Furthermore, when comorbid LD diagnosis was controlled for (e.g., presence of two disorders for all participants in ADHD and comorbid LD group), the predictive relationship between comorbidity and academic achievement was no longer significant. This finding suggests that in particular, the diagnosis of LD was a significant predictor of academic achievement, and as such, confers significant risk for academic underachievement in clinical-referred children. In fact, this hypothesis was further supported when examining which clinical-referred group was most academically impaired.

Group membership and academic achievement.

Overall, the current study anticipated participants would differ significantly on academic achievement according to group membership. Based on previous findings, children with ADHD and comorbid LD were expected to be most academically impaired (Barnard-Brak et al., 2010; Mayes et al., 2000; Willcutt et al., 2001). As expected, children with ADHD and comorbid LD were found to be most academically impaired relative to participants with ADHD and clinical comparisons; however, they were not found to significantly differ in academic impairment from children with LD. In addition, previous studies examining similar research questions, have suggested that despite controlling for comorbid LD's, children with ADHD continue to perform below clinical-referred participants without ADHD academically (Mayes et al., 2000; McConaughy et al., 2011; Rogers, Heungsun, Toplack, Weiss & Tannock, 2011). However, this prediction was not supported in the present study. When controlling for comorbid LD, participants with ADHD did not differ significantly from clinical comparisons on measures of overall academic achievement.

Taken together, these findings suggest that regardless of comorbid diagnoses (including ADHD), children diagnosed with LD are most at risk for academic underachievement. This is not surprising given academic underachievement is a prerequisite criteria for the diagnosis of LD (DSM-5; APA, 2013). In addition, current literature has often described children with LD as a group characterized by relative deficits in areas shown to be predictive of achievement in the current study (e.g., working memory, processing speed, visual-motor integration; Hale et al., 2010; Mayes & Calhoun, 2007a; 2007b; Willcutt et al., 2001).

Strengths and Limitations

When interpreting the results of the current study, a number of strengths and limitations should be considered. In general, the present study examined a large, rigorously diagnosed, medication-naïve clinical-referred sample of children, including children with ADHD, children with LD, and clinical comparisons. In addition, the present study employed the use of standardized measures of cognitive ability and academic achievement that are commonly used in the school setting, and are easily interpretable by school psychologists. Moreover, the results of the current study hold important real-life implications, which may contribute to the early identification and provision of early academic programming and intervention for students at risk of academic underachievement.

However, a number of limitations of the current study were also identified. Although the clinical comparison sample size of the current study was comparable to those of similar research studies, a more homogenous clinical comparison group would have allowed for more in-depth examination of the performance of children with ADHD relative to specific mental health disorders other than LD. In particular, the clinical comparison group in the current study included a heterogeneous sample of mental health diagnoses, as well as clinical-referred children who did not meet criteria for a mental health disorder at the time of assessment. A larger sample size may have provided the opportunity to examine those who met criteria for particular disorders (e.g., mood, anxiety, behaviour, autism spectrum) in comparison to children with ADHD and/or LD more thoroughly.

Moreover, the participants examined in the present study were relatively young at time of assessment. On average, participants were currently enrolled in grade two (e.g., overall mean of 8 years of age). Although it is promising to see that the majority of children were referred at an early stage in their academic development, the results of the current study are difficult to generalize to achievement in children in later stages of academic development. In particular, younger children are required to answer fewer items correctly than older children, in order to score within the average range on measures of academic achievement. It is possible the participants in the current study may have demonstrated more pronounced academic impairment, had the sample been older on average.

Finally, although the present study examined commonly used academic subtests of standardized measures of achievement that are commonly used within similar research studies (e.g., subtests of word reading, numerical operations and spelling; Corkum et al., 2010; McConnaughy et al., 2011; Preston et al., 2009), due to missing subtest data, only subtests that represent basic academic skill acquisition were examined. As such, the results of the current study are difficult to generalize to performance in academic areas that require the application of basic academic skills (e.g., reading comprehension, written expression, math problem-solving), each of which require greater attentional demands. Practically speaking, although the acquisition of basic academic skills is of utmost importance, it does not fully account for the academic skills necessary to succeed academically in a school or classroom setting.

Future Research Studies

Although the core symptoms of ADHD did not significantly predict overall academic achievement above other risk factors, a large proportion of research studies continue to find that a significant association between ADHD and academic underachievement. Therefore, future research could examine whether other possible factors predict academic achievement in clinical and community samples of children with ADHD. This could include investigating whether factors, such as executive functions, objective measures of attention (e.g., using measures such as the Continuous Performance Task), or instructional and/or educational factors other than those examined in the current study, account for the relationship between ADHD and achievement more thoroughly. Increased knowledge of specific predictors of academic underachievement may potentially result in earlier identification of and intervention for academic difficulties.

Based on findings from this study, and those of previous research studies, a number of different questions can be formulated. For example, reported difficulty with inattention was not found to predict academic achievement; however, research findings by a recent research study suggest that objective measures of attention might predict academic performance in children with ADHD (Preston et al., 2009). Therefore, it would be interesting to examine whether attentional networks (e.g., sustained attention, orienting, attentional control/switching) predict academic achievement differently than behavioural reports of attention.

In addition, while the current study found that children with ADHD were less impaired academically relative to their same-age peers with LD, it would be interesting to investigate whether this relationship is maintained when examining subject areas that require the application of basic academic skills. For example, in comparison to academic subtests of word reading, would participants with ADHD be more academically impaired on measures of reading comprehension or written expression? Furthermore, future research studies could examine whether the potential association between ADHD and basic versus applied academic skills is manifested differently in early elementary relative to middle- or high-school.

Clinical Implications

Overall, the results of the current study hold important real-life implications for school psychologists working with students with ADHD, and other mental health disorders. Regardless of comorbidity, children diagnosed with or considered at risk for LD were found to be most academically impaired relative to children with ADHD and clinical comparisons. Although children with ADHD are often found to be underachieving, rather than supporting the hypothesis that the diagnosis of ADHD itself confers risk for academic underachievement, findings in the current study suggest the diagnosis of LD is of most importance when predicting risk for academic difficulty. In particular, this finding highlights the importance of the early assessment and identification of LD. Moreover, considering children with ADHD and comorbid LD demonstrated similar academic impairments to children with LD, the results of the current study point to the importance of investigating the possibility of comorbid LD when assessing for ADHD. It is imperative that school psychologists emphasize the importance of early identification of LD, given that as children with LD continue through school without intervention, the gaps between their TD peers and children with LD widen subtstantially. For instance, previous literature has suggested that over 75% of children that struggle with reading, whose difficulties have not been identified or remediated by grade three or later, will continue to exhibit substantial academic difficulties throughout their academic careers (Lovett, Lacerenza, Borden, Frijters, Steinbach & DePalma, 2000).

In addition, in the current study, the core symptoms of ADHD did not predict academic achievement beyond other cognitive and demographic risk factors. Therefore, although there appears to be a relationship between ADHD and academic performance, the results of the present study highlight the importance and contribution of factors other than the core symptoms of ADHD to academic achievement. This specific finding holds key implications for school psychologists, particularly in regard to psychoeducation surrounding the achievement of children diagnosed with ADHD. Although the recommendation of MPH treatment may result in a decrease in disruptive classroom behaviour, and increased academic productivity, it is crucial for parents and teachers to understand that MPH does not replace the need for evidence-based academic support and intervention in the relevant areas of academic difficulty.

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Table 1
Demographic Statistics for the Total Sample

Sex	N	%
Female	84	30
Male	193	70
Diagnosis		
ADHD	81	29
ADHD and Comorbid LD	65	24
LD	73	26
Clinical Comparisons	58	21
ADHD Subtypes		
Predominantly Inattentive Type	36	13
Predominantly Hyperactive-Impulsive Type	12	4
Combined Type	98	67
Family Structure		
Presence of Single Parent or Parental Separation	116	42
Lives with Both Biological Parents	124	45
No Information Provided	37	13
Mental Health Diagnosis		
ADHD and/or LD	219	79
Diagnosis Other Than ADHD or LD	29	10.5
No Mental Health Diagnosis	29	10.5
Number of Comorbid Diagnoses		
None	156	56
One Comorbid Diagnosis	91	33
Two Comorbid Diagnoses	24	9
Three Comorbid Diagnoses	6	2

Table 2

Means, Standard Deviations and Minimum and Maximum for Demographic Factors by Group

Diagnostic Group	Demographic Variable	*Mean*	*SD*	Minimum Score	Maximum Score
ADHD (n = 81)	Age	7.48	1.57	6.01	12.06
	Grade	1.95	1.48	0.00	7.00
	SES	56.28	22.38	9.00	95.00
	Birth Weight	6.82	1.41	3.04	10.06
	Number of Comorbid Dx	0.33	0.52	0.00	2.00
ADHD + LD (n = 65)	Age	7.83	1.54	6.03	12.03
	Grade	2.44	1.47	1.00	7.00
	SES	59.19	21.14	18.00	91.00
	Birth Weight	7.27	1.26	3.14	11.01
	Number of Comorbid Dx	1.26	0.51	1.00	3.00
LD (n = 73)	Age	8.72	1.66	5.11	12.07
	Grade	3.29	1.84	0.00	8.00
	SES	53.11	23.13	16.00	99.00
	Birth Weight	7.36	1.20	4.09	10.03
	Number of Comorbid Dx	0.47	0.78	0.00	3.00
Clinical Comparison (n = 58)	Age	8.46	1.79	6.00	12.06
	Grade	3.05	1.87	0.00	7.00
	SES	52.56	24.48	9.00	100.00
	Birth Weight	7.34	1.50	4.06	10.08
	Number of Comorbid Dx	0.26	0.69	0.00	3.00

Note. Age measured in years. Grade measured in numeric grade level (Primary = 0). SES = Socioeconomic status; measured using Boyd NP score (Boyd, 2008). Birth weight measured in pounds and ounces.

Table 3

Between Subjects MANOVA F-Values, Degrees of Freedom, and p-Values for Demographic Variables

Dependent Variables	*F*	df	Significance
Age	7.79	(3, 255)	.000
Number of Comorbid Diagnoses	29.67	(3, 255)	.000
Socioeconomic Status	1.03	(3, 255)	.38
Birth Weight	2.22	(3, 255)	.09

Note. Age presented in years. Socioeconomic status based on Boyd NP scores (Boyd, 2008). Birth weight presented in pounds and ounces.

Table 4

Tukey's HSD Comparison for Age

(I) Group	(J) Group	Mean Diff (I-J)	Standard Error	*p*-value
ADHD	ADHD + LD	- 0.35	.28	.61
	LD	- 1.25 *	.27	.000
	Clinical Comparisons	- 0.82*	.30	.03
ADHD + LD	ADHD	0.35	.28	.61
	LD	- 0.90 *	.29	.01
	Clinical Comparison	- 0.48	.31	.42
LD	ADHD	1.25*	.27	.000
	ADHD + LD	0.90*	.29	.01
	Clinical Comparisons	0.43	.30	.50
Clinical Comparisons	ADHD	0.82*	.30	.03
	ADHD + LD	0.48	.31	.42
	LD	-0.43	.30	.50

Note. Age measured in years and months.

Table 5

Tukey's HSD Comparison for Number of Comorbid Diagnoses

(I) Group	(J) Group	Mean Diff (I-J)	Standard Error	*p*-value
ADHD	ADHD + LD	- 0.95*	0.11	.000
	LD	- 0.17	0.11	.41
	Clinical Comparisons	0.02	0.11	.99
ADHD + LD	ADHD	0.95*	0.11	.000
	LD	0.78*	0.11	.000
	Clinical Comparison	0.96*	0.12	.000
LD	ADHD	0.17	0.11	.41
	ADHD + LD	-0.78*	0.11	.000
	Clinical Comparisons	0.18	0.12	.41
Clinical Comparisons	ADHD	-0.02	0.12	.99
	ADHD + LD	-0.96*	0.12	.000
	LD	-0.18	0.12	.41

Note. Number of comorbid diagnoses based on number of diagnoses met in addition to primary diagnosis. In ADHD and comorbid LD group, number of comorbid diagnosis is number of diagnosis met in addition to ADHD and LD.

Table 6

Chi-Squared Values for Demographic Variables

Demographic Variable	ADHD	ADHD + LD	LD	Clinical Controls	X^2	*p*-value
Sex						
Male	59 (73%)	50 (77%)	50 (69%)	34 (59%)	5.40	.15
Female	22 (27%)	15 (23%)	23 (31%)	24 (41%)		
Family Structure						
Yes	37 (46%)	25 (38%)	30 (41%)	30 (45%)	10.40	.11
No	36 (44%)	35 (54%)	33 (45%)	33 (41%)		
No Information	8 (10%)	5 (8%)	10 (14%)	10 (24%)		

Note. Family structure represents presence of single parent and/or parental separation.

Table 7

Means, Standard Deviations, and Minimum and Maximum Scores for WISC Indices Scores by Group

Diagnostic Group	WISC-IV Index	*Mean*	*SD*	Minimum Score	Maximum Score
ADHD	VCI	97.32	13.01	63.00	130.00
	PRI	100.47	14.01	70.00	130.00
	WMI	92.07	12.89	65.00	121.00
	PSI	94.84	13.96	59.00	126.00
	FSIQ	96.36	13.68	64.00	127.00
ADHD + LD	VCI	97.18	12.14	71.00	134.00
	PRI	100.80	12.90	73.00	126.00
	WMI	90.54	11.21	65.00	124.00
	PSI	88.97	11.60	68.00	128.00
	FSIQ	94.31	10.78	73.00	122.00
LD	VCI	98.16	12.94	65.00	130.00
	PRI	101.92	13.12	72.00	136.00
	WMI	93.10	10.39	68.00	121.00
	PSI	90.30	11.60	68.00	121.00
	FSIQ	95.41	10.97	66.00	124.00
Clinical Comparison (CC)	VCI	96.09	15.41	71.00	138.00
	PRI	98.10	15.74	56.00	126.00
	WMI	92.60	14.33	56.00	124.00
	PSI	93.78	14.54	56.00	126.00
	FSIQ	94.31	14.57	66.00	124.00

Note. WISC = Wechsler Intelligence Scale for Children (Third Edition - WISC-III; Fourth Edition – WISC-IV; Wechsler 1991; Wechsler 2003). WISC scores are presented using index composite scores (M = 100; SD = 15).

Table 8

One-Sample t-Test for Group WISC Indices Compared to Normative Sample

Diagnostic Group	WISC-IV Index	*t*	df	*p*-value
ADHD	VCI	- 1.85	80	.07
	PRI	0.30	80	.76
	WMI	-5.53	80	.000
	PSI	-3.33	80	.001
	FSIQ	-2.40	80	.02
ADHD + LD	VCI	-1.87	64	.07
	PRI	0.50	64	.62
	WMI	-6.81	64	.000
	PSI	-7.66	64	.000
	FSIQ	-4.26	64	.000
LD	VCI	-1.21	72	.23
	PRI	1.25	72	.22
	WMI	-5.68	72	.000
	PSI	-7.14	72	.000
	FSIQ	-3.57	72	.001
Clinical Comparisons	VCI	-1.93	57	.06
	PRI	-0.92	57	.36
	WMI	-3.93	57	.000
	PSI	-3.26	57	.002
	FSIQ	-2.95	57	.01

Note. WISC = Wechsler Intelligence Scale for Children (Third Edition - WISC-III; Wechsler, 1991; Fourth Edition – WISC-IV; Wechsler 2003). WISC scores are presented using index composite scores (*M* = 100; *SD* =15).

Table 9

Between Subjects ANOVAs F-Values, Degrees of Freedom, and p-Values for WISC-IV Indices

Dependent Variables	*F*	df	*p*-value
VCI	0.30	(3, 272)	.83
PRI	0.83	(3, 272)	.48
WMI	0.35	(3, 272)	.79
PSI	2.97	(3, 272)	.03
FSIQ	0.41	(3, 272)	.75

Note. WISC = Wechsler Intelligence Scale for Children (Third Edition - WISC-III; Wechsler, 1991; Fourth Edition – WISC-IV; Wechsler 2003). WISC scores are presented using index composite scores (M = 100; SD =15).

Table 10

Tukey's HSD Comparison for Processing Speed Index (PSI) of WISC

(I) Group	(J) Group	Mean Diff (I-J)	Standard Error	*p*-value
ADHD	ADHD + LD	5.87*	2.16	.04
	LD	4.54	2.09	.14
	Clinical Comparisons	1.06	2.23	.96
ADHD + LD	ADHD	-5.87*	2.16	.04
	LD	-1.33	2.21	.93
	Clinical Comparison	-4.81	2.34	.17
LD	ADHD	-4.54	2.09	.14
	ADHD + LD	1.33	2.21	.93
	Clinical Comparisons	-3.47	2.28	.43
Clinical Comparisons	ADHD	-1.06	2.23	.96
	ADHD + LD	4.81	2.34	.17
	LD	3.47	2.28	.43

Note. WISC = Wechsler Intelligence Scale for Children (Third Edition - WISC-III; Wechsler, 1991; Fourth Edition – WISC-IV; Wechsler 2003. PSI = Processing Speed Index of the WISC (Wechsler, 2003).

Table 11

Means, Standard Deviations, and Minimum and Maximum Scores for VMI by Group

Diagnostic Group	*Mean*	*SD*	Minimum Score	Maximum Score
ADHD	94.04	13.12	70.00	131.00
ADHD + LD	92.17	10.55	72.00	125.00
LD	92.08	12.02	65.00	128.00
Clinical Comparison	94.27	12.76	66.00	133.00

Note. VMI = Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery, 1997). Scores are presented in standard scores (M = 100; SD = 15).

Table 12

One-Sample t-Test for Group VMI Standard Scores Compared to Normative Sample

Diagnostic Group	*t*	df	*p*-value
ADHD	30.03	79	.000
ADHD + LD	31.98	63	.000
LD	29.92	72	.000
Clinical Comparison	25.97	55	.000

Note. VMI = Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery, 1997). Scores are presented in standard scores.

Table 13

Between Subjects ANOVA F-Value, Degrees of Freedom, and p-Values for VMI Standard Scores

F	df	*p*-value
0.66	(3, 272)	.58

Note. VMI = Beery-Buktenica Developmental Test of Visual-Motor Integration. Scores are presented in standard scores (*M* = 100; *SD* = 15; Beery, 1997)

Table 14

Means, Standard Deviations, and Minimum and Maximum Scores for Behavioural Symptoms of ADHD

Diagnostic Group	Measure	*Mean*	*SD*	Minimum Score	Maximum Score
ADHD	Symptoms of Inattention (PICS + TTI)	6.27	1.91	0.00	9.00
	Symptoms of Hyperactivity-Impulsivity (PICS + TTI)	5.88	2.15	1.00	9.00
ADHD + LD	Symptoms of Inattention (PICS + TTI)	6.36	1.71	1.50	9.00
	Symptoms of Hyperactivity-Impulsivity (PICS + TTI)	4.95	2.50	0.00	9.00
LD	Symptoms of Inattention (PICS + TTI)	3.27	1.73	0.00	8.00
	Symptoms of Hyperactivity-Impulsivity (PICS + TTI)	2.14	1.63	0.00	7.00
Clinical Comparisons	Symptoms of Inattention (PICS + TTI)	3.85	2.35	0.00	9.00
	Symptoms of Hyperactivity-Impulsivity (PICS + TTI)	3.62	2.24	0.00	8.50

Note. PICS = Parent Interview for Child Symptoms (Schachar, Ickowicz, & Sugarman, 2000). TTI = Teacher Telephone Interview (Tannock, Hum, Masellis, Humphries & Schachar, 2002). Symptoms of inattention and hyperactivity/impulsivity (PICS + TTI) presented as mean number of symptoms across settings out of possible number of nine.

Table 15

Between Subjects MANOVA F-Values, Degrees of Freedom, and p-Values for Behavioural Symptoms of ADHD

Measure	*F*	df	*p*-value
Symptoms of Inattention (PICS + TTI)	48.59	(3, 271)	.000
Symptoms of Hyperactivity-Impulsivity (PICS + TTI)	33.34	(3, 271)	.000

Note. PICS = PICS = Parent Interview for Child Symptoms (Schachar, Ickowicz, & Sugarman, 2000). TTI = Teacher Telephone Interview (Tannock, Hum, Masellis, Humphries & Schachar, 2002). Symptoms of inattention and hyperactivity/impulsivity (PICS + TTI) presented as mean number of symptoms across settings out of possible number of nine.

Table 16

Tukey's HSD Comparison for Mean Number of Symptoms of Inattention

(I) Group	(J) Group	Mean Diff (I-J)	Standard Error	*p*-value
ADHD	ADHD + LD	- 0.10	0.32	.99
	LD	2.99*	0.31	.000
	Clinical Comparisons	2.41*	0.33	.000
ADHD + LD	ADHD	0.10	0.32	.99
	LD	3.09*	0.33	.000
	Clinical Comparison	2.51*	0.35	.000
LD	ADHD	-2.99*	0.31	.000
	ADHD + LD	-3.09*	0.33	.000
	Clinical Comparisons	-0.58	0.34	.32
Clinical Comparisons	ADHD	-2.41*	0.33	.000
	ADHD + LD	-2.51*	0.35	.000
	LD	0.58	0.34	.32

Note. Symptoms of inattention presented as mean number of symptoms endorsed across settings out of possible number of nine (PICS; Schachar, Ickowicz, & Sugarman, 2000; TTI; Tannock, Hum, Masellis, Humphries & Schachar, 2002).

Table 17

Tukey's HSD Comparison for Symptoms of Hyperactivity

(I) Group	(J) Group	Mean Diff (I-J)	Standard Error	*p*-value
ADHD	ADHD + LD	0.94*	0.36	.04
	LD	3.74*	0.35	.000
	Clinical Comparisons	2.26*	0.37	.000
ADHD + LD	ADHD	-0.94*	0.36	.04
	LD	3.74*	0.35	.000
	Clinical Comparison	2.26*	0.37	.000
LD	ADHD	-3.74*	0.35	.000
	ADHD + LD	-2.81*	0.37	.000
	Clinical Comparisons	-1.48*	0.38	.001
Clinical Comparisons	ADHD	-2.26*	0.37	.000
	ADHD + LD	-1.33*	0.39	.004
	LD	1.48*	0.38	.001

Note. Symptoms of hyperactivity/impulsivity presented as mean number of symptoms endorsed across settings out of possible number of nine (PICS; Schachar, Ickowicz, & Sugarman, 2000; TTI; Tannock, Hum, Masellis, Humphries & Schachar, 2002).

Table 18

Means, Standard Deviations, and Minimum and Maximum Scores for Overall Achievement on WIAT-II by Group

Diagnostic Group	*Mean*	*SD*	Minimum Score	Maximum Score
ADHD	97.22	11.05	72.33	127.00
ADHD + LD	88.50	10.76	66.67	114.33
LD	88.19	10.13	62.33	114.00
Clinical Comparison	95.51	12.20	65.33	120.67

Note. WIAT-II = Wechsler Individual Achievement Test – Second Edition (Wechsler, 2002). Overall achievement measured by mean of Word Reading, Numerical Operations and Spelling subtest standard scores (M = 100; SD = 15).

Table 19

One-Sample t-Test for Overall Achievement on WIAT-II Compared to Normative Sample

Diagnostic Group	*t*	df	*p*-value
ADHD	- 2.27	(80)	.03
ADHD + LD	-8.62	(64)	.000
LD	-9.96	(72)	.000
Clinical Comparison	-2.80	(57)	.01

Note. WIAT-II = Wechsler Individual Achievement Test – Second Edition (Wechsler, 2002). Overall achievement measured by mean of Word Reading, Numerical Operations and Spelling subtest standard scores (*M* = 100; *SD* = 15).

Table 20

Between Subjects ANOVA F-Values, Degrees of Freedom, and p-Values for Academic Achievement on WIAT-II

F	df	*p*-value
11.55	(3, 272)	.000

Note. WIAT-II = Wechsler Individual Achievement Test – Second Edition (Wechsler, 2002). Academic achievement based on mean of Word Reading, Numerical Operations, and Spelling subtest standard scores.

Table 21

Tukey's HSD Comparison for Academic Achievement on WIAT-II

(I) Group	(J) Group	Mean Diff (I-J)	Standard Error	*p*-value
ADHD	ADHD + LD	8.72*	1.83	.000
	LD	9.03*	1.78	.000
	Clinical Comparisons	1.71	1.89	.80
ADHD + LD	ADHD	-8.72*	1.83	.000
	LD	0.31	1.88	.99
	Clinical Comparison	-7.01*	1.99	.003
LD	ADHD	-9.03*	1.78	.000
	ADHD + LD	-0.31	1.88	.99
	Clinical Comparisons	-7.32*	1.94	.001
Clinical Comparisons	ADHD	-1.71	1.89	.80
	ADHD + LD	7.01*	1.99	.003
	LD	7.32*	1.94	.001

Note. WIAT-II = Wechsler Individual Achievement Test – Second Edition (Wechsler, 2002). Academic achievement based on mean of Word Reading, Numerical Operations, and Spelling subtest standard scores.

Table 22

Pearson's Correlations for Demographic Variables and Overall Academic Achievement on the WIAT-II

	Age		SES		Birth Weight		Number of Comorbid Dx		Sex		Family Structure	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
WIAT-II	-.20	.001	.04	.57	.01	.89	-.18	.003	.02	.75	.03	.67

Note. WIAT-II = Wechsler Individual Achievement Test – Second Edition (Wechsler, 2002). Overall achievement measured by mean of Word Reading, Numerical Operations and Spelling subtest standard scores.

Table 23

Pearson's Correlations for WISC Indices and Overall Academic Achievement on the WIAT-II

	VCI		PRI		WMI		PSI		FSIQ	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
WIAT-II	.51	.000	.37	.000	.44	.000	.36	.000	.56	.000

Note. WISC = Wechsler Intelligence Scale for Children (Third Edition - WISC-III; Wechsler, 1991; Fourth Edition – WISC-IV; Wechsler 2003). WISC scores are presented using index composite scores (*M* = 100; *SD* =15). WIAT-II = Wechsler Individual Achievement Test – Second Edition (Wechsler, 2002). Academic achievement measured as mean of WIAT-II Word Reading, Numerical Operations, and Spelling subtest standard scores.

Table 24

Pearson's Correlations for VMI and Overall Academic Achievement on the WIAT-II

	VMI	
	r	*p*
WIAT-II	.35	.000

Note. VMI = Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery, 1997). Scores are presented in standard scores (M = 100; SD = 15).

Table 25

Pearson's Correlations for Symptoms of ADHD and Overall Academic Achievement on the WIAT-II

	Inattention (PICS + TTI)		Hyperactive-Impulsive (PICS + TTI)	
	r	*p*	*r*	*p*
WIAT-II	-.17	.05	.09	.13

Note. PICS = Parent Interview for Child Symptoms (Schachar, Ickowicz, & Sugarman, 2000). TTI = Teacher Telephone Interview (Tannock, Hum, Masellis, Humphries & Schachar, 2002). Symptoms of inattention and hyperactivity/impulsivity presented as mean number of symptoms endorsed across settings on the PICS and TTI.

Table 26

Hierarchical Regression Analysis Predicting Overall Academic Achievement on WIAT-II

	B	*SE*	β	*t*	*p*-value
Step 1					
Age	-1.40	0.41	-.20	-3.38	.001
Step 2					
VCI	0.29	0.05	.33	5.44	.000
PRI	-0.04	0.06	-.04	-0.62	.53
WMI	0.25	0.05	.26	4.68	.000
PSI	0.10	0.05	.11	1.97	.05
VMI	0.17	0.06	.18	3.08	.002
Step 3					
PICS + TTI Inattention	0.05	0.24	.01	0.19	.85
Step 4					
Number of Comorbid Dx	-2.47	0.75	-.16	-3.28	.001

Note. WIAT-II = Wechsler Individual Achievement Test – Second Edition (Wechsler, 2002). VCI = Verbal Comprehension Index. PRI = Perceptual Reasoning Index. WMI = Working Memory Index of WISC. PSI = Processing Speed Index of WISC (Wechsler, 1991; 2003). VMI = Beery-Buktenica Developmental Test of Visual-Motor Integration. PICS = Parent Interview for Child Symptoms (Schachar, Ickowicz, & Sugarman, 2000). TTI = Teacher Telephone Interview (Tannock, Hum, Masellis, Humphries & Schachar, 2002). Symptoms of inattention presented as composite number of symptoms on PICS and TTI.